



BSI Standards Publication

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

National foreword

This British Standard is the UK implementation of EN 15316-4-2:2017, incorporating corrigendum October 2017. It supersedes BS EN 15316-4-2:2008, which is withdrawn.

The start and finish of text introduced or altered by corrigendum is indicated in the text by tags. Text altered by CEN corrigendum October 2017 is indicated in the text by AC AC.

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Energy performance of buildings - Method for calculation
of system energy requirements and system efficiencies -
Part 4-2: Space heating generation systems, heat pump
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Performance énergétique des bâtiments - Méthode de
calcul des besoins énergétiques et des rendements des
systèmes - Partie 4-2 : Systèmes de génération de
chauffage des locaux, systèmes de pompes à chaleur
Module M3-8-2, M8-8-2

Energetische Bewertung von Gebäuden - Verfahren zur
Berechnung der Energieanforderungen und
Nutzungsgrade der Anlagen - Teil 4-5: Fernwärme und
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This document consolidates EN 15316-4-2:2017 and the corrigendum EN 15316-4-2:2017/AC:2017.



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European foreword

This document (EN 15316-4-2:2017) has been prepared by Technical Committee CEN/TC 228 “Heating systems and water based cooling systems in buildings”, the secretariat of which is held by DIN.

This document supersedes EN 15316-4-2:2008.

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of an identical text or by endorsement, at the latest by October 2017, and conflicting national standards shall be withdrawn at the latest by October 2017.

The revision keeps the main principles of the calculation unchanged but the structure of the document was changed. Informative content was removed to the accompanying technical report CEN/TR 15316-6-2. The provisions cover also other energy carriers than heat now. The values may be altered in a national annex.

Calculation methods to determine energy source indicators like the renewable energy ratio have been added.

The main changes compared to EN 15316-4-2:2008 are:

- a) type of heat pumps are now limited to hot water production at the output of the condenser;
- b) informative content was removed to the accompanying technical report CEN/TR 15316-6-2;
- c) calculation for performance of the heat pumps at different conditions is based on interpolation provisions;
- d) input data for energy performance of the heat pumps are based on part load and/or full load information;
- e) Annex A contains a template for the data and parameters used in the standards and Annex B a set of default values.

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

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.

This document includes the corrigendum EN 15316-4-2:2017/AC:2017 which corrects Table D.3.

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 European 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”.

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.

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

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

- energy performance calculation for heating systems;
- inspection of heating systems;
- design of heating systems;
- installation and commissioning of heating systems.

This standard specifies to take into account the energy performance of heat pump systems used for domestic or heating purpose.

For the correct use of this standard, Annex A is to be used to specify the choices with the required input data. Default values are presented in Annex B. 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, in particular for the application within the context of EU Directives transposed into national legal requirements. These choices can be made available as National Annex or as separate (e.g. legal) document. It is expected, if the default values and choices in Annex A are not followed due to national regulations, policy or traditions, that:

- either the national standardization body will consider the possibility to add or include a National Annex in agreement with the template of Annex A.
- or the national or regional authorities will, in the building regulations, reference the standard and prepare data sheets containing the national or regional choices and values, in agreement with the template of Annex A.

This updated standard covers hourly, monthly, annual time-steps and temperatures classes (bin method).

1 Scope

This European Standard covers heat pumps for space heating, heat pump water heaters (HPWH) and heat pumps with combined space heating and domestic hot water production in alternate or simultaneous operation, where the same heat pump delivers the heat to cover the space heating and domestic hot water heat requirement.

The standard provides a calculation method under steady conditions that corresponds to one calculation step.

The results of this calculation are incorporated in larger building models and take in account the influence of the external conditions and building control that influence the energy requirements for heating supplied by the heat pump system.

The scope of this part is to standardize the:

- required inputs;
- calculation methods;
- required outputs

Generation for space heating and domestic hot water production of the following heat pump systems, including control of:

- electrically-driven vapour compression cycle (VCC) heat pumps;
- combustion engine-driven vapour compression cycle heat pumps;
- thermally-driven vapour absorption cycle (VAC) heat pumps,

using combinations of heat source and heat distribution listed in Table 1.

Table 1 — Heating sources and energy distribution

Source	Distribution
Outdoor air	Water
Exhaust-air	
Indirect ground source with brine	
Indirect ground source with water	
Direct ground source (Direct expansion (DX))	
Surface water	
Ground water	

This standard does not cover sizing or inspection of heat pumps.

This standard deals with heat generators for heating or for combined domestic hot water and heating service. Generators for domestic hot water only are taken into account into module M8-8.

NOTE 1 Heat pumps for cooling systems are taken into account into module M4-8.

NOTE 2 Heat pumps for space heating using air (distribution) are taken into account in module M5-8.

Other generation systems such as boilers are covered in other sub modules of part M3-8.

This is the revision of EN 15316-4-2:2008. The revision covers the adaptation of the standard to hourly and monthly energy calculation.

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 3 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 4 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	Hot Domestic water	Lighting	Building automation and control	Electricity production
sub 1		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			
					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
					8-6	Direct electrical heater	15316-4-6					15316-4-6			
					8-7	Wind turbines									15316-4-7
					8-8	Radiant heating, stoves	15316-4-8								
9	Calculated Energy Performance		9	Building Dynamics (thermal mass)	9	Load dispatching and operating conditions									
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	1545 9-1													

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 12309-4, *Gas-fired sorption appliances for heating and/or cooling with a net heat input not exceeding 70 kW - Part 4: Test methods*

EN 12309-6, *Gas-fired sorption appliances for heating and/or cooling with a net heat input not exceeding 70 kW - Part 6: Calculation of seasonal performances*

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

EN 14511 (all parts), *Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling*

EN 14825, *Air conditioners, liquid chilling packages and heat pumps, with electrically driven compressors, for space heating and cooling - Testing and rating at part load conditions and calculation of seasonal performance*

EN 16147, *Heat pumps with electrically driven compressors - Testing, performance rating and requirements for marking of domestic hot water units*

EN ISO 15927-6, *Hygrothermal performance of buildings - Calculation and presentation of climatic data - Part 6: Accumulated temperature differences (degree-days) (ISO 15927-6)*

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 definitions apply.

3.1

alternate operation

production of heat energy for the space heating and domestic hot water system by a heat generator with combined service by switching the heat generator either to the domestic hot water operation or the space heating operation

3.2

application rating conditions

mandatory rated conditions within the operating range of the unit that are published by the manufacturer or supplier

3.3

auxiliary energy

electrical energy used by technical building systems for heating, cooling, ventilation and/or domestic water to support energy transformation to satisfy energy needs

Note 1 to entry: This includes energy for fans, pumps, electronics, etc. Electrical energy input to a ventilation system for air transport and heat recovery is not considered as auxiliary energy, but as energy use for ventilation.

Note 2 to entry: The driving energy input for electrically-driven heat pumps in the system boundary of the COP and an electrical back-up heater is not entitled auxiliary energy.

3.4

back-up heater

heater to supply heat not covered by the heat pump system itself

Note 1 to entry: If the back-up heater is an electrical heater, the system is calculated according to this standard, if it is external system, this standard gives the demand of missing heat not supplied by the heat pump as output data.

3.5

bin hours

sum of all hours occurring at a given temperature for a specific location equal

Note 1 to entry: In EN 14825, the number is rounded to a whole number and is derived from representative weather data over the 1982–1999 period.

3.6**bivalent temperature**

lowest temperature at which the heat pump heating power and the building heat load are equal

Note 1 to entry: Below this point, the unit may still deliver capacity, but additional back up heating is necessary to fulfill the full heating load.

Note 2 to entry: According to the definition bivalent temperature is not fixed at the heating load depends on temperature and internal gains; but bivalent temperature is mainly consider a fixed by the control system to operate additional back-up heater.

3.7**bin**

statistical temperature class (sometimes a class interval) for the outdoor air temperature, with the class limits expressed in a temperature unit

3.8**coefficient of performance COP**

ratio of the heating capacity to the effective power input of the unit

3.9**combustion engine heat pump**

compressed vapour heat pump driven by a combustion engine.

3.10**cut-out period**

time period in which the electricity supply to the heat pump is interrupt by the supplying utility

3.11**effective power input**

average power input of the unit within the defined interval of time obtained from:

- the power input for operation of the compressor or burner and any power input for defrosting;
- the power input for all control and safety devices of the unit; and
- the proportional power input of the conveying devices (e.g. fans, pumps) for ensuring the transport of the heat transfer media inside the unit based on the operating time of the heat pump

3.12**electrically-driven heat pump**

vapour compression cycle heat pump, which incorporate a compressor that is driven by an electric motor

3.13**combined heat pump**

heat generator, which supplies energy to two different systems, e.g. the space heating system and the domestic hot water system in alternate or simultaneous combined operation

3.14**gas absorption heat pump**

heat pump working with a thermodynamic cycle that uses ammonia as a refrigerant and water as absorber, powered through a combustion direct flame

3.15

heat pump

appliance which takes up heat at a certain temperature and releases heat at a higher temperature

Note 1 to entry: When operated to provide heat (e.g., for space heating or water heating), the appliance is said to operate in the heating mode; when operated to remove heat (for example, for space cooling), it is said to operate in the cooling mode.

3.16

heat transfer medium

any medium (water, air, etc.) used for the transfer of the heat without change of state, that can be:

- the fluid cooled by the evaporator;
- the fluid heated by the condenser

3.17

heating power $P_{HW,gen,out}$

heat flow rate given off by the unit to the heat transfer medium per unit of time for heating, or domestic hot water or a combination of these

Note 1 to entry: If heat is removed from the indoor heat exchanger for defrosting, it is taken into account.

3.18

monovalent H.P

unitary or split type assembly using only one energy carrier to transfer heat, other than electricity for auxiliary systems only

Note 1 to entry: This energy carrier can be also electricity.

3.19

bivalent H.P

unitary or split type assembly using one energy carrier to transfer heat and the same or another energy carrier to produce heat by conversion in an auxiliary device placed into the same assembly, other than electricity for auxiliary systems only

Note 1 to entry: One of these energy carriers can be also electricity.

3.20

operation temperature limit

TOL

lowest outdoor temperature at which the unit can still deliver heating capacity, as declared by the manufacturer

Note 1 to entry: Below this temperature the heat pump will not be able to deliver any heating capacity.

3.21

operating range

range indicated by the manufacturer and limited by the upper and lower limits of use (e.g. temperatures, air humidity, voltage) within which the unit is deemed to be fit for use and has the characteristics published by the manufacturer

3.22**part load operation**

operation state of the heat pump system where the actual load requirement is below the actual output capacity of the device

3.23**part load ratio****LR**

ratio between the generated heat during the calculation period and the maximum possible output from the heat generator during the hourly calculation period or bin temperature

Note 1 to entry: Part load ratio is not used for monthly method.

3.24**primary pump**

pump mounted in the circuit containing the generator and hydraulic decoupling, e.g. a heating buffer storage in parallel configuration or a hydronic distributor

3.25**produced (thermal) energy**

heat produced by the heat pump system to cover the energy requirement of the distribution subsystem and the generation subsystem heat losses for space heating and/or domestic hot water

3.26**set-point temperature of a conditioned zone**

indoor (minimum intended) temperature, as fixed by the control system in heating mode

3.27**simultaneous operation during the heating period**

simultaneous production of heat energy for the space heating and domestic hot water use by a combined heat pump

3.28**simultaneous operation during the heating period**

simultaneous production of heat energy for the space heating and domestic hot water use by a combined heat pump

4 Symbols and abbreviations**4.1 Symbols**

For the purposes of this document, the symbols given in EN ISO 52000-1, and the specific terms listed in Table 3 apply.

Table 3 — Symbols

LR	Part load ratio
----	-----------------

4.2 Subscripts

For the purposes of this document, the subscripts given in EN ISO 52000-1, and the specific subscripts listed in Table 4 apply.

Table 4 —Subscripts

add	additional	cont	continuous	OL	Operative limit
biv	Bivalent	dgn	Design	P0	At zero load
bu	Back - up	dh	Degradation heating	Pdn	At P design
ci	calculation interval	eng	Engine	Pint	At intermediate load
Comp	Compressor	evap	evaporator	Pn	At nominal power
cond	condenser	LRxx	load ratio xx%	stb	Stand by
lim	Limit	lw	Low	up	Upper
exer	exergy				

5 Description of the methods

5.1 General

These methods (hourly, bin, monthly, annual) cover the calculation of energy input, renewable energy, auxiliary energy and recoverable losses of heat pump for heating and/or domestic hot water.

The time step of the output can be:

- Hourly (method A);
- Bin (method A or B);
- Monthly (method B);
- Annual (Method B)

according to the time-step of the input.

Heat pump performance strongly depends on the operating conditions, basically the source and the sink temperature and part load operation. As source and sink temperatures vary over the heating periods and the year, the heat pump performance shall be calculated according with an adapted step period, in line with the climatic data used.

The time step shall be adapted to according to the climatic data available and the accuracy required for the calculation

NOTE For some alternative methods, calculation periods are not oriented at the time scale, i.e. monthly values, but on the frequency of the outdoor air temperature (bin method). This method is described in EN 14825 and EN 12309-6.

5.2 Multiple heat generators

Heat pumps systems for heating can be independent or used as part of a system including other generators.

Priority given to the heat pump and back-up system when designed is indicated by GEN_CTRL_PRIO (Annex A) and based on information received from the building automation control (BAC).

5.3 System boundary

5.3.1 General

The system boundary defines the components of the entire heating systems that are considered in this standard. For the heat pump generation subsystem the system boundary comprises the heat pump, the heat source system, attached internal and external storages and attached electrical back-up heaters. Auxiliary components connected to the generation subsystem are considered, as long as no transport energy is transferred to the distribution subsystem. For fuel back-up heaters the required back-up energy is included in the system boundary.

Distribution and emission systems are out of the system boundaries.

5.3.2 Physical factors taken into account:

The calculation method takes into account the following physical factors, which have an impact on the energy performance of the heat pump during the calculation period and thereby on the required energy input to meet the heat requirements of the distribution subsystem:

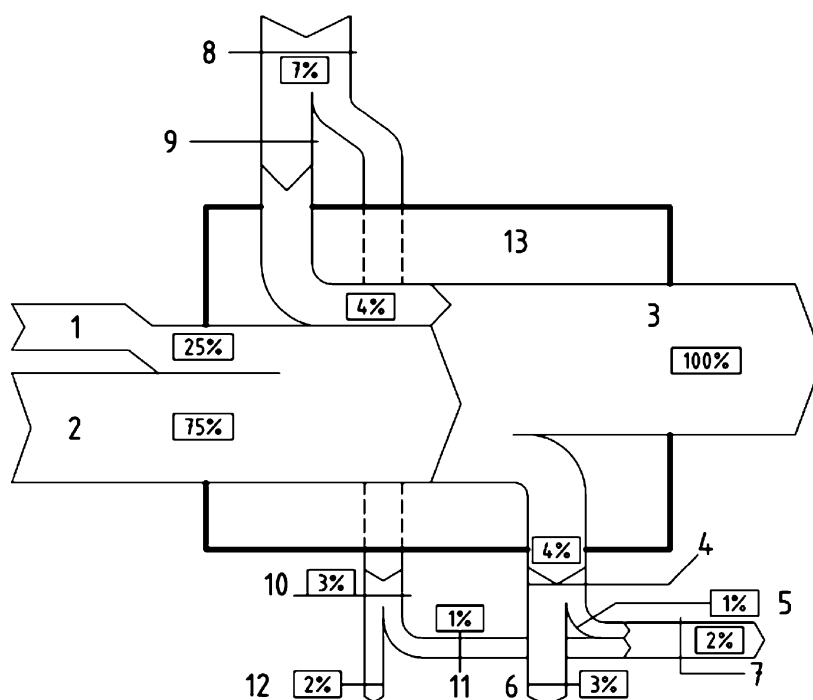
- type of generator configuration (monovalent heat pump, bivalent heat pump);
- type of heat pump (driving energy (e.g. electricity or fuel), thermodynamic cycle (VCC, VAC));
- combination of heat source and sink (e.g. ground-to-water, air-to-water);
- space heating and domestic hot water energy requirements of the distribution subsystem(s);
- effects of variation of source and sink temperature on thermal capacity and COP according to standard product testing;
- effects of compressor control in part load operation (ON-OFF, stepwise, variable speed units) as far as they are reflected in the thermal capacity and COP according to standard testing or further test results on part load operation exist;
- auxiliary energy input needed to operate the generation subsystem, if not considered in standard testing of thermal capacity and COP;
- location of the generation subsystem.

5.4 Schematisation of the heat pump for heating

A schematisation of the heat pump is presented in Figure 1.

The numbers indicated in Figure 1 refer to the percentage of the energy flows to cover the distribution subsystem heat requirement (100 %). They are intended to give an idea of the size of the respective energy flows. The numbers vary dependent on the physical factors listed before. The numbers given in Figure 1 refer to an electrically-driven ground-source heat pump in monovalent space heating-only operation including buffer storage.

The heat source can be considered as renewable (i.e. ground source) or recovered (air recovery) depending on the type of system and the system boundary considered.



Key

- | | |
|---|--|
| 1 driving energy input to cover the heat requirement (e.g. electricity, fuel) $E_{HW;gen;in}$ | 8 auxiliary energy input $W_{HW;gen;aux}$ |
| 2 heat used as heat source of the heat pump $Q_{HW;gen;in}$ | 9 recovered heat loss of auxiliary components $Q_{HW;gen;aux;ls;rvd}$ |
| 3 heat output of generation subsystem corresponding to the heat requirement of the distribution subsystem $Q_{HW;gen;out} = Q_{HW;gen;dis;out}$ | 10 unrecovered heat loss of auxiliary components $Q_{HW;gen;aux;ls}$ |
| 4 generation subsystem heat losses $Q_{HW;gen;ls;tot}$ | 11 recoverable heat loss of auxiliary components $Q_{H;gen;aux;ls;rbl}$ |
| 5 recoverable generation subsystem heat losses $Q_{H;gen;ls;rbl}$ | 12 not recoverable heat loss of auxiliary components $Q_{HW;gen;aux;ls;nrb}$ |
| 6 not recoverable generation subsystem heat losses $Q_{HW;gen;ls;nrb}$ | 13 generation subsystem |
| 7 total recoverable generation subsystem heat losses $Q_{H;gen;ls;rbl;tot}$ | |

Figure 1 — Example of energy balance of generation subsystem for heating

5.5 Energy input needed to meet the heat requirements for heat pumps system

The energy balance for the electrically-driven generation heat pump in heating mode given by:

$$E_{HW;gen;in} \times COP_{HW;gen} = Q_{HW;gen;out} + Q_{HW;gen;ls;tot} - Q_{HW;gen;in} - f_{gen;aux;ls;rvd} \times W_{HW;gen;aux} \quad [\text{kWh}] \quad (1)$$

where

$E_{HW;gen;in}$	is the energy input from electrical energy, fuel or heat input to cover the heat requirement of the distribution subsystem for heating(H) and domestic hot water(W);
$COP_{HW;gen}$	is the average coefficient of performance for heating and domestic hot water
$Q_{HW;gen,out}$	is the thermal energy output;
$Q_{HW;gen;ls,tot}$	is the total heat losses of the generation subsystem;
$Q_{HW;gen;in}$	is the ambient heat energy used as heat source of the heat pump;
$f_{gen;aux;ls;rvd}$	is the recovered fraction of heat energy from the auxiliaries (if not included in the COP);
$W_{HW;gen;aux}$	is the auxiliary energy input to operate the generation subsystem.

In case of electrically-driven heat pumps, the term $E_{HW;gen;in}$ is the electrical energy input necessary for the heat pump system to cover the energy requirement of the distribution subsystem. It comprises the electrical energy input to the heat pump system and possibly installed back-up heaters.

According to the EN 14511 series, $E_{HW;gen;in}$ also includes the fractions of the auxiliary energies included in the COP, i.e. the energy for control and safety devices during operation, the proportional energy input for pumps and fans to ensure the transport of the heat transfer media inside the unit as well as eventually energy for defrost operation and additional heating devices for the oil supply of the compressor.

- Thus, $W_{HW;gen;aux}$ only comprises the fractions not included in the COP standard testing. $f_{gen;aux;ls;rvd}$ describes the fraction of auxiliary energy, which is recovered as thermal energy, e.g. for pumps where a fraction of the auxiliary energy is directly transferred to the heat transfer medium as thermal energy. This fraction is already contained in the COP according to the EN 14511 series for electrically-driven heat pumps, so $f_{gen;aux;ls;rvd} = 0$.
- For total heat losses $Q_{HW;gen;ls,tot}$, the heat losses of the heat pump over the envelope are neglected unless heat loss values of the heat pump are known, e.g. given in a national Annex. For systems with integrated or external heating buffer or DHW hot water storage, generation subsystem losses in form of storage heat losses and losses of the connecting circulation pipes to the storage are considered.

In case of the combustion engine-driven and absorption heat pumps:

- $E_{HW;gen;in}$ describes the driving energy input to cover the heat requirement of the distribution subsystem for heating and domestic hot water. For combustion engine-driven heat pumps, this driving energy is fuel, e.g. as diesel or natural gas. For thermally-driven absorption heat pumps, fuel-driven burners, but also solar energy or waste heat can be the driving energy input.
- $Q_{HW;gen,out}$ the heat energy output of the generation equals the heat requirement of the distribution subsystem and contains all fractions of heat recovered from the engine or the flue gas of the engine, i.e. recovered heat from the engine is entirely considered within the system boundary of the generation subsystem.
- $f_{gen;aux;ls;rvd}$ gives the fraction of the auxiliary energy recovered as thermal energy and depends on the test method. The fraction $f_{gen;aux;ls;rvd} = 0$, if the recovered heat is already included in the COP.

5.6 Auxiliary energy ($W_{HW;gen;aux}$)

Auxiliary energy is energy needed to operate the generation subsystem, e.g. the source pump or the control system of the generator.

For electrically-driven heat pumps thermal capacity and COP in this standard are calculated on the basis of results from product testing, according to the EN 14511 series, only the auxiliary energy not included in the test results, e.g. the power to overcome the external pressure drop and the power in stand-by operation, shall be considered in $W_{HW;gen;aux}$.

For combustion- engine driven heat pump, the electrical energy necessary to operate the heat pump is not measured according to EN 12309-2. $f_{gen;Pn;aux;el}$ considers this energy use as a percentage of the energy input at full load" with the electrical energy necessary to operate the heat pump is measured according to EN 12309-4.

Auxiliary energy is accounted to the generation subsystem as long as no transport energy is transferred to the distribution subsystem. That means, in general the circulation pump is accounted to the distribution subsystem, unless a hydraulic decoupling exist. For a hydraulic decoupling between the generation and various distribution subsystems, e.g. by a heating buffer or domestic hot water storage in parallel configuration, the primary pump is accounted to the generation subsystem, as well.

In this case, the power to overcome the external pressure drop has to be taken into account. If no primary pump is considered, since there is no hydraulic decoupling between the generation and distribution subsystem, the COP-values have to be corrected for the internal pressure drop, which is included in the COP-values by the standard testing.

5.7 Recoverable, recovered and unrecoverable heat losses

The calculated losses are not necessarily lost. Parts of the losses are recoverable, and parts of these recoverable losses are actually recovered. The recovered losses are determined by the location of the generator and the utilization factor (gain/loss ratio, see EN ISO 13790).

Recoverable heat losses $Q_{H;gen;ls;rbt}$ are e.g. heat losses through the envelope of a generation subsystem, e.g. in form of storage losses when the storage is installed in the heated space. For a generation subsystem installed outside the heated space, however, the heat losses through the envelope of the generator are not recoverable.

Flue gas losses of fuel engine-driven heat pumps are considered not recoverable, since all recovered flue gas losses inside the generation subsystem limits are contained in the heat output $Q_{HW;gen;out}$

Neglecting the thermal losses if below a certain percentage of the heating or cooling demand, can be introduce at a national level.

Neglecting the recovered and recoverable losses from auxiliary energy demand if below a certain percentage of the heating or cooling demand, can be introduce at a national level.

5.8 Calculation by zones

A heating system may be split up in zones with different distribution subsystems. A separate circuit may be used for domestic hot water production.

Several heat generation subsystems may be available. The total heat output of the generation subsystems equals the sum of heat requirement of all connected distribution subsystems of the different services

$$\sum_j Q_{H;gen;out;j} = \sum_k Q_{H;gen;nd;out,k} \quad [\text{kWh}] \quad (2)$$

where

$Q_{H;gen;out,j}$ is the space heating heat energy requirement to be covered by the generation subsystem j [kWh];

$Q_{H;gen;nd;out,k}$ is the heat energy requirement of space heating distribution subsystem k [kWh].

5.9 Combined heating and domestic hot water preparation

When more generators are available (multivalent system configuration), the total heat demand of the distribution subsystem(s) $Q_{H;gen;nd;out}(k)$ shall be distributed among the available generators and the calculation described in Clause 7 shall be performed independently for each generation subsystem k on the basis of $Q_{H;gen;out,k}$. This is accomplished in case of an installed back-up heater.

For intermittent heating, the requirements of ISO 13790 shall be considered.

For combined operation of the heat pump for space heating and domestic hot water production, two kinds of operation modes can be distinguished, alternate and simultaneous operation.

For simultaneous operation, space heating and domestic hot water requirements are covered at the same time. Three operation modes have to be distinguished:

- space heating only operation:
only the space heating system is in operation (winter time, DHW storage entirely loaded)
- domestic hot water-only operation:
only the domestic hot water system is in operation (summer operation, no space heating demand)
- both heating and domestic hot water operation:

The calculation used in this standard implies, that both the single operation modes and the simultaneous operation are tested according to standard testing, so thermal capacity- and COP characteristic of all three respective operation modes are available. As thermal capacity and COP characteristic of the simultaneous operation may differ significantly from the other two operation modes, these test results have to be available and taken into account.

6 Generation with heat pump systems - Energy calculation (hourly, bin) - Method A

6.1 Output data

The output data are listed in Table 5. These output data are identical for all time steps.

Table 5 — Output data of this method:

Description	Symbol	Unit	Intended destination module
Generation input	$E_{H;gen;in}$	kWh	M3-1
Recoverable heat	$Q_{H;gen;ls;rbl}$	kWh	M2-2
Renewable energy input ^a	$Q_{H;gen;ren;in}$ a b	kWh	M3-1
Total auxiliary energy	$W_{H;gen;aux}$	kWh	M3-1
Fuel type	HP_FUEL	List	M3-1
Back up energy	$E_{H;gen;bu;in}$	kWh	M3-1
Fuel type for back-up	HP_BU_FUEL	List	M3-1
Heat pump type	HP_TYP	List	M3-1
Energy delivered for heating	$Q_{H;gen;out}$	kWh	M3-6
Energy delivered for Domestic Hot Water	$Q_{W;gen;out}$	kWh	M8-7
Energy delivered for storage heating	$Q_{H;gen;sto;out}$	kWh	M3-7
Additional energy needed for heating	$Q_{HX;out;add}$	kWh	M3-1
Additional energy need for domestic hot water	$Q_{WX;out;add}$	kWh	M8-1
Driving energy type	HP_FUEL_TYPE	List	M3-1
^a Energy input could also be recovered from internal air; in this case the symbol attached to recovered energy input is changed into $Q_{H;gen;rvd;in}$. ^b Whether heat captured from the environment is renewable or not is based on information from EN ISO 52000-1.			

Generation input $E_{H;gen;in}$ is the amount of energy required by the heat pump in the calculation interval.

Recoverable heat $Q_{H;gen;ls;rbl}$ is the recoverable heat for heating in the calculation interval.

Renewable input $E_{H;gen;ren;in}$ is the energy input from a renewable source in the calculation interval.

Back-up energy $E_{H;gen;bu;in}$ is the surplus energy needed to satisfy the energy demand when the heat pump is not operating or to cover lack of power thermal capacity from the heat pump.

Destination modules are presented in Figure 1.

6.2 Input data

6.2.1 General

Input information for the procedure may consist of:

- type of building and sector;
- climatic data adapted to the local consideration;
- operating condition (including typical occupancy patterns of the relevant building sector operating conditions taken into account, comfort level and room temperature/humidity);

- heat pump function (space heating, domestic hot water production, any combination of these);
- type of heat pump (electrically-driven, engine-driven, etc);
- type of energy input (electricity, natural gas, LPG, oil, etc);
- type of heat source;
- test results produced in accordance with standard tests (e.g. EN 14825 and the EN 14511 series for electrically-driven heat pumps and the EN 12309 series for heat pumps by absorption);
- thermal (heating) capacity;
- whether performance data include the effect of an integrated storage, if any;
- integrated domestic hot water storage characteristics (volume / dimensions, specific loss);
- Information about control of the heat pump system and priority given to the energy use (e.g. priority to domestic hot water during heating mode);
- design and operation of the generation heat pump system, Calculation time step and calculation period;
- characteristics of the integrated back up heater.

NOTE The energy provided by non-integrated back-up system is obtained from other generators. This information is supervised by the control system for multi-generator systems.

Calculation period shall be subdivided in three sub period as the heat pump system is operating for:

- domestic hot water;
- space heating;
- alternate domestic hot water and space heating.

The climatic data shall be considered as constant for any calculation time step.

6.2.2 Product data

6.2.2.1 Product description data (qualitative)

The product description data of heat pumps is given by:

HP_TYPE: heat pump type (air, water, brine,...);

HP_TECH: type of control for the compressor unit (ON/OFF, inverter,...);

HP_USE: Use of the output heat (i.e. services, heating, domestic hot water, etc.);

HP_FUEL: Fuel type (gas, oil, electricity);

HP_BU: Type of Back-up associated to the heat pump system);

and are identified by the conventional strings defined in Annex B.

6.2.2.2 Product technical data

Required technical data for this calculation procedure are listed in the following table.

Table 6 — Product technical input data list

Characteristics	Symbol	Catalogue unit	Validity interval	Ref.	Varying
Thermal capacity at standard rating conditions at full load	$\Phi_{\text{gen;ref},X}^a$	kW	$[0;+\infty[$		NO
COP at standard rating conditions at full load	$\text{COP}_{\text{gen,ref},X}^a$	-	$[0...10[$	EN 14825 EN 14511 series	NO
Energy input at standard rating conditions at full load	$E_{\text{gen;ref},1}^a$	kWh	$[0;+\infty[$	EN 14825 EN 14511 series	NO
Inlet temperature at standard rating conditions at full load	$\vartheta_{\text{gen;in;ref}}^a$	°C	$] -100,100[$	EN 14825 EN 14511 series	NO
Temperature spread at the evaporator for standard rating conditions at full load	$\Delta\vartheta_{\text{gen;in;ref}}^a$	K	$] -100,100[$	EN 14825 EN 14511 series	NO
Outlet temperature at standard rating conditions at full load	$\vartheta_{\text{gen,out;ref}}^a$	°C	$] -100,100[$	EN 14825 EN 14511 series	NO
Temperature spread at the condenser for standard rating conditions at full load	$\Delta\vartheta_{\text{gen,out;ref}}^a$	K	$] -100,100[$	EN 14825 EN 14511 series	NO
Part Load factor at reference conditions ^a	$f_{LR,X}^{a,b}$	-	$[0:1]$		
Degradation coefficient	C_{cd}	-	$[0-1]$	EN 14825	NO
Part of the electrical power to operate the heat pump (auxiliaries)	$f_{\text{gen,Pn,aux,int}}$	-	$[0:1]$	Local	NO
Power of auxiliary	$P_{\text{gen,aux}}$	kW	$[0;+\infty[$	B-1	NO
Minimum value of the part load ratio consider for balancing ON_OFF mode to modulating mode for inverter technology	$LR_{\text{cont,min}}$	-	$[0:1]$	B-1	NO
Time constant for the ON-OFF operation	τ_{eq}	s	$[0;+\infty[$		NO
Time constant for recovering thermal condition for the distribution	$\tau_{\text{out,em,type}}$	s	$[0;+\infty[$		NO
Part of the auxiliary energy recovered	$f_{\text{vd,aux}}$	-	$[0:1]$		NO
^a Depending on the input data available $X = \{-\}$ for the EN 14511 series or $X = \{A;B;C;D\}$ and $\{E;F;G\}$ if available.					
^b The matrix describing the input data according to EN 14825 are precised in Annex E					

Default data are given in Annex B.

6.2.2.3 Process design

The process design data are given by

- HP_LOC location of the heat pump;
- HP_USE type of service (heating, domestic hot water).

Default data are given in Annex B.

6.2.2.4 Control

The process control options are defined given by:

- HEAT_GEN_CTRL_HP control of the output temperature from the heat pump;
- HEAT_GEN_CTRL_HP_BU control of the temperature when the back up is operating (could be different from the main operation for HP)
- HEAT_GEN_CTRL_SEQ control of priority for multiple generator (this standard address energy calculation for a single unit)
- GEN_CTRL_PRIO type of priority between the different energy end use;
- GEN_CTRL_BU authorization for back-up system to operate

Default data are given in Annex B.

6.2.3 Operating conditions

Required operating conditions data for this calculation procedure are listed in Table 7.

Table 7 — Operating conditions data list

Name	Symbol	Unit	Range	Origin Module	Varying
Operating conditions					
Thermal capacity at design temperature load	Φ_{dgn}	kW	$[0;+\infty[$	A.1	NO
Design temperature	$\vartheta_{\text{gen,dgn}}$	°C	$[-50...100]$	M3-1	NO
Operation temperature limit (TOL)	$\vartheta_{\text{gen,TOL,min}}$	°C	$[-50...100]$	M3-1	NO
Maximum operative temperature	$\vartheta_{\text{gen,OL,max}}$	°C	$[0...100]$	M3-1	NO
Heat output to the heat distribution sub-system(s)	$Q_{\text{H;gen;dis;out}}$	kWh	$[0...\infty[$	M3-6	NO
Required flow temperature for heating	$\vartheta_{\text{H;gen,flw}}$	°C	$[0...100]$	M3-6	NO
Heat output to the DHW distribution sub-system(s)	$Q_{\text{W;gen;dis;out}}$	kWh	$[0...\infty[$	M8-6	NO
Required flow temperature for domestic hot water	$\vartheta_{\text{W;gen,flw}}$	°C	$[0...100]$	M8-6	NO
Heat input to the heat generation	$Q_{\text{H;gen,in}}$	kWh	$[0...\infty[$	M3-1	YES
Input temperature to the heat generation	$\vartheta_{\text{H;gen,in}}$	°C	$[0...100]$	M3-1	YES
Heat output to the storage sub-system(s)	$Q_{\text{sto;gen;dis;out}}$	kWh	$[0...\infty[$	M3-7	NO
Required flow temperature for storage	$\vartheta_{\text{sto;gen,flw}}$	°C	$[0...100]$	M3-7	NO
Calculation interval	t_{ci}	h	$[1...8760]$	M1-9	YES
Temperature difference at the inlet side (evaporator)	$\Delta\vartheta_{\text{H;in}}$	K	$[0-50]$	Local	YES
Temperature difference at the outlet side (condenser)	$\Delta\vartheta_{\text{H,out}}$	K	$[0-50]$	M3-6	YES
External temperature of the calculation interval	ϑ_{ext}	°C	$[-50...+50]$	M1-13	YES

6.2.4 Calculation parameters

Table 8 — Variables and terms used for the calculation procedure

Name	Symbol	Unit	Range	Origin Module	Varying
Calculation parameters					
Thermal capacity the generator at full load for the time step conditions	$\Phi_{\text{gen,LR100}}$ (t)	kW	[0;+∞]	EN 14825 EN 14511 series EN 12309-6	NO
Thermal energy delivered by the heat pump at full load for the time step condition	$Q_{\text{gen,LR100}}$ (t)	kWh	[0;+∞]	EN 14825 EN 14511 series EN 12309-6	NO
COP at full load for the time step conditions	$\text{COP}_{\text{gen,LR100}}$ (t)	-	[0;10]	EN 14825 EN 14511 series EN 12309-6	NO
heat output to the heating distribution sub-system(s)	$Q_{\text{H,gen,out}}$	kWh	0...∞	M3-6	YES
heat output to the domestic hot water distribution sub-system(s)	$Q_{\text{W,gen,out}}$	kWh	0...∞	M3-6	YES
Multiplying factor for adaptation of COP without influence of auxiliaries	$\phi_{\text{LR;cont;min;net}}$	-	[0-1]	Local	NO
Fraction of power used by auxiliaries	$f_{\text{gen;aux}}$	-	[0-1]	Local	NO
Weighting factor used for construction of the COP matrix for column k and line l	$\phi_{\text{COP,k,l}}$	-	[0-10]	Local	NO
Multiplying factor for adaptation of COP at full load from a reference situation	$\phi_{\text{gen;COP;LR100;}}$	-	[0-10]	Local	NO
Multiplying factor for adaptation of the thermal capacity at full load from a reference situation	$\phi_{\text{gen;Pn;LR100}}$	-	[0-10]	Local	NO
Load factor ratio	LR	-	[0-1]	Local	NO
Exergetic efficiency factor corresponding to test conditions X (X = A;B;C;D)	$f_{\text{LR;exer;X}}$	-	[0-1]	Local	No
Weighting factor for adaptation of the heat demand bin, monthly and annual time step)	$f_{\text{H;j}}$		[0-1]	Local	No