INTERNATIONAL STANDARD

ISO 13612-2

First edition
2014-05-01

Heating and cooling systems in buildings — Method for calculation of the system performance and system design for heat pump systems —

Part 2: Energy calculation

Systèmes de chauffage et de refroissement dans les bâtiments — Méthode de calcul de la performance du système et de la conception du système pour les systèmes de pompes à chaleur —

Partie 2: Calcul énergétique

Reference number
ISO 13612-2:2014(E)

Contents

Page

Foreword

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

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

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 205, *Building environment design*.

ISO 13612 consists of the following parts, under the general title *Heating and cooling systems in buildings — Method for calculation of the system performance and system design for heat pump systems*:

— *Part 1: Design and dimensioning*

— *Part 2: Energy calculation*

Introduction

This International Standard is a part of a series of standards on the methods for calculation of heating system energy requirements and heating and cooling system efficiencies.

— ISO 13612-1 deals with design and sizing of heat pump systems.

— ISO 13612-2 presents the energy calculation method.

The energy performance can be assessed by determining either the heat generation subsystem efficiencies or the heat generation subsystem losses due to the system configuration.

This part of ISO 13612 presents methods for calculation of the additional energy requirements of a heat generation subsystem in order to meet the distribution subsystem demand. The calculation is based on the performance characteristics of the products given in product standards and on other characteristics required to evaluate the performance of the products as included in the system. Product data, e.g. heating capacity or COP of the heat pump, is determined according to products standards.

This method can be used for the following applications:

— judging compliance with regulations expressed in terms of energy targets;

— optimization of the energy performance of a planned heat generation subsystem, by applying the method to several possible options;

— assessing the effect of possible energy conservation measures on an existing heating/cooling generation subsystem, by calculating the energy use with and without the energy conservation measure.

Only the calculation method is normative. The user shall refer to other standards or to national documents for input data. Additional values necessary to complete the calculations are to be given in a national annex; if no national annex is available, default values are given in an informative annex where appropriate.

NOTE The results of this method can be used to assess the energy performance of the heating/cooling system when summing up the results over a period of calculation.

Heating and cooling systems in buildings — Method for calculation of the system performance and system design for heat pump systems —

Part 2:
Energy calculation

1 Scope

This International Standard is applicable to heat pumps for space heating and cooling, heat pump water heaters (HPWH), and heat pumps with combined space heating and/or cooling and domestic hot water production, in alternate or simultaneous operation, where the same heat pump is used for space heating and domestic hot water heating.

This part of ISO 13612 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 into account the influence of the external conditions and building control that influence the energy requirements for heating and cooling supplied by the heat pump system.

This part of ISO 13612 specifies the required inputs, calculation methods, and required outputs for output thermal power generation for space heating and cooling and domestic hot water production of the following heat pump systems, including control:

— 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/cooling sources and energy distribution

Source	Distribution
Outdoor air	Air
Exhaust-air	Water
Indirect ground source with brine distribution	Direct condensation/evaporation of the refrigerant in the appliance (VRF)
Indirect ground source with water distribution	
Direct ground source [Direct expansion (DX)]	
Surface water	
Ground water	

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 ISO 7345:1995, *Thermal insulation — Physical quantities and definitions*

ISO 13612-1, *Heating and cooling systems in buildings — Method for calculation of the system performance and system design for heat pump systems — Part 1: Design and dimensioning*

ISO 13675, *Heating systems in buildings — Method and design for calculation of the system energy performance — Combustion systems (boilers)*

ISO 13790, *Energy performance of buildings — Calculation of energy use for space heating and cooling*

ISO/TR 16344, *Energy performance of buildings — Common terms, definitions and symbols for the overall energy performance rating and certification*

3 Terms and definitions

For the purposes of this document, the terms and definitions in ISO 13612-1, EN ISO 7345:1995, and ISO/TR 16344 and the following apply.

3.1
alternate operation
production of heat energy for the space heating and domestic hot water system by a heat generator with double 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: In EN ISO 9488, the energy used for pumps and valves is called “parasitic energy”.

Note 3 to entry: In the frame of this part of ISO 13612, the driving energy input for electrically driven heat pumps in the system boundary of the COP and an electrical back-up heater is not considered auxiliary energy but only additional electrical input not considered in the COP.

3.4
balance point temperature
temperature at which the heat pump heating capacity and the building heat load are equal

3.5
bin
statistical temperature class (sometimes a class interval) for the outdoor air temperature

Note 1 to entry: The class limits are expressed in a temperature unit.

3.6
building service
service provided by technical building systems and by appliances to provide indoor climate conditions, domestic hot water, illumination levels, and other services related to the use of the building

3.7
calculation period
period of time over which the calculation is performed

Note 1 to entry: The calculation period can be divided into a number of calculation steps.

3.8
calculation step
discrete time interval for the calculation of the energy needs and uses for heating, cooling, humidification, and dehumidification

Note 1 to entry: Typical discrete time intervals are 1 h, 1 mon, or one heating and/or cooling season, operating modes, and bins.

Note 2 to entry: In the frame of the bin method, calculation steps are based on outdoor temperature classes.

3.9
coefficient of performance
COP
ratio of the heating/cooling capacity to the effective power input of the unit

3.10
cumulative frequency
frequency of the outdoor air temperature cumulated over all 1 K bins

3.11
cut-out period
time period in which the electricity supply to the heat pump is interrupted by the supplying utility

3.12
domestic hot water heating
process of heat supply to raise the temperature of the cold water to the intended delivery temperature

3.13
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

3.14
electrically driven heat pump
vapour compression cycle heat pump which incorporates a compressor driven by an electric motor

3.15
energy need for domestic hot water
heat to be delivered to the needed amount of domestic hot water to raise its temperature from the cold network temperature to the prefixed delivery temperature at the delivery point, not taking into account the technical building thermal systems

3.16
energy need for heating or cooling
heat to be delivered to or extracted from a conditioned space to maintain the intended temperature during a given period of time, not taking into account the technical building thermal systems

Note 1 to entry: The energy need is calculated and cannot be easily measured.

Note 2 to entry: The energy need can include additional heat transfer resulting from non-uniform temperature distribution and non-ideal temperature control, if they are taken into account by increasing (decreasing) the effective temperature for heating (cooling) and are not included in the heat transfer due to the heating (cooling) system.

3.17
energy use for space heating or cooling or domestic hot water
energy input to the heating, cooling, or hot water system to satisfy the energy need for heating, cooling (including dehumidification), or hot water, respectively

Note 1 to entry: If the technical building system serves several purposes (e.g. heating and domestic hot water), it can be difficult to split the energy use into that used for each purpose. It can be indicated as a combined quantity (e.g. energy need for space heating and domestic hot water).

3.18
frequency
<statistical> number of times the event occurred in the sample

Note 1 to entry: The frequencies are often graphically represented in histograms. In the frame of this part of ISO 13612, the frequency of the outdoor air temperature is evaluated based on a sample of hourly averaged data for one year.

3.19
heat generator with double service
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

3.20
heat pump
unitary or split-type assemblies designed as a unit to transfer heat

Note 1 to entry: It includes a vapour compression refrigeration system or a refrigerant/sorbent pair to transfer heat from the source by means of electrical or thermal energy at a high temperature to the heat sink.

3.21
heat recovery
heat generated by a technical building system or linked to a building use (e.g. domestic hot water) which is utilized directly in the related system to lower the heat input and which would otherwise be wasted (e.g. preheating of the combustion air by flue gas heat exchanger)

3.22
heat transfer medium
medium (water, air, etc.) used for the transfer of the heat without change of state

Note 1 to entry: The fluid cooled by the evaporator, the fluid heated by the condenser, and the fluid circulating in the heat recovery heat exchanger.

3.23
heated space
room or enclosure which, for the purposes of the calculation, is assumed to be heated to a given set-point temperature or set-point temperatures

3.24
heating capacity
ϕ_{g}
heat given off by the unit to the heat transfer medium per unit of time

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

3.25
heating or cooling season
period of the year during which a significant amount of energy for heating or cooling is needed

Note 1 to entry: The season lengths are used to determine the operation period of technical systems.

3.26
internal temperature
arithmetic average of the air temperature and the mean radiant temperature at the centre of the occupied zone

Note 1 to entry: This is the approximate operative temperature according to ISO 7726.

3.27
low temperature cut-out
temperature at which heat pump operation is stopped and the total heat requirements are covered by a back-up heater

3.28
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

3.29
part load operation
operation state of the technical system (e.g. heat pump) where the actual load requirement is below the actual output capacity of the device

3.30
part load ratio
ratio between the generated heat during the calculation period and the maximum possible output from the heat generator during the same calculation period

3.31
primary pump
pump mounted in the circuit containing the generator and hydraulic decoupling

EXAMPLE A heating buffer storage in parallel configuration or a hydronic distributor.

3.32
produced heat
heat produced by the generator subsystems

Note 1 to entry: In the context of this part of ISO 13612, this is the heat produced to cover the energy requirement of the distribution subsystem and the generation subsystem heat losses for space heating and/or domestic hot water.

3.33
recoverable system thermal loss
part of a system thermal loss which can be recovered to lower either the energy need for heating or cooling or the energy use of the heating or cooling system

3.34
recovered system thermal loss
part of the recoverable system thermal loss which has been recovered to lower either the energy need for heating or cooling or the energy use of the heating or cooling system

3.35
seasonal performance factor
SPF
ratio of the total annual energy delivered to the distribution subsystem for space heating and/or domestic hot water to the total annual input of driving energy (electricity in case of electrically driven heat pumps and fuel/heat in case of combustion engine-driven heat pumps or absorption heat pumps) plus the total annual input of auxiliary energy

3.35.1
cooling seasonal performance factor
CSPF
ratio of the total annual amount of heat that the equipment can remove from the indoor air when operated for cooling in active mode to the total annual amount of energy consumed by the equipment during the same period

3.35.2
heating seasonal performance factor
HSPF
ratio of the total annual amount of heat that the equipment, including make-up heat, can add to the indoor air when operated for heating in active mode to the total annual amount of energy consumed by the equipment during the same period

3.36
set-point temperature of a conditioned zone
internal (minimum intended) temperature, as fixed by the control system in normal heating mode or internal (maximum intended) temperature, as fixed by the control system in normal cooling mode

3.37
simultaneous operation during the heating period
simultaneous production of heat energy for the space heating and domestic hot water system by a heat generator with double service (e.g. by refrigerant desuperheating or condensate subcooling)

3.38
simultaneous operation during the cooling period
simultaneous production of output thermal power for the space cooling and domestic hot water system by a heat generator with double service (e.g. by refrigerant desuperheating or condensate subcooling)

3.39
space heating/cooling
process of heat supply for thermal comfort

3.40
standard rating condition
mandatory condition that is used for marking and for comparison or certification purposes

3.41
system thermal losses
thermal loss from a technical building system for heating, cooling, domestic hot water, humidification, dehumidification, ventilation, or lighting that does not contribute to the useful output of the system

Note 1 to entry: Thermal energy recovered directly in the subsystem is not considered as a system thermal loss but as heat recovery and directly treated in the related system standard.

3.42
technical building system
technical equipment for heating, cooling, ventilation, domestic hot water, lighting, and electricity production composed of subsystems

Note 1 to entry: A technical building system can refer to one or to several building services (e.g. heating system, heating and DHW system).

Note 2 to entry: Electricity production can include cogeneration and photovoltaic systems.

3.43
technical building subsystem
part of a technical building system that performs a specific function (e.g. heat generation, heat distribution, heat emission)

4 Symbols and abbreviated terms

For the purposes of this part of ISO 13612, the symbols and units in Table 2 and indices in Table 4 apply. Abbreviated terms are listed in Table 3.

Table 2 — Symbols and units

Symbol	Name of quantity	Unit
ϕ	Thermal power, heating capacity, heat flow rate	W
η	Efficiency factor	-
θ	Celsius temperature	°C
ρ	Density	kg/m³
$\Delta\theta$	Temperature difference, - spread	K
Δp	Pressure difference	Pa
b	Temperature reduction factor	-
c	Specific heat capacity	J/(kg·K)
DH	degree hours	°Ch
COP	Coefficient of performance	W/W
COP_t	Coefficient of performance for the tapping of hot water	W/W
E	Quantity of energy, fuel	J
f	factor (dimensionless)	-
β	Load factor	-
m'	Mass flow rate	kg/s
N	number of items	-
k	factor (fraction)	-
P	Power, electrical power	W
Q	Quantity of heat	J
SPF	Seasonal performance factor	-
t	Time, period of time	s
T	Thermodynamic temperature	K
V	Volume	m³
V'	Volume flow rate	m³/s
W	Electrical (auxiliary) energy	J

Table 3 — Abbreviated terms

Abbreviation	Description
ATTD	Accumulated time-temperature difference
DHW	Domestic hot water
SH	Space heating

Table 3 *(continued)*

Abbreviation	Description
SC	Space cooling
TTD	Time-temperature difference
VCC	Vapour compression cycle
VAC	Vapour absorption cycle

Table 4 — Index

Δθ	temperature corrected	eng	engine	nrbl	non-recoverable
θllim	lower temperature limit	es	storage values acc. to EN 255-3, phase 4	on	running, in operation
θhlim	upper temperature limit	ex	exergetic	opr	operating, operation limit
amb	ambient	f	flow	out	output from subsystem
aux	auxiliary	gen	generation subsystem	p	pipe
avg	average	H	space heating	r	return
bal	balance point	hot	hot process side	rbl	recoverable
bu	back-up (heater)	ho	hour	rvd	recovered
C	space cooling	hp	heat pump	st	storage
cap	lack of capacity	Int	internal	sby	stand-by
co	cut-out	In	input to subsystem	sk	sink
cold	cold process side	j	index, referring to bin j	sngl	single (operation)
combi	combined operation	k	index	sc	source
crnt	Carnot	Ls	loss	standard	acc. to standard testing
dis	distribution subsystem	Ltc	low temperature cut-out	tot	total
des	at design conditions	max	maximum	w	water, heat transfer medium
Ext	external	n	nominal	W	domestic hot water (DHW),DHW operation
eff	effective				

NOTE The indices specifying the symbols in this part of ISO 13612 are put in the following order:

— the first index represents the type of energy use (H = space heating, W = domestic hot water). If the formula can be applied for different energy uses by using the values of the respective operation mode, the first level index is omitted;

— the second index represents the subsystem or generator (gen = generation, dis = distribution, hp = heat pump, st = storage, etc.);

— the third index represents the type (ls = losses, gs = gains, in = input, etc.);

— other indices can be used for more details (rvd = recovered, rbl = recoverable, i = internal, etc.);

— a prefix n means non (rbl = recoverable, nrbl = non-recoverable).

The indices are separated by a comma.

5 Principle of the method

5.1 Flowchart of the calculation method

Heat pump systems for heating and cooling can be independent or used as part of a system including other generators. Figure 1 explains how the information and output of the calculation are used in such multiple systems. In this case, the heat pump, including its integrated back-up system (if any), is considered as the priority generator.

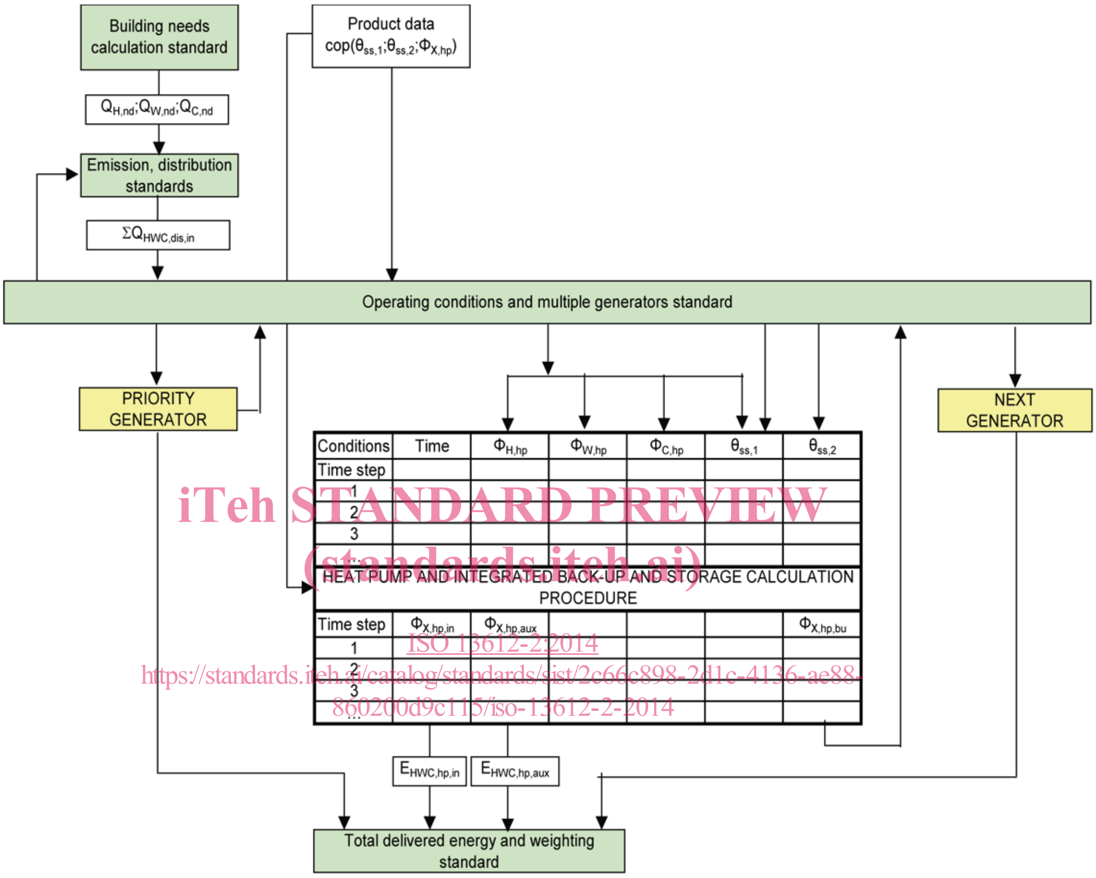

Figure 1 — Heat pump systems and interaction with other generators

The performance calculation method for the generation subsystem is described in the flowchart presented in Figure 2.

The method is based on calculating the amount of energies delivered to the heat pump system using tabulated values. Methods to establish the coefficient of performance (COP) according to the different heat pump system characteristics and available data are presented in Annexes A, B, C, D, and E.

The methodology is based on an hourly calculation as default time step for the calculation. The time step should be adapted according to the climatic data available and the accuracy required for the calculation.

An overview of the calculation steps to be performed is listed below. A more detailed overview for different system configurations can be seen in the flowchart in Figure 2.

The elementary calculation steps are explained in detail in the part of Clause 6 as indicated. For each step, the description covers the different operation modes (space heating, domestic hot water) and the different types of heat pumps (electrically driven, engine-driven, absorption), if applicable. Additionally,

