BS ISO 12655:2013

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Energy performance of buildings — Presentation of measured energy use of buildings

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee B/540/8, Mirror committee for ISO/TC 163 - Thermal Performance and Energy use in the built Environment.

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

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Published by BSI Standards Limited 2013.

ISBN 978 0 580 73618 6

ICS 91.120.10

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 March 2013.

Amendments issued since publication

Date	Text affected

BS ISO 12655:2013

INTERNATIONAL STANDARD

ISO 12655

First edition
2013-03-01

Energy performance of buildings — Presentation of measured energy use of buildings

Performance énergétique des bâtiments — Présentation de l'utilisation énergétique réelle des bâtiments

Reference number
ISO 12655:2013(E)

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Published in Switzerland

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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.

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ISO 12655 was prepared by Technical Committee ISO/TC 163, *Thermal performance and energy use in the built environment*.

Introduction

This International Standard is prepared by ISO/TC 163,/WG 4, a joint group between ISO/TC 163, *Thermal performance and energy use in the built environment* and ISO/TC 205, *Building environment design*.

It provides a set of clear definitions, terms and procedures for presenting the energy use in buildings in a consistent and uniform way, including:

— Classifications of building energy use by purpose (e.g. energy for space heating, energy for cooking, energy for lighting);

— Categories of energy use by boundaries inside or outside of buildings (e.g. actual heat/cold reaching the building space (E_B), energy delivered to the building's technical system (E_T), energy used by the district heating/cooling system (E_D);

— Building energy data shall be presented with original energy carriers or with equivalent energy, and the indication (subscript) is required to make the data understandable.

Such a comprehensive expression of building energy use is of great importance for an in-depth understanding of building energy performances and trends. And it is conducive to:

a) Regulating the presentation of the energy use of buildings with respect to data collection, metering and analysis;

b) Providing a uniform platform for the assessment and comparison of building energy;

c) Laying the foundation of energy data collection, metering, statistics, audit and analysis for both regional and national buildings.

The measuring methods are out of scope of this International Standard.

Relationship with ISO/TR 16344**,** ISO 16343 **and** ISO 16346

Three relevant International Standards, ISO/TR 16344, ISO 16343 and ISO 16346, were developed to form a uniform platform for calculation and evaluation of building energy performance. However, some ambiguities still exist, due to lack of uniform specifications, such as the classification of energy usage, the boundaries related to the energy data, and the basis of the aggregation methods. Hence, the present International Standard is complementary to these International Standards on energy rating and energy performance. It provides common rules for how to present the energy uses, as a uniform platform for exchanging information, without prescribing what has to be measured or assessed as it is the case for procedures aiming at energy performance assessment and certification.

At the same time, the relevant terms, definitions and symbols in ISO/TR 16344, such as space heating, space cooling and domestic hot water heating, are incorporated by reference in the present International Standard, so as to be consistent with the existing International Standards.

INTERNATIONAL STANDARD ISO 12655:2013(E)

Energy performance of buildings — Presentation of measured energy use of buildings

1 Scope

This International Standard sets out a consistent methodology to present energy use in buildings, which is specified clearly with the energy usage, corresponding boundary and the energy data (presented with original energy carriers or equivalent energy).

This International Standard is applicable to the presentation of energy use of civil buildings for data collection, metering, statistics, audit and analysis.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/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 given in ISO/TR 16344 and the following apply.

3.1
building energy
energy used during the operation of buildings, including the energy used for building basic functions and the energy provided for occupant's activities

EXAMPLE Examples of occupant's activities include working, cooking, leisure, sanitation, etc.

Note 1 to entry: The energy used during the manufacture of building materials, the energy for material transportation and the energy during building construction are not included.

3.2
energy usage
specific usage of building energy

EXAMPLE Space heating, space cooling, domestic hot water, lighting, etc.

3.3
boundary
position in relation to the energy usage chain of buildings

3.4
equivalent energy
equivalent value of the energy carrier used in buildings to combine or share different energy carriers with the same platform according to the standardized conversion approach

4 Building energy use defined by usage

4.1 Classification of building energy use by usage

According to the energy usage in buildings, as shown in Figure 1, the total building energy use shall be classified as the following:

— Energy for HVAC and domestic hot water, including energy for space heating, energy for space cooling, energy for air movement and energy for domestic hot water.

— Energy for lighting and plug-in, including energy for lighting and energy for household/office appliances.

— Energy for other ultimate usage, including energy for indoor transportation and energy for building auxiliary devices.

— Energy for other special usage, including energy for cooking, energy for cooling storage, energy for devices in data center and energy for other specific functional devices.

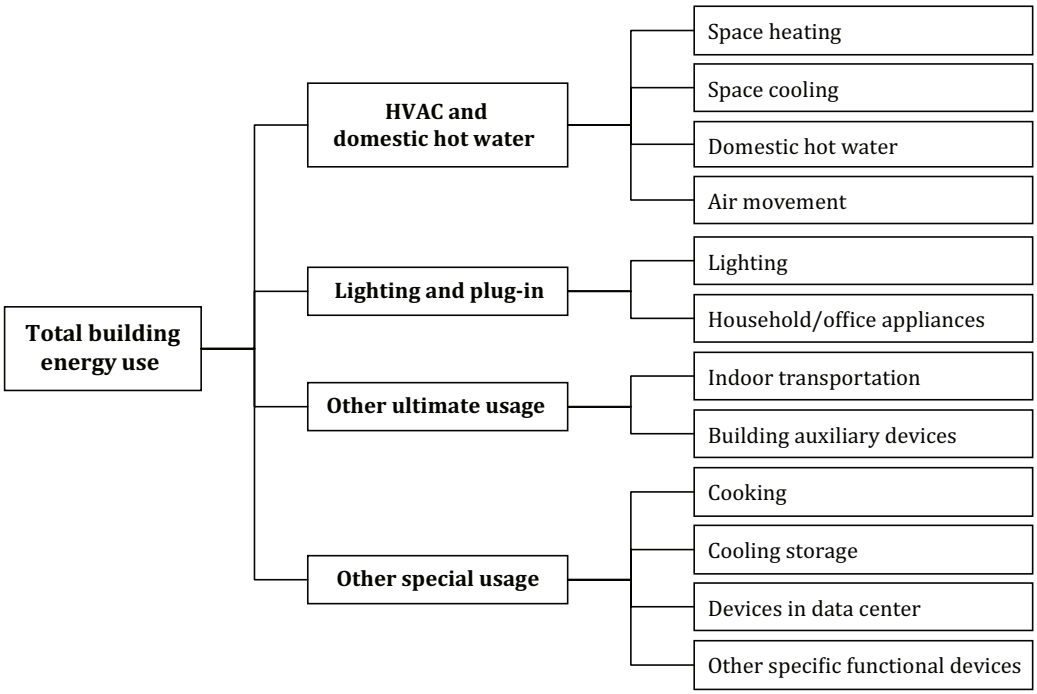

Figure 1 — The usage of energy in buildings

4.2 Energy for space heating

The energy used to provide heat (including humidification) for space heating of the building shall be *energy for space heating*.

4.3 Energy for space cooling

The energy used to provide cold (including dehumidification) for space cooling of the building shall be *energy for space cooling*.

4.4 Energy for air movement

The energy used by the mechanical ventilation fans for building ventilation and air circulation shall be *energy for air movement*. It includes electricity consumed by fans inside air handling devices (air

handling unit, outdoor air processor, fan coil unit, etc.), exhaust fans in toilet, ventilation fans in the garage and other ventilated spaces.

4.5 Energy for domestic hot water

The energy used to produce and transport hot water for building domestic water service shall be *energy for domestic hot water*.

4.6 Energy for lighting

The energy used by the lamp(s), control gear and control circuit in or associated with the luminaries shall be *energy for lighting*. It includes the indoor lighting and exterior lighting. The indoor lighting is usually composed of lighting for public space and private space.

4.7 Energy for household/office appliances

The energy used by the household and office appliances, such as personal computers, printers, drinking fountains and TVs, shall be *energy for household/office appliances*.

4.8 Energy for indoor transportation

The energy used by the indoor transportation devices in buildings, such as lifts, escalators and passenger conveyors, shall be *energy for indoor transportation*.

4.9 Energy for building auxiliary devices

The energy used by all kinds of the building auxiliary devices that serve the building, such as pumps for water supply and drainage, automatic door, shall be *energy for building auxiliary devices*.

4.10 Energy for cooking

The energy used for cooking inside a building shall be *energy for cooking*. It includes the fuel and electricity consumed by cooking utensils and exhaust fans in the kitchen.

NOTE The energy used by the exhaust fans in the kitchen doesn't belong to the item of *energy for air movement* anymore.

4.11 Energy for cooling storage

The energy used by the refrigeration devices for storage shall be *energy for cooling storage*.

4.12 Energy for devices in data center

The energy used by the devices in data centers inside the building, including servers and ancillary air-conditioning, shall be *energy for devices in data center*.

4.13 Energy for other specific functional devices

The energy used by other specific functional devices, such as medical equipment, laundry equipment and auxiliary devices of swimming pool, shall be *energy for other specific functional devices*.

5 Building energy use defined by boundary

5.1 Identification of building energy use by boundary

Considering energy flow through the buildings, the building energy use shall be defined according to boundary, and the categories are as follows:

— Heat/cold reaching the building space (E_B);

— Energy delivered to the building's technical system (E_T);

— Energy input to the district heating/cooling system (E_D);

— Renewable energy produced on the building site (E_R).

Schematic of the categories of building energy use determined by the boundaries mentioned above are shown in Figure 2.

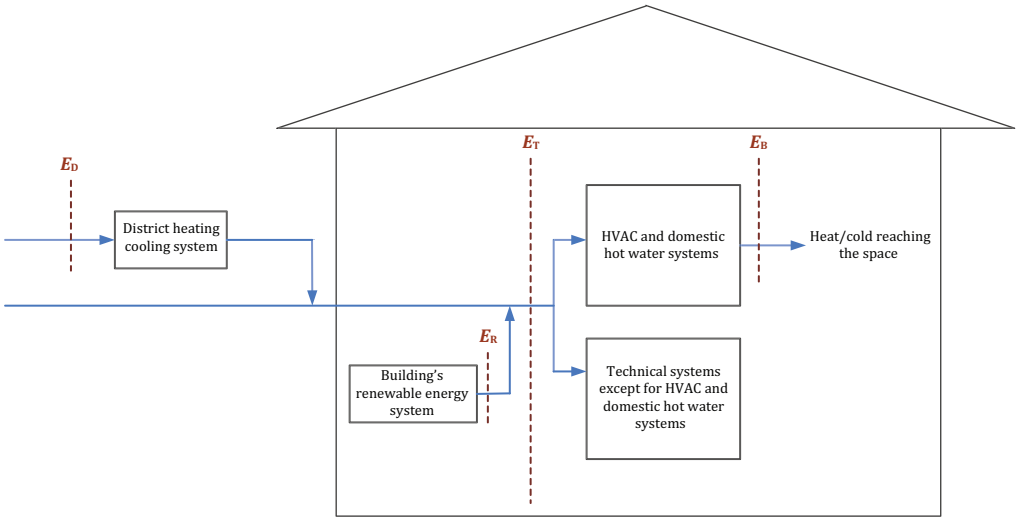

Figure 2 — Identification of building energy use by boundary (shown as dotted line)

5.2 Heat/cold reaching the building space (E_B)

The heat/cold gained by the building space through HVAC system or domestic hot water system shall be *heat/cold reaching the building space*, denoted as E_B. It is irrelevant to the process of energy conversion in the technical systems of the building.

5.3 Energy delivered to the building's technical system (E_T)

The energy delivered to and used by the technical systems of the building (including energy conversion devices and transportation devices of the HVAC system and domestic hot water system, lighting, household/office appliances and other devices in the building) shall be *energy delivered to the building's technical systems*, denoted as E_T.

NOTE 1 Sources of E_T include the directly input fuel (such as coal, oil and gas), electricity and the energy provided by the district heating/cooling system (such as electricity, heat and cold energy), and the renewable energy produced on the building site.

NOTE 2 For space cooling, $E_{T,C}$ includes the energy used by energy conversion devices (such as chillers and heat pumps) and auxiliary devices (such as chilled water pumps, cooling water pumps and fans in cooling towers) when the cold energy is acquired from the building's own technical system. If the cold energy is provided by the district cooling system, $E_{T,C}$ refers to the input cold energy and the energy used by auxiliary devices within the building (such as chilled water pumps).

NOTE 3 For space heating or domestic hot water, $E_{T,h}$ or $E_{T,hw}$ includes the energy used by energy conversion devices (such as boilers and heat pumps) and auxiliary devices (such as hot water pumps, the water pumps and fans related to the heat pumps) when the heat is acquired from the building's own technical system. If the heat is provided by the district heating system, $E_{T,h}$ or $E_{T,hw}$ refers to the input heat and the energy used by auxiliary devices within the building (such as hot water pumps).

If the energy produced by the energy conversion devices (such as co-generation units (CHPs), chillers, heat pumps and boilers) serve more than one technical system or building, E_T of a certain technical system shall be shared according to its actual acquisition.

5.4 Energy input to the district heating/cooling system (E_D)

The energy delivered to and consumed by the district heating/cooling system outside of the building shall be *energy input to the district heating system*, denoted as E_D.

5.5 Renewable energy produced on the building site (E_R)

The energy generated by the active renewable energy system integrated with the building (such as photovoltaic panels, solar heat collectors and wind power generators) with renewable energy sources, shall be *renewable energy produced on the building site*, denoted as E_R. Passive application of renewable energy is not included.

5.6 Terms and symbols of the categories of building energy use determined by boundary

The terms and corresponding subscripts to distinguish among different energy usage, different boundaries of the building energy use are shown in Table 1 (E_R is not listed).

NOTE More details, such as the consistency in the order of the subscripts and the examples of the application of the symbols and subscripts are given in Annex A (normative).

Table 1 — Terms and symbols of the categories of building energy use determined by boundary

Energy usage	Heat/cold reaching the building space (E_B)	Energy delivered to the building's technical system (E_T)	Energy input to the district heating /cooling system (E_D)
Space heating	$E_{B,h}$ Heat reaching the building space for space heating	$E_{T,h}$ For district heating system, $E_{T,h}$ is the input heat from district heating system and the electricity used for the hot water pumps within the building for space heating. Otherwise, $E_{T,h}$ is the energy input for space heating inside the building, including energy input to energy conversion devices and auxiliary devices, excluding indoor fans.	$E_{D,h}$ Energy input to the conversion devices and transportation system in district heating system for space heating

Table 1 *(continued)*

Energy usage	Heat/cold reaching the building space (E_B)	Energy delivered to the building's technical system (E_T)	Energy input to the district heating /cooling system (E_D)
Space cooling	$E_{B,c}$ Cold reaching the building space for space cooling	$E_{T,c}$ For district cooling system, $E_{T,c}$ is the input cold energy from district cooling system and the electricity used for the chilled water pumps within the building. Otherwise, $E_{T,c}$ is the energy input for space cooling inside the building, including energy input to energy conversion devices and auxiliary devices, excluding indoor fans.	$E_{D,c}$ Energy input to the conversion devices and transportation system in district cooling system for space cooling
Domestic hot water	$E_{B,hw}$ Heat reaching the domestic hot water in the building	$E_{T,hw}$ For district heating system, $E_{T,hw}$ is the input heat from district heating system and the electricity used for the hot water pumps within the building for domestic hot water. Otherwise, $E_{T,hw}$ is the energy input for domestic hot water inside the building, including energy input to energy conversion devices and auxiliary transportation device.	$E_{D,hw}$ Energy input to the conversion devices and transportation system in district heating system for domestic hot water
Air movement	/	$E_{T,am}$ Energy used by the mechanical ventilation fans for building ventilation and air circulation, including electricity consumed by fans inside air handling devices, exhaust fans in toilet, ventilation fans in the garage and other ventilated spaces, excluding fans in cooling towers.	/
Lighting	/	$E_{T,lt}$	/
Household/ office appliances	/	$E_{T,app}$	/
Indoor transportation	/	$E_{T,transp}$	/
Building auxiliary devices	/	$E_{T,aux}$	/
Cooking	/	$E_{T,ck}$	/
Cooling storage	/	$E_{T,stor}$	/
Devices in data center	/	$E_{T,data}$	/
Other specific functional devices	/	$E_{T,func}$	/

6 Expression of energy carriers

6.1 Expression methods of energy carriers

The energy carriers used in buildings shall be presented as one of the following two ways:

— Presenting with original energy carriers;

— Presenting with equivalent energy.

The latter presenting mode is suggested only when various energy carriers are required to be added or divided.

6.2 Presenting building energy use data with original energy carriers

Both the type and the quantity of the energy carrier shall be presented according to the actual energy use, such as 1 m^3 (natural gas), 1 kWh (electricity).

6.3 Presenting building energy use data with equivalent energy

There are different types of conversion approaches to convert different energy carriers into the same platform.

— Calorific value approach, based on the heat included in the energy carriers, and the unit shall be indicated with subscript “CV”;

— Primary energy approach, tracing to the original energy resources, and the unit shall be indicated with subscript “PE”;

— CO_2 emission approach, including all CO_2 emissions associated with the primary energy, and the unit shall be indicated with subscript “CO_2”;

— Exergy approach, based on the exergy included in the energy carriers, and the unit shall be indicated with subscript “EX”; and

— Any other equivalent energy conversion approach for specified purpose can also be used with a clear description of the approach as well.

The conversion approach should be selected according to the purpose of energy analysis. Both the type of equivalent energy and corresponding quantity shall be presented.

NOTE 1 The principles for the primary energy approach and CO_2 emission approach are provided in ISO 16346, which also contains an ISO set of conversion factors as optional set for international comparison.

NOTE 2 The subscripts of different conversion approach and examples are given in Annex A (normative), and Annex B (informative) provides some worked examples of the different approaches.

7 Presentation of building energy use

Energy use of buildings shall be specified clearly with the following three aspects:

— The usage of the energy;

— The boundary the energy use belongs to;

— The energy data presented with original energy carriers or equivalent energy.

Annex A
(normative)

Symbols and abbreviations

A.1 Introduction

This International Standard introduces a series of associated terms to rule the presentation of energy use in buildings. To facilitate the use of this International Standard, a common set of symbols and subscripts have been defined, as given in Clause A.2.

A.2 Principal symbols and subscripts

The symbol for measured energy use in buildings is E, and its units are kg, m^3, kWh, kJ, etc.[1)].

The subscripts to distinguish between different energy usage, different boundaries are listed in Table A.1. And they are categorised into different levels, which are placed in the following order:

— 1st position: level 1;

— 2nd position: level 2.

EXAMPLES:

Heat reaching the building space: $E_{B,h}$

Energy delivered to the building's space heating system: $E_{T,h}$

Energy input into the district heating system for space heating: $E_{D,h}$

Energy for cooking: $E_{T,ck}$

Energy for lighting: $E_{T,lt}$

The subscripts to distinguish between different equivalent energy are listed in Table A.2. For convenience, the abbreviations are adopted as the subscript of the units.

EXAMPLES:

10 kilojoules weighted by calorific value approach: $10\ kJ_{CV}$

20 J weighted by primary energy approach: $20\ J_{PE}$

1) The unit depends on the type of energy carrier and the way its amount is expressed.

Table A.1 — Subscripts to denote the boundaries and types of energy usage

Level 1 Boundary		Level 2 Type of energy usage	
Subscript	**Term**	**Subscript**	**Term**
B	The building space or terminal user	h	Space heating
T	The inlet of the building's technical system	c	Space cooling
D	The inlet of the district heating/cooling system	hw	Domestic hot water
R	Renewable energy produced on the building site	am	Air movement
		lt	Lighting
		app	Household/office appliances
		transp	Indoor transportation
		aux	Building auxiliary devices
		ck	Cooking
		stor	Cooling storage
		data	Devices in data center
		func	Other specific functional devices

Table A.2 — Subscripts to denote the types of equivalent energy approach

Subscript	Term
CV	Calorific value approach
PE	Primary energy approach
CO_2	CO_2 emission approach
EX	Exergy approach

Annex B
(informative)

Presentations of building energy use: examples

B.1 Case 1: Presenting the energy use in a building

The energy use of a building as an example is shown schematically in Figure B.1. Energy used in the building is provided from the following energy carriers for different usage:

— Natural gas is used for space heating (delivered to the district heating system: 45,000 m^3);

— Hot water provided by the district heating system is used for space heating;

— Hot water heated by the solar water heater inside the building is used to provide domestic hot water;

— Electricity is used as power for driving chillers, pumps, fans, lighting, office appliances, elevators, devices in data center and building auxiliary devices.

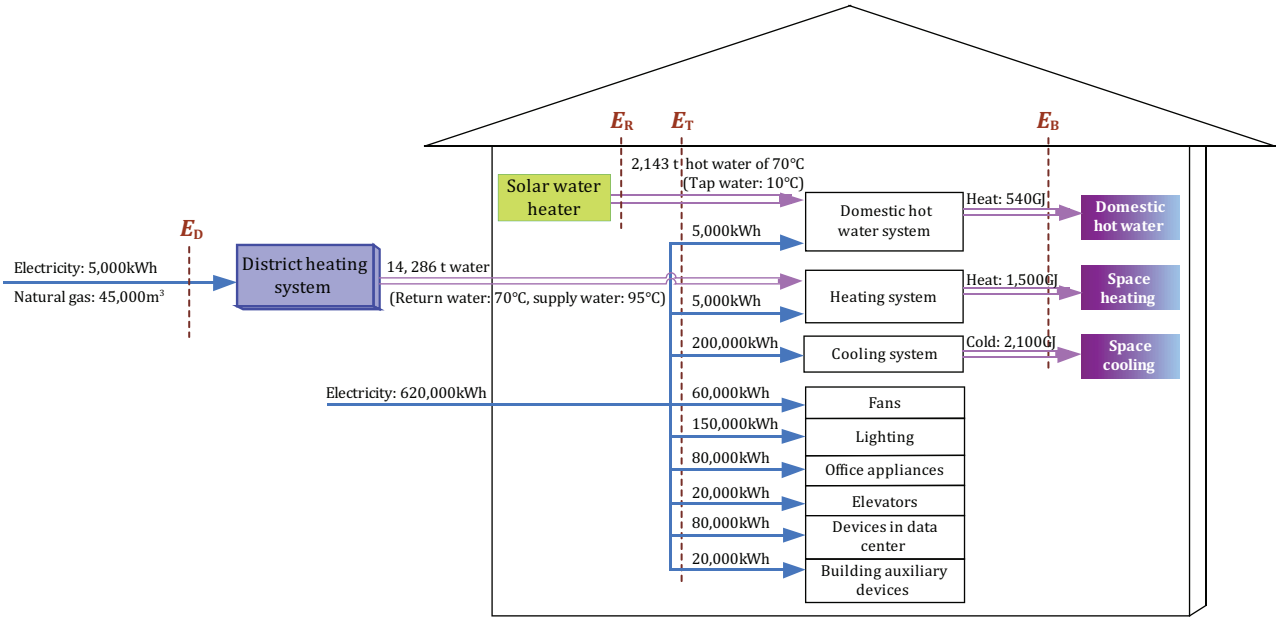

Figure B.1 — Energy use of a typical building at each stage

In the process of energy conversion and distribution, there are great differences among the energy use data on different boundaries. Taking the energy use of space heating as an example, in the district heating system, there are 45 000 m^3 natural gas used by the boiler to heat 14 286 t water from 70 °C to 95 °C, and this hot water is delivered to the building by pumps outside buildings with 5 000 kWh electricity. Within the building, the heat provided by the district heating system is distributed among the radiators by indoor circulation pumps with 5 000 kWh electricity. Finally, about 1 500 GJ heat reaches the building space through the heating system. On different boundaries, both the type and the quantity of the energy carriers vary considerably. Hence, the energy use of buildings shall be specified clearly with the category of energy use defined by boundary in Clause 5.

According to the energy usage, corresponding boundary and energy use data shown in Figure B.1, the energy use of the building could be presented as Table B.1.

Table B.1 — Energy use of a building

Energy usage	E_B	E_T	E_R	E_D
Space heating	$E_{B,h}$: 1 500 GJ heat	$E_{T,h}$: 14 286 t water (95°C/70°C) + 5 000 kWh electricity	-	$E_{D,h}$: 45 000 m^3 natural gas + 5 000 kWh electricity
Space cooling	$E_{B,c}$: 2 100 GJ cold	$E_{T,c}$: 200 000 kWh electricity	-	-
Domestic hot water	$E_{B,hw}$: 540 GJ heat	$E_{T,hw}$: 2 143 t water (70°C/10°C) + 5 000 kWh electricity	$E_{R,hw}$: 540 GJ heat	-
Air movement	/	$E_{T,am}$: 60 000 kWh electricity	-	/
Lighting	/	$E_{T,lt}$: 150 000 kWh electricity	-	/
Office appliances	/	$E_{T,app}$: 80 000 kWh electricity	-	/
Indoor transportation	/	$E_{T,transp}$: 20 000 kWh electricity	-	/
Devices in data center	/	$E_{T,data}$: 80 000 kWh electricity	-	/
Building auxiliary devices	/	$E_{T,aux}$: 20 000 kWh electricity	-	/

Table B.2 shows the example of presenting the building energy use by the calorific value approach, and Table B.3 shows the example of presenting the building energy use by the exergy approach. Other conversion methods can be chosen according to the purpose of the analysis. The indication of the adopted conversion approach should be denoted as the subscript shown in Table A.2.

Table B.2 — Energy use of a building presented by the calorific value approach

Energy usage	E_B	E_T	E_R	E_D
Space heating	$E_{B,h}$=1 500 GJ_{CV}	$E_{T,h}$=1 518 GJ_{CV}	-	$E_{D,h}$=1 770 GJ_{CV}
Space cooling	$E_{B,c}$=2 100 GJ_{CV}	$E_{T,c}$=720 GJ_{CV}	-	-
Domestic hot water	$E_{B,hw}$=540 GJ_{CV}	$E_{T,hw}$=558 GJ_{CV}	$E_{R,hw}$=540 GJ_{CV}	-

Table B.3 — Energy use of a building presented by the exergy approach

Energy usage	E_B	E_T	E_R	E_D
Space heating	$E_{B,h}$=348 GJ_{EX}	$E_{T,h}$=366 GJ_{EX}	-	$E_{D,h}$=1 770 GJ_{EX}
Space cooling	$E_{B,c}$=152 GJ_{EX}	$E_{T,c}$=720 GJ_{EX}	-	-
Domestic hot water	$E_{B,hw}$=67,5 GJ_{EX}	$E_{T,hw}$=85,5 GJ_{EX}	$E_{R,hw}$=67,5 GJ_{EX}	-

B.2 Case 2: District heating system with gas-fired boilers

Figure B.2 illustrates a heating system with gas-fired boilers in a building. The produced heat from the gas-fired boiler is used for space heating and domestic hot water.

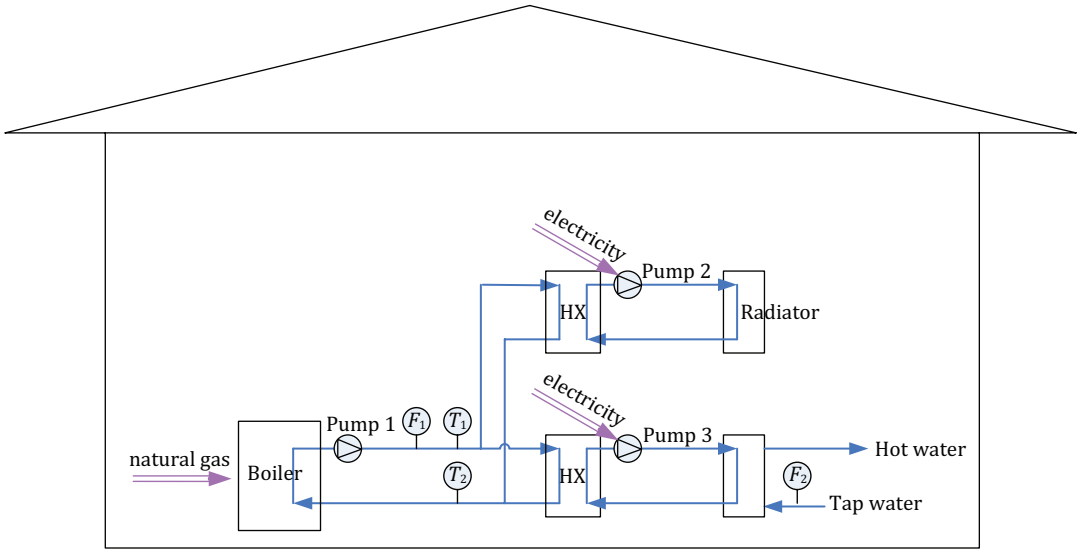

Figure B.2 — Case study of a heating system

(1) Heat reaching the building space and domestic hot water

The total heat reaching the building space and domestic hot water ($E_{B,h}$+$E_{B,hw}$) can be done by measuring the supplied and returned temperatures of the hot water and its flow rate:

$$E_{B,h} + E_{B,hw} = \rho c_p \int F_1(\tau) \times (T_1(\tau) - T_2(\tau)) d\tau \quad \text{(B.1)}$$

where

T_1 and T_2 are the supplied and returned temperatures of the hot water delivered into the building respectively;

F_1 is the flow rate;

ρ and c_p are density and specific heat capacity of hot water.

Heat acquired by the domestic hot water ($E_{B,hw}$) can be obtained by:

$$E_{B,hw} = \rho c_p \int F_2(\tau) \times (T_{hw} - T_{tap}) d\tau \quad \text{(B.2)}$$

where

T_{hw} is the temperature of domestic hot water used in the building;

T_{tap} is the temperature of tap water;

F_2 is the flow rate of domestic hot water.

Therefore, the heat reaching the building space ($E_{B,h}$) can then be obtained.

(2) Energy delivered to the building's space heating and domestic hot water system presented with equivalent energy

The energy delivered to the technical system for space heating ($E_{T,h}$) is:

$$E_{T,h} = \alpha_h E_{B,h} + \alpha_{el} E(\text{pump2}) \quad \text{(B.3)}$$

where

E (pump2) is the electricity used by Pump 2 to drive hot water circulation for space heating;

α_h and α_{el} are the conversion factors of the heat (hot water) and electricity respectively.

The conversion factors depend on the selected conversion approach.

The energy delivered to the technical system for domestic hot water ($E_{T,hw}$) is:

$$E_{T,hw} = \alpha_h E_{B,hw} + \alpha_{el} E(\text{pump3}) \quad \text{(B.4)}$$

where E (pump3) is the electricity used by Pump 3 to drive hot water in domestic hot water system.

Bibliography

[1] ISO 16346[2)], *Energy performance of buildings — Assessment of overall energy performance*

2) To be published.

ICS 91.120.10
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