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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

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 1: Conception et dimensionnement

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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).

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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 will be part of a series of standards on the method for the calculation of heating system energy requirements and heating and cooling system efficiencies.

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

— ISO 13612-2 presents the energy calculation method.

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

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 cooling and domestic hot water production, in alternate or simultaneous operation, where the same heat pump is used for space heating and cooling and domestic hot water heating.

This part of ISO 13612 establishes the required inputs, calculation methods, and required outputs for heat generation for space heating and domestic hot water production and control of the following heat pump systems:

— electrically driven vapour compression cycle (VCC) heat pumps;

— combustion engine-driven VCC heat pumps;

— thermally-driven vapour absorption cycle (VAC) heat pumps.

This part of ISO 13612 specifies the design and dimensioning criteria for the heating and cooling systems in buildings using heat pumps alone or in combination with other heat generators. These include the following:

— water–water;

— brine–water;

— refrigerant–water (direct expansion systems);

— air–air;

— air–water;

— combined;

— systems driven by electricity or gas.

This part of ISO 13612 takes into account the heating requirements of attached systems (e.g. domestic hot water, process heat) in the design of heat supply, but does not cover the design of these systems. This part of ISO 13612 covers only the aspects dealing with the heat pump, the interface with the heat distribution and emission system (e.g. buffering system), the control of the whole system, and the aspects dealing with the energy source of the system.

Table 1 — Heat pump systems (within this scope)

Source system (energy extraction)		Sink system (energy rejection)	
Energy source[a]	**Medium**[b]	**Medium**	**Energy sink**[c]
Exhaust air Outdoor air	Refrigerant	Refrigerant	Air
	Air	Air	Air
		Water	Indoor air Water
Surface water Ground water	Water	Water	Indoor air Water
		Air	Indoor air
Ground	Brine (Water)	Air	Water
		Water	Indoor air Water
	Refrigerant (Direct expansion)	Water	Indoor air Water
		Refrigerant	Indoor air

[a] Energy source is the location where the energy is extracted.

[b] Medium is the fluid transported in the corresponding distribution system.

[c] Energy sink is the location where the energy is used; this can be the air-conditioned space or water in case of domestic hot water (DHW) production.

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.

ISO 16818, *Building environment design — Energy efficiency — Terminology*

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

EN 15243, *Ventilation for buildings — Calculation of room temperatures and of load and energy for buildings with room conditioning systems*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 16818 and the following apply.

3.1
balance point temperature
lowest design external air temperature at which the heat pump output capacity and the building heating demand (heat load) are equal

Note 1 to entry: At lower external air temperatures, a second heat generator is employed to cover the entire or part of the building heating demand.

3.2
bivalent alternative mode
low-temperature cut out
operational mode in which a second heat generator (e.g. gas boiler) completely accounts for the heat demand of the heating system if the external temperature falls below the balance point temperature

3.3
bivalent parallel mode
operational mode in which a second heat generator (e.g. gas boiler) accounts for the remaining heat demand of the heating system which cannot be supplied by the heat pump when the external temperature falls below the balance point temperature

3.4
coefficient of performance
COP
momentary ratio of the thermal heat flux (Θ_{HP}) of the heat pump to the electrical power input of the unit

Note 1 to entry: The electrical power of the unit includes auxiliary power requirements, but not the additional power requirements for circulation pumps (heat sink and heat source).

3.5
minimum operating temperature
$\boldsymbol{\theta}_{\mathbf{MOT}}$
minimum recommended value of the external temperature to operate the heat pump

3.6
monovalent mode
operational mode in which the heat pump is designed to cover the entire energy demand of the heating and cooling system alone

Note 1 to entry: The heat pump output capacity is equal to the design heat load.

3.7
seasonal performance factor
ratio of the annual heat Q_{HP} supplied by the heat pump to the total electrical energy consumed (including all auxiliary sources)

3.8
source (heat–cool)
source of energy extracted to the heat pump system

4 Symbols and abbreviations

The symbols and units and abbreviations used in this part of ISO 13612 are listed in Tables 2 and 3.

Table 2 — Symbols and units

Symbol	Description	Unit
Φ_{supply}	Heating capacity of the supply system	kW
θ_{MOT}	Minimum operating temperature (external)	°C
$\theta_{e, h}$	Design external temperature (heating)	°C
$\theta_{min, h}$	Minimal operating temperature of the heat pump (heating)	°C

Table 3 — Abbreviations and subscripts

Abbreviation	Description
H	Heating
C	Cooling
DWH	Domestic hot water

5 System design requirements

5.1 General

The heat pump system shall be designed to satisfy the design heating and cooling load of the building and the requirements of any attached system.

Any other recognized energy load calculation method shall only be used if accepted by the client.

The heating supply system and/or the cooling supply system shall be designed and dimensioned taking into account the type of energy source.

General consideration shall be given to the energy efficiency of the heat pump system.

5.2 Heating/cooling source

5.2.1 Air as heat source

The minimum air flow declared by the manufacturer shall be taken into account when designing the system. For monovalent systems, the required capacity of the heat pump shall be determined by using the design external air temperature. For bivalent systems, a suitable balance point temperature shall be set depending on the selected operational mode (bivalent-alternative or bivalent-parallel mode) and the minimum air flow entering the system. The air quality shall be checked and airborne salinity (a function of the distance from seawater) shall be taken into consideration.

5.2.2 Water as heat source

Water sourced from groundwater, seawater, a lake, or a river can be used as a heat source.

The required water flow rate for the heat pump unit shall be made available, taking into account local regulations which can place limits on the availability and flow rates.

The average groundwater temperature can be obtained from local authorities, from a test borehole, or (in the case of dwellings) by a qualified assumption (e.g. the annual mean external temperature at the location).

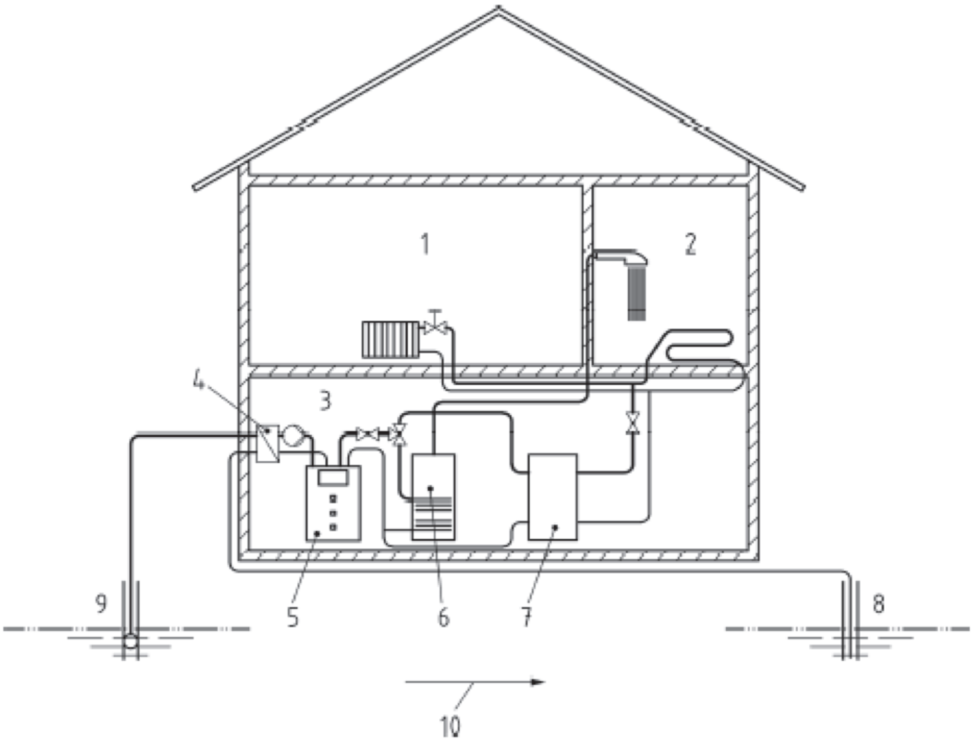
The water source shall enable a continuous extraction of the design flow rate of the attached heat pumps. The possible extraction flow rate is dependent on local geological factors and can be ascertained by continuously extracting the nominal flow rate in a test run of sufficient duration to attain quasi-steady-state conditions. For larger systems, hydrogeological investigations (e.g. well test) can be necessary.

The quality of the water shall match the manufacturer's requirements. If the manufacturer's requirements cannot be achieved (e.g. in the case of seawater), a secondary circuit or water treatment shall be considered (see Annex B).

Provisions for returning the water shall be provided. The direction of the ground water flow shall be taken into account when selecting the position of the injection well. The extraction well shall be situated upstream of the injection well if the heat pump is only used for heating purposes (see Figure 1).

The heat extraction system shall be designed and controlled so as to avoid the risk of freezing.

The water shall be returned to the environment as clean as possible and in accordance with local regulations.



Key
1 living room
2 bathroom
3 cellar
4 heat exchanger
5 heat pump
6 storage water heater
7 buffer storage
8 injection well
9 extraction well (including pump)
10 ground-water flow direction

Figure 1 — Arrangement of a heat pump heating system with ground-water flow

5.2.3 Ground as heat source

The minimum temperature of the ground at the appropriate depth shall be taken into account when designing the ground heat pump system. Information on typical temperature profiles is given in Annex A.

The temperature reduction of the ground, as a result of the heat extraction over the heating period, as well as the long-term temperature drop, due to consecutive years of heat pump operation, shall be taken into account so as to never jeopardize the operation of the heat pump and also to ensure economical as well as reasonable environmental operating conditions.

5.3 Electrical supply

The availability of a suitable electrical supply (both power and amperage) shall be ensured.

The operation time, the tariff, and the cut-out time shall be taken into account.

The maximum current withdrawn during the start-up phase shall be considered, especially for single-phase electrically driven heat pumps.

5.4 Heat pump system design

The design of a heat pump system shall consider the following aspects.

— The heat pump system shall be designed to achieve the highest seasonal performance factor with respect to the selected heat source. The seasonal energy efficiency ratio (or seasonal energy performance) increases with decreasing temperature difference between the source temperature and the sink temperature. High source temperatures and low sink temperatures are desirable in the heating period (reducing the sink temperature by 1 K leads to an increase in the COP of about 2 %).

— The heat pump system shall be designed so that its seasonal performance factor is equal to or higher than the minimum values given in a corresponding national annex. In case no national values have been published, the default minimum values are given in Annex C.

NOTE 1 Additionally, the target values for the seasonal performance factor are given in a corresponding national data set. In case no national annex has been published, the default target values are given in Annex C.

— The environmental impact due to the heat pump operation shall be minimized. Care shall be taken in order not to emit the refrigerant into the atmosphere due to leakages during operation as well as during maintenance.

NOTE 2 Monoblock systems are hermetically sealed and the leakage rate is under 1 %.

— The heat pump system shall be designed to be user-friendly and require limited maintenance.

5.5 Positioning

The positioning of a heat pump shall consider the following aspects:

— the location of the heat pump (e.g. outside the building) within the heated space or in an unheated space;

— the allowable temperature range of the environment surrounding the heat pump (given by the manufacturer);

— the possibility of damage to the unit or the components due to freezing;

— the accessibility for installation and maintenance purposes.

5.6 Noise level

Heat pumps using air as a heat source are prone to cause noise problems resulting from the sound conducted through solids and transmitted through air. The noise levels and information regarding the installation shall be provided in the technical documents provided by the manufacturer.

6 Dimensioning of the heat pump system

6.1 General

The heat supply system shall be designed to satisfy the design heat load of the building and the requirements of any attached system (e.g. domestic hot water production). The design heating and cooling loads shall be calculated in accordance with the rules given in the accepted methodologies.

NOTE 1 ISO 15265 provides benchmark results for the validation of the building simulation model used for the calculation of the design heating and cooling loads.

NOTE 2 Information on the design scheme is presented in Annex A.

6.2 Methodology for sizing

The method for dimensioning the heat pump is provided in Figure 2.

The maximum power supply required for any period of activity (heating or cooling) shall be calculated and the heat pump system shall be designed to satisfy the energy demand in any case.

Designers shall take into account the energy uses required by any combination of heating, domestic hot water production, and cooling.

The priority given to the energy used to satisfy the demand shall also be identified.

For a heat pump system sized below this maximum value, a supply system shall be attached to satisfy the energy demand. For a bivalent system, the minimum operating temperature shall be identified as the thermal load is calculated for this value of the minimum operating temperature. The temperature operating limit and the bivalent temperature shall be identified by the designer.

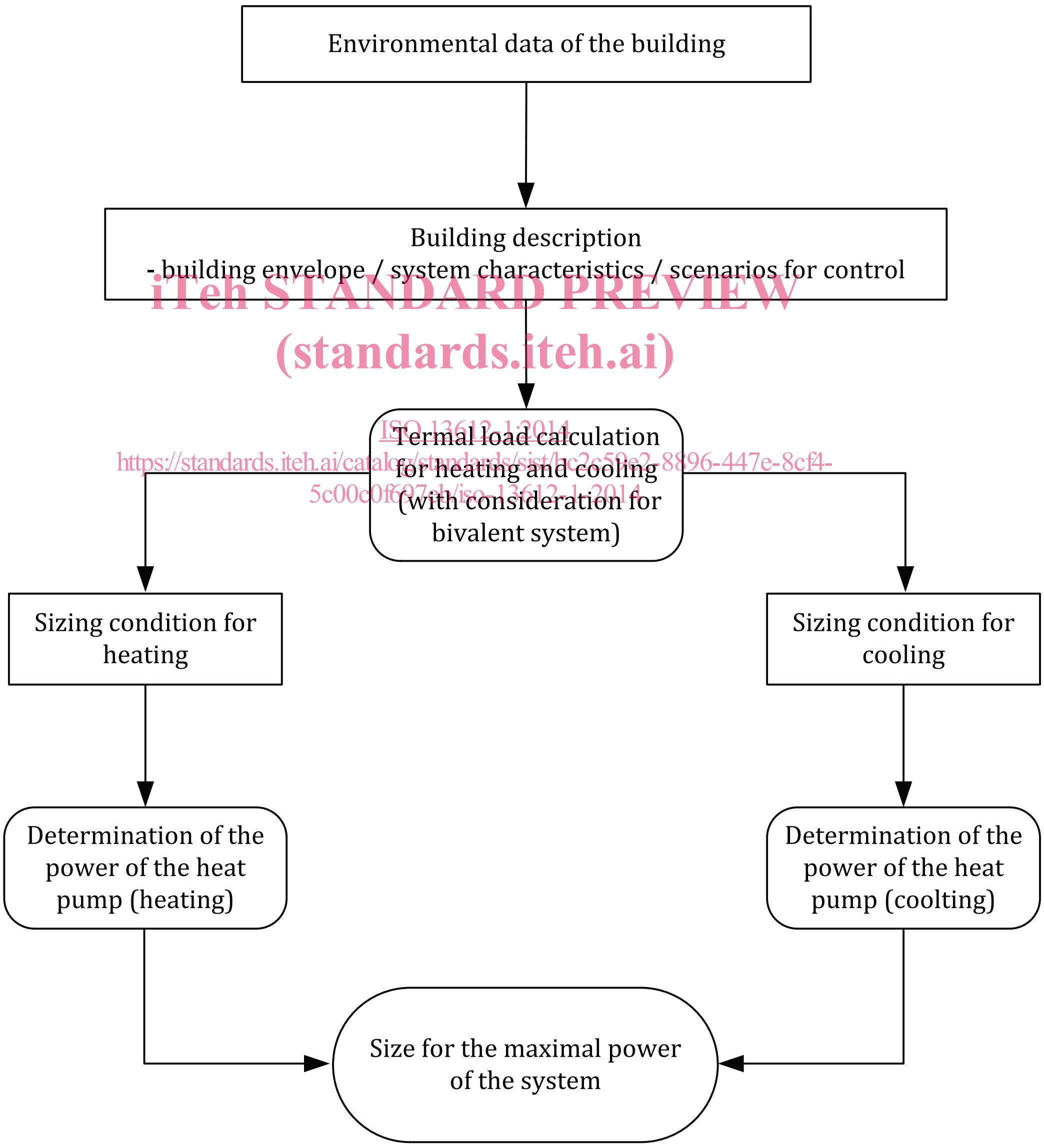


Figure 2 — Flowchart for dimensioning the heat pump system

6.3 Dimensioning the heat pump system for the heating period

6.3.1 Heat supply conditions

The heat supply to serve the system shall be sized according to EN 15243. For the heat pump systems, the design factors in Formula (1) are:

$$\Phi_{SU} = f_{HL} \cdot \Phi_{HL} + f_{DHW} \cdot \Phi_{DHW} + f_{AS} \quad (1)$$

where

- Φ_{SU} is the capacity of the heat supply system, in kW;
- f_{HL} is the design factor for the heat load;
- Φ_{HL} is the heat load capacity, in kW;
- f_{DHW} is the design factor for the domestic hot water systems;
- Φ_{DHW} is the domestic hot water capacity, in kW;
- f_{AS} is the design factor for the attached systems;
- Φ_{AS} is the capacity of the attached systems, in kW.

Table 4 — Heat pump systems design factor (informative)

Load	Heat pump design factor	Design criteria	Default value for the design factor
Heat load	f_{HL}	Low building mass (suspended ceilings and raised floors and light walls) $C_{th} < 20$ Wh/m^2	1,00
		Medium building mass (concrete floors and ceilings and light walls) 20 Wh/m^2 < C_{th} < 40 Wh/m^2	0,95
		High building mass (concrete floors and ceilings combined with bricks or concrete walls) $C_{th} > 20$ Wh/m^2	0,90
Domestic hot water	f_{DHW}	Standard class of sanitary systems	1
Attached systems	f_{AS}		1
NOTE C_{th} is the effective internal heating capacity of the building element.			

6.3.1.1 Incorporated additional backup heater

Heat pumps incorporating an additional backup heater shall be selected so that the energy supplied by the backup system is reduced to a minimum, particularly if the energy source of the backup heater is not renewable.

In order to secure sufficient domestic hot water production, the designer shall calculate and document the daily quantity of hot water which can be delivered by the backup system alone.

6.3.1.2 Domestic hot water production or other attached systems

The maximum daily hot water demand and relevant tapping pattern shall be identified to size the system.

Annex A presents the information on the alternative requirements for domestic hot water use.

Annex E presents the basic data, based on a European survey in the domestic sector, to specify the energy use for domestic hot water and the energy performance of domestic hot water appliances.

6.3.1.3 Heat pump data

The data shall be obtained from the manufacturer's specifications, which shall be based on the test data according to the product standards (see Bibliography).

6.3.2 Dimensioning for space heating

The maximum heat load, Φ_{HL}, for space heating is obtained from the rules given in the accepted methodologies.

The design values are based on the regional set of data or accepted methodologies.

NOTE EN 12831 can be used for the dimensioning for space heating.

6.3.3 Dimensioning for DHW

6.3.3.1 Hot water demand for sizing the system

The designer shall identify the critical value, Q_{DP}, of the daily hot water energy demand during a defined period and the duration of this corresponding period, t_{DP}. Annex A and Annex E provide the information on the domestic hot water demand for the residential sector. Different strategies are available depending on the electrical tariff and the cost-reflective messages for energy management, the space available for the heat pump system and energy collectors, and the cost effectiveness of the design solutions.

The accumulation system results in a larger volume of the DHW storage, which is sized on the maximum daily demand. The selected thermal capacity of the heat pump allows the DHW storage to be heated during the defined period to restore the storage at set temperature conditions.

The defined period corresponds as a maximum to the low-cost period tariff for the electrically driven heat pump.

The volume of the storage shall be reduced accordingly with the availability of the corresponding energy output from the heat pump. The tables given in Annex D and Annex E provide guidance to define the total hot water energy demand (Q_{daily}), the critical value (Q_{DP}), and the duration of the corresponding period (t_{DP}).

6.3.3.2 Definition of the DHW storage volume V_s

The size of the DHW storage and the thermal capacity needed to heat and maintain enough DHW to fulfil the demand are closely related.

The simplest way to design the DHW storage is to define a volume and subsequently check whether or not the thermal power of the heat pump is sufficient to meet the requirements for the DHW demand alone as well as during the heating period. If the thermal power of the heat pump is not sufficient, the volume of the DHW storage shall be adapted.

6.3.3.2.1 Accumulation

As a basis, the average daily consumption given in Annex E is doubled (e.g. from 25 l to 50 l at 60 °C per person) and this value is considered for sizing the system. Larger values can be used if the use of DHW and large bathrooms are considered.

