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Energy performance of buildings — Assessment of overall energy performance

Performance énergétique des bâtiments — Evaluation de la performance énergétique globale

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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).

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 163, *Thermal performance and energy use in the built environment*, in collaboration with Technical Committee ISO/TC 205, *Building environment design*.

Introduction

This International Standard is prepared by ISO/TC 163, *Thermal performance and energy use in the built environment*, in collaboration with Technical Committee ISO/TC 205, *Building environment design* and is one of three closely linked documents dealing with definitions and general procedures for the overall building energy performance rating and certification (see also Figure 1):

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

— ISO 16343: *Energy performance of buildings — Methods for expressing energy performance and for energy certification of buildings*;

— ISO 16346: *Energy performance of buildings — Assessment of the overall energy performance*.

ISO/TR 16344 provides a coherent set of terms, definitions, and symbols for concepts and physical quantities related to the overall energy performance of buildings and its components, including definitions of system boundaries, to be used in all International Standards elaborated within ISO on energy performance of buildings.

ISO 16343 sets out ways of expressing the energy performance in an energy performance certificate of a building (including the technical building systems) and ways of expressing requirements as to the energy performance. This includes an overall numerical energy performance indicator and classes against benchmarks.

Their development greatly benefited from similar CEN documents (viz. CEN/TR 15615, EN 15217, and EN 15603) developed to support the European Energy Performance of Buildings Directive (EPBD).

A revision of the set of CEN standards to support the EPBD is anticipated in the near future. Issuing the ISO documents aims to bring the key subjects of building energy performance assessment to the global international level.

Given the strong demand for these International Standards at ISO level, it was decided not to delay the advancement of these International Standards and Technical Report by waiting on these CEN developments. However, it is expected that a future revision of these International Standards and Technical Report will be carried out in collaboration with CEN under the Vienna Agreement.

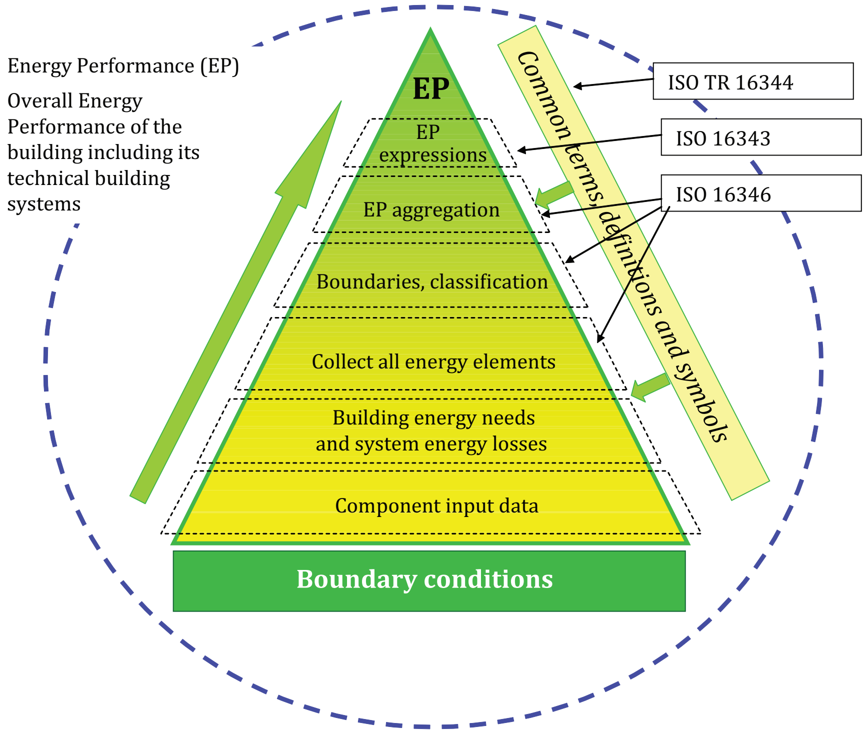


Figure 1 — Flow diagram illustrating the successive elements of the general procedures

Introduction to the assessment of overall energy performance

Energy assessments of buildings are carried out for various purposes, such as:

a) judging compliance with building regulations expressed in terms of a limitation on energy use or a related quantity;

b) checking for transparency in commercial operations through the energy certification and/or display of a level of energy performance (energy performance certification);

c) monitoring of the energy efficiency of the building and its technical building systems;

d) helping in planning retrofit measures through prediction of energy savings which would result from various actions.

This International Standard specifies a general framework for the assessment of overall energy use of a building and the calculation of energy ratings in terms of primary energy, CO_2 emissions, or parameters defined by a national energy policy. Separate standards calculate the energy use of services within a building (heating, cooling, hot water, ventilation, lighting, and transport for people) and produce results that are used here in combination to show overall energy use. This assessment is not limited to the building alone, but takes into account the wider environmental impact of the energy supply chain.

An allowance is made for energy that may be generated within or on the surface of the building and which is used to offset fuel and power drawn from other sources. Energy generated at the building site and exported is credited, provided it is exported for use elsewhere.

Energy certification of buildings requires a method that is applicable to both new and existing buildings and which treats them in an equivalent way. Therefore, a method to obtain equivalent results from different sets of data is presented in this International Standard. A method to assess missing data and to calculate a standard energy use for space heating and cooling, ventilation, domestic hot water, and lighting is provided. This International Standard also provides a method to assess the energy effectiveness of possible improvements.

Two principal types of energy ratings for buildings are proposed in this International Standard:

a) calculated energy rating;

b) measured energy rating.

Because of the differences in the way these two ratings are obtained, they cannot be directly compared. However, the difference between the two ratings for the same building can be used to assess the cumulative effects of actual construction, systems, and operating conditions versus standard ones and the contribution of energy uses not included in the calculated energy rating.

Values for factors and coefficients needed to calculate primary energy and CO_2 emissions related to energy policy should be defined in a national annex.

NOTE Energy is not produced, but only transformed. However, in this International Standard, energy is used in one form by systems that generate other forms of energy. At its final stage in the building, energy is used to provide services such as heating, cooling, ventilation, hot water, lighting.

Energy performance of buildings — Assessment of overall energy performance

1 Scope

This International Standard defines the general procedures to assess the energy performance of buildings, including technical building systems, and defines the different types of ratings, and the building boundaries.

The purpose of this International Standard is to

a) collate results from other International Standards that calculate energy use for specific services within a building,

b) account for energy generated in the building, some of which may be exported for use elsewhere,

c) present a summary of the overall energy use of the building in tabular form,

d) provide energy ratings based on primary energy, carbon dioxide emission, or other parameters defined by a national energy policy, and

e) establish general principles for the calculation of primary energy factors and carbon dioxide emission coefficients.

This International Standard defines the energy services to be taken into account for setting energy performance ratings for planned and existing buildings and provides for

1) a method to compute the standard calculated energy rating, a standard energy use that does not depend on occupant behaviour, actual weather, and other actual (environment or indoor) conditions,

2) a method to assess the measured energy rating, based on the delivered and exported energy,

3) a method to improve confidence in the building calculation model by comparison with actual energy use, and

4) a method to assess the energy effectiveness of possible improvements.

This International Standard is applicable to a part of a building (e.g. flat), a whole building, or several buildings.

It is up to national bodies to define under which conditions, for which purposes, and for which types of buildings the various ratings apply.

This International Standard handles the energy performance of a building as a whole. The assessment of the energy performance of specific technical building systems is handled in the appropriate part of the EN 15241, EN 15243, and EN 15316 series or the appropriate International Standards or national standards as listed in Annex A.

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

ISO 12569, *Thermal performance of buildings and materials — Determination of specific airflow rate in buildings — Tracer gas dilution method*

ISO 13789, *Thermal performance of buildings — Transmission and ventilation heat transfer coefficients — Calculation method*

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

ISO 14025, *Environmental labels and declarations — Type III environmental declarations — Principles and procedures*

ISO 16343, *Energy performance of buildings — Methods for expressing energy performance and for energy certification of buildings*

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

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

EN 15193:2007, *Energy performance of buildings — Energy requirements for lighting*

EN 15232:2007, *Energy performance of buildings — Impact of Building Automation, Controls and Building Management*

EN 15241, *Ventilation for buildings — Calculation methods for energy losses due to ventilation and infiltration in commercial buildings*

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

EN 15316 (all parts), *Heating systems in buildings — Method for calculation of system energy requirements and system efficiencies*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 7345 and ISO/TR 16344 apply.

NOTE These terms and definitions are applicable to energy calculations according to this International Standard and to International Standards that are based on this one, to provide input to or use output from this International Standard.

4 Symbols and abbreviated terms

The International Standards dealing with the energy performance of buildings introduce a large number of quantities and their associated symbols.

To facilitate the use of the International Standards, a common set of symbols and subscripts has been defined, as given in ISO/TR 16344 (Terms, definitions, and symbols). The symbols follow established standards of nomenclature, such as ISO 7345, and introduce others that are common to the set of International Standards needed to assess the energy performance of buildings, in particular a set of subscripts to distinguish between different energy uses, different energy carriers, etc.

The symbols given in ISO/TR 16344 concern only data passed from one International Standard (or part of an International Standard) to another.

5 Assessment of energy performance of buildings

5.1 Energy uses

The assessment of the annual energy used by a building shall comprise the following services:

— heating;

— cooling and dehumidification;

— ventilation and humidification;

— hot water;

— lighting (optional for residential buildings);

— transport for people (optional);

— other services (optional).

The annual energy use includes auxiliary energy and losses of all systems.

National bodies decide if energy for lighting in residential buildings, as well as energy for transport for people and other services (e.g. electrical appliances, cooking, industrial processes) in all types of buildings shall be included or not in the calculated rating.

NOTE Energy uses for lighting and other services are included in the measured energy rating.

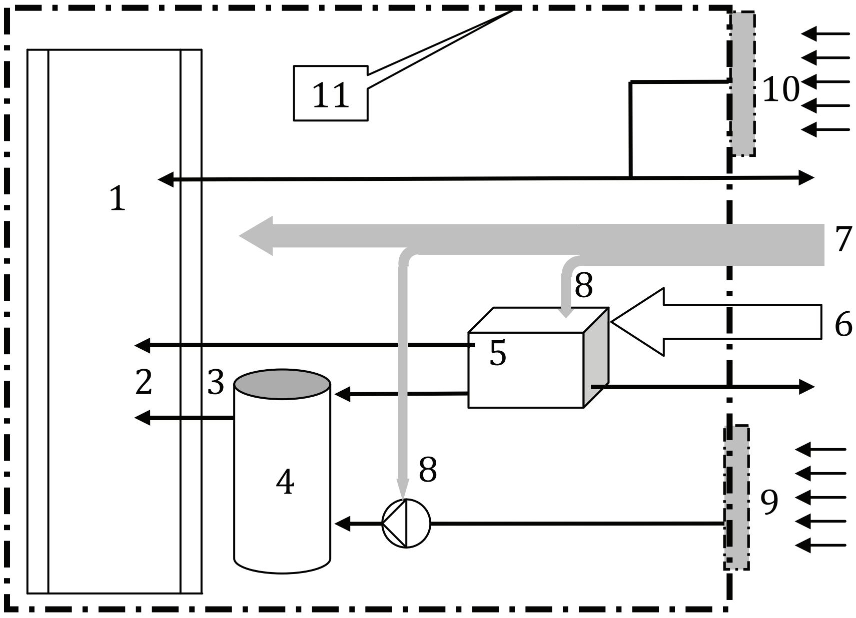
5.2 Assessment boundaries

The boundary for the energy performance assessment shall be clearly defined before the assessment. It is called system boundary. The system boundary is related to the rated object (e.g. flat, building).

Inside the system boundary, the system losses are taken into account explicitly; outside the system boundary, they are taken into account in the conversion factor.

Energy can be imported or exported through the system boundary. Some of these energy flows can be quantified by meters (e.g. gas, electricity, district heating, and water). The system boundary for energy carriers is the meters for gas, electricity, district heating, and water, the loading port of the storage facility for liquid, and solid energy carriers.

Consequently, if a part of a technical building system (e.g. boiler, chiller, cooling tower, etc.) is located outside the building envelope but forms part of the building services assessed, it is considered to be inside the system boundary and its system losses are therefore taken into account explicitly.



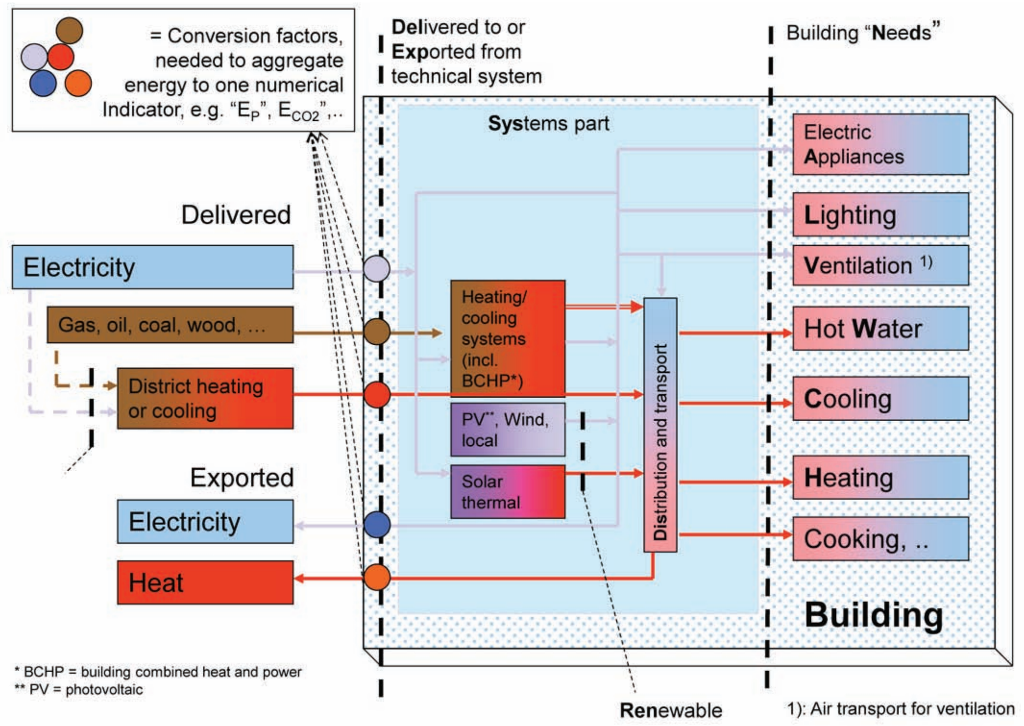
Key

1 user
2 emission
3 distribution
4 storage
5 boiler
6 fuel
7 electricity
8 auxiliary energy
9 thermal solar collector
10 photovoltaic panels
11 boundary

Figure 2 — Boundary — Examples of energy flows across the system boundary

The following two figures illustrate the energy flows inside and across the system boundary.

NOTE 1 These illustrations are more complete than Figure 2.



NOTE 2 Part of the recoverable heat or cold from the systems may be recovered in the building, thus reducing or augmenting the building energy needs for heating and/or cooling.

Figure 3 — Boundary and energy flows — Main energy flows within and crossing the boundaries

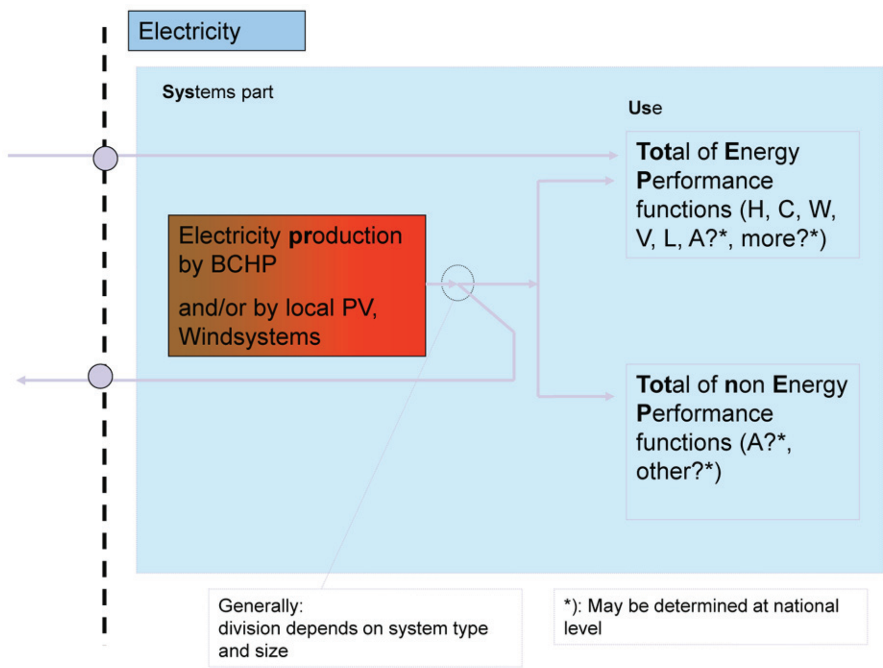


Figure 4 — Boundary and energy flows — More detailed view on the energy flows for produced, used, and exported electricity at and from the building site

For active solar, wind, or water energy systems, the incident solar radiation on solar panels or the kinetic energy of wind or water is not part of the energy balance of the building. Only the energy delivered by the generation devices and the auxiliary energy needed to supply the energy from the source (e.g. solar collector) to the building are taken into account in the energy balance. It is decided on the national level whether this energy is part or not of the delivered energy.

The assessment can be made for a group of buildings if they are on the same lot or are serviced by the same technical systems.

Specific rules for the boundaries, depending on the purpose of the energy performance assessment and the type of the buildings, may be provided at national level.

5.3 Types and uses of ratings

This Internatonal Standard gives two principal options for energy rating of buildings:

— calculated energy rating;

— measured energy rating.

The calculated energy rating includes energy use for heating, cooling, ventilation, hot water, and when appropriate, fixed built-in lighting. It does not include energy for other services unless so decided at national level. Therefore, both ratings cannot be compared without special caution, as mentioned in Clause 8.

The calculated energy rating can be either:

— standard, based on conventional climate, use, surroundings, and occupant-related input data defined at national level and given in a national annex. This rating is called “design rating” when applied to a planned building;

— tailored, calculated with climate, occupancy, and surroundings data adapted to the actual building and the purpose of the calculation.

The assessment method of the measured energy rating is given in Clause 8.

National bodies determine

— which type of rating applies for each building type and purpose of the energy performance assessment,

— under what conditions the design rating can be considered as or converted to a calculated energy rating for the actually realized building, and

— if renewable energy produced on site is part or not of delivered energy.

The types of rating are summarized in Table 1.

Table 1 — Types of ratings

	Name	Input data			Utility or purpose
		Use	Climate	Building	
Calculated	Design	Standard	Standard	Design	Building permit, certificate under conditions
	Standard	Standard	Standard	Actual	Energy performance certificate, regulation
	Tailored	Depending on purpose		Actual	Optimization, validation, retrofit planning
Measured	Operational	Actual	Actual	Actual	Energy performance certificate, regulation

6 Weighted energy ratings

6.1 Types of ratings and indicators used

NOTE 1 Annex G contains a worked example of the procedures in this clause.

NOTE 2 ISO 16343 describes different levels of ratings, from integrated building energy performance to energy performance at component level. So it is to be discussed if the performance ratings of the envelope and of systems would not be better placed in ISO 16343.

ISO/FDIS 23045 presents a list of indicators for the different aspects of the energy efficiency of buildings, as in the following:

— performance of the building envelope;

— performance of the building envelope including the building technical systems;

— performance of technical building systems;

— performance of the building expressed in terms of primary energy use;

— performance of the building expressed in terms of related CO_2.

The indicators may be expressed as an absolute value that gives information about the global performance of the building or a relative value that allows comparison between the buildings and/or the technical building systems of the same category. As energy required and, consequently, energy delivered are closely related to designed comfort, indoor design conditions shall also be given at project definition stage.

Area (or volume) considered for the expression of efficiency and performance factors is the heated and/or cooled area as defined in ISO 16818. If not applicable, the definition of the floor area shall be defined as most factors can be related to this area.

A building usually uses more than one energy carrier. Therefore, a common expression of all energy carriers shall be used to aggregate the used amounts, sometimes expressed in various units and always having various impacts.

According to this International Standard, the aggregation methods are based on the following impacts the use of energy have:

— primary energy;

— carbon dioxide emission;

— parameters defined by national energy policy.

NOTE 3 Cost is a parameter that may be used in the energy policy aggregation method.

6.2 Types of factors or coefficients

6.2.1 General

The aggregation needs factors and coefficients determined at a national level according to the rules given below. Values for factors needed to calculate the primary energy and/or CO_2 emissions should be defined in a national annex.

NOTE 6.4.2 provides factors which can be used if no national values are given.

In a multi-plant generation system (e.g. electricity, district heating), the weighting factor at any time depends on which generation plants operate continuously and which plants are affected by a change in energy demand. A distinction between average, marginal, and end-use factors or coefficients may therefore be appropriate for the aggregation.

6.2.2 Average factor or coefficient

The average factor or coefficient reflects the annual average impact of all plants delivering energy (directly or indirectly) to the building. It is calculated by estimating the total impact (primary energy use, CO_2 production) during a year and divided by the total energy delivered.

6.2.3 Marginal factor or coefficient

If energy use or production is reduced (or increased), not all power stations are affected equally: the operation of “base load” stations is unchanged. A decrease in demand is met by reduced operation of other plants. Exported energy by a building reduces the need for a new plant.

The marginal factor or coefficient takes into account only production units that are affected by such changes in energy demand or production. For example, the marginal new plant factor or coefficient relates to a new plant that should be built if the energy demand increases or that is saved due to exported electricity produced at the building sites.

6.2.4 End-use factor or coefficient

Different services (e.g. lighting, heating, air-conditioning) produce demands at different times, each having very different demand patterns that may justify the use of specific demand-weighted factors for different end uses.

6.2.5 Use of environmental declaration

The environmental declaration, as defined in ISO 14025, is based on the Life Cycle Assessment (LCA) Methodology. Information about use of energy resource and CO_2 can be used as a basis to express the useful indicator related to primary energy or CO_2.

6.3 Energy use indicator

6.3.1 General

The energy use indicator represents the performance of the building envelope. This indicator does not take into account the performance of the technical building systems. It may be used to consider the intrinsic ability of the building as the lifetime of the building may exceed the lifetime of the component of the technical building systems.

6.3.2 Energy use indicator

This indicator is calculated from the energy use for heating, cooling, and lighting including solar and internal gains but no heat recovery by technical systems.

$$E_D = \sum Q_i \qquad (1)$$

where

Q_i is the energy needed for any purpose, as defined in 5.1.

NOTE Recovered losses are not taken into account as they are related to the definition of the technical building systems.

For comparison purposes, this indicator can be used as an absolute value (MJ or kWh) or as a relative value compared to the surface unit of the energy use for the building.

6.4 Primary energy rating

6.4.1 General

The primary energy approach makes possible the simple addition from different types of energies (e.g. thermal and electrical) because primary energy includes the losses of the whole energy chain, including those located outside the building system boundary. These losses (and possible gains) are included in a primary energy factor.

EXAMPLE If building A exports heat to building B, which is located outside the assessment boundaries, this heat is taken into account in the same way as district heating. The primary energy factor used for building B includes the system losses (generation, heat losses between building A and B, etc).

6.4.2 ISO weighted energy use

Primary energy factors vary in the world. Nevertheless, for an international comparison of the energy performance of buildings, a common “ISO” energy performance indicator may be used. In this case, the information given in Table 2 shall be used.

NOTE 1 Because of different primary energy factors, different climate conditions, and different operation assumptions, international comparisons are often difficult and can mislead. The design of a building should follow the concrete conditions and not average international values.

The ISO weighted energy use, E_{ISO}, is calculated from the delivered and exported energy for each energy carrier:

$$E_{\text{ISO}} = \sum_{ci} E_{\text{ISO;del;}ci} - \sum_{ci} E_{\text{ISO;exp;}ci} \quad (2)$$

with

$$E_{\text{ISO;del;}ci} = E_{\text{EPdel,}ci} \times f_{\text{ISO,del,}ci} \quad (3)$$

$$E_{\text{ISO;exp;}ci} = E_{\text{exp,}ci} \times f_{\text{ISO,exp,}ci} \quad (4)$$

where

E_{ISO} is the annual ISO weighted energy use for all energy uses included in the energy performance assessment, in MJ or kWh;

$E_{\text{ISO;del;}ci}$ is the annual delivered energy in ISO weighted energy units, for energy carrier *ci*, in MJ or kWh, determined according to Formula (3);

$E_{\text{ISO;exp;}ci}$ is the annual exported energy in ISO weighted energy units, for energy carrier *ci*, in MJ or kWh, determined according to Formula (4);

$E_{\text{EPdel;}ci}$ is the annual delivered energy, for energy carrier *ci*, for all energy uses included in the energy performance assessment, in MJ or kWh, determined according to Formula (10);

$E_{\text{exp;}ci}$ is the annual exported energy, for energy carrier *ci*, in MJ or kWh, determined according to Formula (17) for electricity and Formula (18) for thermal energy;

$f_{\text{ISO,del,}ci}$ is the ISO factor for the delivered energy carrier *ci*, to be determined according to Table 2;

$f_{\text{ISO,exp,}ci}$ is the ISO factor for the exported energy carrier *ci*, to be determined according to Table 2.

Table 2 — Conversion factors for ISO weighted energy use $f_{ISO,del,ci}$ and $f_{ISO,exp,ci}$

	Total energy factor	Non-renewable energy factor
Fossil fuels	1,2	1,2
Electricity	3,0	2,5
Log	1,1	0,1
Liquid biomass and biogas	1,5	0,5

NOTE 2 For Table 2, the results of an inventory of national primary energy conversion factors have been used.

6.4.3 Primary energy

The annual primary energy use, E_P, is calculated from the delivered and exported energy for each energy carrier:

$$E_P = \sum_{ci} E_{P;del;ci} - \sum_{ci} E_{P;exp;ci} \quad (5)$$

with

$$E_{P;del;ci} = E_{EPdel,ci} \times f_{P,del,ci} \quad (6)$$

$$E_{P;exp;ci} = E_{exp,ci} \times f_{P,exp,ci} \quad (7)$$

where

E_P is the annual primary energy use for all energy uses included in the energy performance assessment, in MJ or kWh;

$E_{P;del;ci}$ is the annual delivered energy in primary energy units, for energy carrier *ci*, in MJ or kWh, determined according to Formula (6);

$E_{P;exp;ci}$ is the annual exported energy in primary energy units, for energy carrier *ci*, in MJ or kWh, determined according to Formula (7);

$E_{EPdel;ci}$ is the annual delivered energy, for energy carrier *ci*, for all energy uses included in the energy performance assessment, in MJ or kWh, determined according to Formula (10);

$E_{exp;ci}$ is the annual exported energy, for energy carrier *ci*, in MJ or kWh, determined according to Formula (17) for electricity and Formula (18) for thermal energy;

$f_{P,del,ci}$ is the primary energy factor for the delivered energy carrier *ci*, to be determined according to 6.2;

$f_{P,exp,ci}$ is the primary energy factor for the exported energy carrier *ci*, to be determined according to 6.2.

These two factors, $f_{P,del,ci}$ and $f_{P,exp,ci}$, can be the same.

Table 2 is used for the primary energy calculations. The energy used for different purposes and by different fuels is recorded separately.

6.4.4 Primary energy factors

There are two conventions for defining primary energy factors.

a) Total primary energy factor: The conversion factors represent all the energy overheads of delivery to the point of use (e.g. production outside the building system boundary, transport, extraction). In this case, the primary energy conversion factor always exceeds unity.

b) Non-renewable primary energy factor: The conversion factors represent the energy overheads of delivery to the point of use but exclude the renewable energy component of primary energy, which may lead to a primary energy conversion factor less than unity for renewable energy sources.

The primary energy factors shall include at least

— energy to extract the primary energy carrier,

— energy to transport the energy carrier from the production site to the utilization site, and

— energy used for processing, storage, generation, transmission, distribution, and any other operations necessary for delivery to the building in which the delivered energy is used.

The primary energy factors may also include

— energy to build the transformation units,

— energy to build the transportation system, and

— energy to clean up or dispose the wastes.

National annexes giving tables of values representing local conditions for electricity generation and fuel supply may be added to this International Standard. Such tables shall give values for primary energy factors or non-renewable primary energy factors, depending on which are to be used at national level. Examples of such factors are given in Annex B.

Any national annex that defines primary energy factors and non-renewable primary energy factors shall state which of the above overheads have been included (e.g. energy to build the transformation and transportation system). If the coefficients for fuels are given by energy unit, they shall be based on gross calorific values. In the national annex, it shall also be clearly stated which type of factor or coefficient defined in 6.2 is used.

6.5 Carbon dioxide rating

6.5.1 Carbon dioxide emissions

The emitted mass of CO_2 is calculated from the delivered and exported energy for each energy carrier:

$$m_{CO_2} = \sum (E_{del,ci} \times k_{del,ci}) - \sum (E_{exp,ci} \times k_{exp,ci}) \qquad (8)$$

where

$E_{del,ci}$ is the delivered energy for energy carrier *ci*, according to 7.2;

$E_{exp,ci}$ is the exported energy for energy carrier *ci*, according to 7.2;

$k_{del,ci}$ is the CO_2 emission coefficient for delivered energy carrier *ci*, to be determined according to 6.2;

$k_{exp,ci}$ is the CO_2 emission coefficient for exported energy carrier *ci*, to be determined according to 6.2.

The two coefficients $K_{del,ci}$ and $K_{exp,ci}$ can be the same.

The CO_2 emission calculation shall be reported in accordance with Table 3.

Table 3 — Calculation of ratings (example: CO_2 rating)

Row		**C1**	**C2**	**C3**
		Delivered energy		
		Energy carrier 1	Energy carrier *i*	
1	Energy delivered (unweighted)	$E_{del,1}$	$E_{del,i}$	
2	Weighting factor or coefficient	$k_{del,1}$	$k_{del,i}$	
3	Weighted delivered energy or CO_2	$m_{CO_2,del,1}$	$m_{CO_2,del,i}$	$\sum m_{CO_2,del,i}$
		Exported energy		
		thermal	electrical	
4	Energy exported (unweighted)	$Q_{exp,T}$	$E_{exp,el}$	
5	Weighting factor	$k_{exp,T}$	$k_{exp,el}$	
6	Weighted exported energy or CO_2	$m_{CO_2,exp,T}$	$m_{CO_2,exp,el}$	$\sum m_{CO_2,exp,i}$
7	**Rating**			m_{CO_2}

6.5.2 CO_2 emission coefficients

The CO_2 emission coefficients shall include all CO_2 emissions associated with the primary energy used by the building, as defined in 6.4. It shall be defined at national level whether the CO_2 emission coefficients also include the equivalent emissions of other greenhouse gas emissions, e.g. methane.

Any national annex that defines CO_2 emission coefficients shall state which of the additional overheads mentioned in 6.2 have been included. If the coefficients for fuels are given by energy unit, they shall be based on gross calorific values. This annex shall also state which type of coefficient defined in 6.2 is used.

6.6 Policy energy rating

In order to influence the energy behaviour of citizens, policy factors can be used to favour or penalize some energy carriers. The policy energy rating is calculated from the delivered and exported energy for each energy carrier:

$$E_{\text{pol}} = \sum \left(E_{\text{del},ci} \times f_{\text{pol,del},ci} \right) - \sum \left(E_{\text{exp},ci} \times f_{\text{pol,exp},ci} \right) \quad (9)$$

where

$E_{\text{del},ci}$ is the delivered energy for energy carrier *ci*, according to 7.2;

$E_{\text{exp},ci}$ is the exported energy for energy carrier *ci*, according to 7.2;

$f_{\text{pol,del},ci}$ is the policy factor for delivered energy carrier *ci*, to be determined according to 6.2;

$f_{\text{pol,exp},ci}$ is the policy factor for exported energy, to be determined according to 6.2.

7 Calculated energy rating

7.1 Calculation procedure

7.1.1 General

The calculation direction goes from the needs to the source (e.g. from the building energy needs to the primary energy).

Electrical services (e.g. lighting, ventilation, auxiliary) and thermal services (e.g. heating, cooling, humidification, dehumidification, domestic hot water) are considered separately inside the building boundaries.

The building's on-site energy production based on locally available renewable resources and the delivered energy are considered separately.

NOTE Annex B provides some information on the methods for collecting building data in the case of existing buildings.

7.1.2 Calculation step

The objective of the calculation is to determine the annual overall energy use, primary energy, or CO_2 emission. For the different energy services, this may be done using one of the following two different ways:

— Calculation is performed using annual average values.

— Calculation is performed by dividing the year into a number of calculation steps (e.g. months, hours, etc.), performing the calculations for each step using step-dependent values, and summing up the results for all the steps over the year.

NOTE The use of annual values is unsatisfactory in many cases, especially when calculating CO_2 emissions of seasonal energy uses.

Reporting tables summarize the annual energy performance of the building envelope and the technical building systems. The time step in these tables is the year.

7.1.3 Calculation principles of the recovered gains and losses

7.1.3.1 General

The interactions between the different energy services (e.g. heating, cooling, lighting) are taken into account by the calculation of heat gains and recoverable system losses which can have a positive or negative impact on the energy performance of the building.

The starting point for each calculation is the building needs according to ISO 13790. The heat gains and recoverable thermal losses (e.g. solar heat gains, metabolic heat gains, etc.) included in the building needs shall be defined at national level. It shall be specified in the report which heat gains and recoverable thermal losses (e.g. solar gains, metabolic gains, etc.) have been taken into account.

Two approaches are allowed for taking into account the recoverable thermal losses which are not included in the building energy needs at the starting point (see 7.1.3.2 and relevant definitions in ISO/TR 16344).

NOTE The choice may be different for different technical building systems.

7.1.3.2 Holistic approach

In the holistic approach, the totality of the effects of the heat sink and sources in the building and the technical building systems that are recoverable for space conditioning are considered in the calculation of the thermal energy needs.

As the technical building thermal systems losses depend on the energy input, which itself depends on the recovered system thermal sources, iteration might be required.

The calculation procedure is the following.

a) Do the subsystem calculation according to EN 15241, EN 15243, and EN 15316 series or the relevant International Standards listed in Annex A and determine the recoverable thermal system losses.

b) Add the recoverable thermal system losses to the other recoverable heat sources already included (e.g. solar and internal heat gains, recoverable thermal losses from lighting, and/or other technical building systems like domestic hot water) in the calculation of the needs for heating and cooling.

c) Calculate the thermal energy needs for heating and cooling again.

d) Repeat steps a) to c) until changes in the energy needs between two iterations are less than a defined limit (e.g. 1 %) or stop after a number of iterations, as specified at the national level.

e) Calculate the difference between the energy at the start and at the end of the iteration. These are the recovered system thermal losses.

7.1.3.3 Simplified approach

In the simplified approach, the recovered system heat losses obtained by multiplying the recoverable thermal system losses by a conventional recovery factor are directly subtracted from the loss of each technical building system considered.

This avoids iterations.

The calculation procedure is the following.

a) Do the subsystem calculation according to EN 15241, EN 15243, and EN 15316 series or the relevant standards listed in Annex A and determine the recoverable system thermal losses.

b) Calculate the recovered thermal system losses by multiplying the recoverable system thermal losses by a conventional recovery factor.

c) Subtract the recovered thermal system losses from the total thermal system losses.

The recovered thermal system losses have to be included per energy carrier before the final energy rating. The procedure is given in 7.4.2.

Conventional values of the recovery factor are given at national level. If no national value is available, then the recovery factor is 80 % of the utilization factor of the gains in the heat balance calculated according to ISO 13790 using the monthly method.

For complex systems (e.g. heating and cooling installations), the holistic approach is recommended.

NOTE 1 Heat recovery in systems (e.g. preheating of the combustion air or recovery from exhaust air) is treated in applicable system standards.

7.1.4 Effect of integrated control

The preferred option is to take the effects of control systems into account directly when calculating the energy delivered and not as a factor at the end of the calculation.

As a simplified approach, the impact of integrated controls combining the control of several systems may be taken into account according to EN 15232 or the relevant standards listed in Annex A.

7.2 Set of formulae

7.2.1 Top level formulae

The annual delivered energy for energy carrier *ci*, $E_{\mathrm{del,ci}}$, is equal to Formula (10) or Formula (11).

For electricity (*ci* = el):

The annual delivered electricity, $E_{\mathrm{del;el}}$, is equal to the electricity used for the energy performance, minus the part of electricity produced at the building site [e.g. from combined heat and power (CHP), PV, wind power] that is used to cover part of its own use.

$$E_{\mathrm{EPdel;el}} = E_{\mathrm{EPus,el}} - E_{\mathrm{pr,EPus,el}} \tag{10}$$

For all other energy carriers:

The annual delivered energy for energy carrier *ci*, $E_{\mathrm{del,ci}}$, is equal to the energy, in the form of this energy carrier, that is used for the energy performance:

$$E_{\mathrm{EPdel};ci} = E_{\mathrm{EPus},ci} \tag{11}$$

NOTE 1 It is for the time being assumed that thermal energy produced at the building site (e.g. by thermal solar energy systems) and used to cover part of its own energy use, is always implicitly accounted for in the assessment of the energy use of the system.

where

$E_{\mathrm{EPdel},ci}$ is the annual delivered energy, for energy carrier *ci*, for the energy performance, including (if any) energy used to produce energy at the building site, in MJ or kWh.

NOTE 2 "Energy used to produce energy at the building site" is for instance gas or coal used in a local CHP system. The benefits from the electricity production are taken into account in the terms $E_{\mathrm{pr;EP;us},ci}$ [Formula (10) and (11), with *ci* = electricity] and $E_{\mathrm{exp};ci}$ [Formulae (1) to (7), with *ci* = electricity]

$E_{\mathrm{EPus};ci}$ is the annual used energy for the energy performance, for energy carrier *ci*, in MJ or kWh, determined according to Formulae (12) and (13);

$E_{\mathrm{pr;EPus;el}}$ is the part of the annual electricity produced on site, that is used at the building site for the energy performance, in MJ or kWh, determined according to Formula (14).

NOTE 3 The addition of "that is used at the building site for the energy performance" is necessary because there may be other electricity uses at the building site (e.g. certain appliances) which are not included in the energy performance assessment but also use part of the produced electricity.

The annual used energy for the energy performance, for energy carrier *ci*, $E_{\mathrm{EP;us};ci}$, is equal to Formula (12) or Formula (13).

For electricity (*ci* = el):

$$E_{\mathrm{EPus,el}} = E_{\mathrm{H,el}} + W_{\mathrm{H;aux}} + E_{\mathrm{hum,el}} + W_{\mathrm{hum;aux}} + E_{\mathrm{V;el}} + E_{\mathrm{L;el}} + E_{\mathrm{C,el}} + W_{\mathrm{C;aux}} + E_{\mathrm{dhum,el}} + W_{\mathrm{dhum;aux}} + E_{\mathrm{W,el}} + W_{\mathrm{W;aux}} \quad (12)$$

For all other energy carriers:

$$E_{\mathrm{EPus},ci} = E_{\mathrm{H},ci} + E_{\mathrm{hum},ci} + E_{\mathrm{V},ci} + E_{\mathrm{L},ci} + E_{\mathrm{C},ci} + E_{\mathrm{dhum},ci} + E_{\mathrm{W},ci} \quad (13)$$

NOTE 4 The distinction is due to the common definition that auxiliary energy is only electric energy. Usually, lighting and ventilation (fans) will only be electric; however, this is not a necessity, and therefore they are kept here for other energy carriers.

where

$E_{EPus;ci}$ is the annual used energy for the energy performance, for energy carrier *ci*, in MJ or kWh;

$E_{H,ci}$ is the annual energy used for space heating, in the form of energy carrier *ci*, in MJ or kWh, determined according to the relevant standard for heating systems, listed in Annex A;

$W_{H;aux}$ is the annual energy used for auxiliary energy for space heating, determined according to the relevant standard for space heating systems, listed in Annex A;

$E_{hum,ci}$ is the annual energy used for humidification, in the form of energy carrier *ci*, in MJ or kWh, determined according to the relevant standard for humidification systems (see Annex A);

$W_{hum;aux}$ is the annual energy used for auxiliary energy for humidification, determined according to the relevant standard for humidification systems, listed in Annex A;

$E_{V,ci}$ is the annual energy used for ventilation (air transport), in the form of energy carrier *ci*, in MJ or kWh, determined according to the relevant standard for ventilation systems, listed in Annex A;

$E_{L,ci}$ is the annual energy used for lighting, in the form of energy carrier *ci*, in MJ or kWh, determined according to the relevant standard for lighting systems, listed in Annex A;

$E_{C,ci}$ is the annual energy used for space cooling, in the form of energy carrier *ci*, in MJ or kWh, determined according to the relevant standard for cooling systems, listed in Annex A;

$W_{dhum;aux}$ is the annual energy used for auxiliary energy for dehumidification, determined according to the relevant standard for dehumidification systems, listed in Annex A;

$E_{W,ci}$ is the annual energy used for domestic hot water heating, in the form of energy carrier *ci*, in MJ or kWh, determined according to the relevant standard for domestic hot water heating systems, listed in Annex A;

$W_{W;aux}$ is the annual energy used for auxiliary energy for domestic hot water heating, determined according to the relevant standard for domestic hot water heating systems, listed in Annex A.

NOTE 5 In these formulae, the used energy is presented per type of energy use (H, W, ...); if one generator is used for more than one energy use, the used energy has to be divided over the different uses.

For the formulae related to the produced energy on site and the determination of the amount of exported energy, a distinction is made between thermal energy (heat or cold) and electricity.

NOTE 6 The distinction is made to make it easier to recognize specific characteristics of production and export of thermal energy versus electricity. The formulae for production and export of thermal energy are for the time being restricted to renewable (solar) energy produced at the building site; in this case the produced thermal energy which is used at the building site is normally (implicitly) taken into account in the assessment of the energy use for the thermal system. Electricity produced at the building site is normally an output partly used at the building site and partly exported. The part used at the building site may include energy uses that are not part of the energy performance assessment which requires a few extra data to obtain the correct energy balance.

The part of the annual electricity produced on site that is used at the building site for the energy performance, $E_{pr;EPus;el}$, is the weighted fraction of total electricity produced on site and used at the building site.

$$E_{pr;EPus;el} = E_{pr;us;el} \times \left(\frac{E_{EPus;el}}{E_{EPus;el} + E_{nEPus;el}}\right) \quad (14)$$

where

$E_{pr;EPus;el}$ is the part of the annual electricity produced on site that is used at the building site for the energy performance, in MJ or kWh;

$E_{pr;us;el}$ is the part of the annual electricity produced on site that is used at the building site, in MJ or kWh, determined according to Formulae (15) and (16);

$E_{EPus;el}$ is the annual electricity used at the building site for the energy performance, in MJ or kWh, determined according to Formula (12);

$E_{nEPus;el}$ is the annual electricity used at the building site for uses which are not included in the assessment of the energy performance, in MJ or kWh, to be determined at national level.

NOTE 7 This amount is not part of the energy performance assessment; it may include electricity for appliances which are not covered in the energy performance assessment. The procedures and input data are to be determined at national level.

The part of the annual electricity produced on site that is used at the building site, $E_{pr;us;el}$, is the sum of the fractions used at the building site for individual electricity producing systems (such as CHP, PV, and wind power), with the amount of electricity used at the building site as maximum.

$$E_{pr;us;el} = \sum_i (f_{us;el;i} \times E_{pr;el;i}) \quad (15)$$

With the following upper limit:

$$E_{pr;us;el} \leq (E_{EPus;el} + E_{nEPus;el}) \quad (16)$$

where:

$E_{pr;us;el}$ is the annual electricity produced on site, in MJ or kWh;

$E_{pr;el;i}$ is the annual electricity produced at the building site, by system i (e.g. CHP, PV, or wind power), in MJ or kWh, determined according to the relevant standard, listed in Annex A;

$f_{us;el;i}$ is the annual fraction of electricity produced at the building site, by system i (e.g. CHP, PV, or wind power) that is usable at the building site, to be determined at national level.

NOTE 8 The fraction may be different per type (and size) of the electricity producing system; the fraction should take into account the fact that the amounts of electricity used and produced are total annual numbers while production and use will not be synchronous. At certain moments, there may be a surplus that will be exported, at other moments there will be a shortage, requiring electricity from the grid (delivered electricity).

$E_{EPus;el}$ is the annual electricity used at the building site for the energy performance, in MJ or kWh, determined according to Formula (12);

$E_{nEPus;el}$ is the annual electricity used at the building site for uses which are not included in the assessment of the energy performance, in MJ or kWh, to be determined at national level (see Note 7 under 7.2.1).

The part of the annual electricity produced on site by system *i* (e.g. CHP, PV, or wind power) that is exported, $E_{exp;el;i}$, is the weighted fraction of the difference between the sum of electricity produced at the building site and the part of it that is used at the building site.

$$E_{exp;el;i} = E_{pr;el;i} - E_{pr;us;el} \times \left(\frac{E_{pr;el;i}}{\sum_j E_{pr;el;j}} \right) \tag{17}$$

NOTE 9 The contributions from the individual sources to the exported electricity cannot be traced; therefore, the contributions are supposed to be weighted fractions. The individual contributions are needed because the conversion factor for exported electricity (see Clause 6) may be different for different types of electricity producing systems at the building site.

where:

$E_{exp;el;i}$ is the annual exported electricity, for system *i* (e.g. CHP, PV, or wind power), in MJ or kWh;

$E_{pr;el;i}$ is the annual electricity produced at the building site, by system *i*, in MJ or kWh, determined according to the relevant standard, listed in Annex A;

$E_{pr;us;el}$ is the annual electricity produced on site, in MJ or kWh, determined according to Formulae (15) and (16);

$j = 1,2,...$ is the number indicating all systems that produce electricity on site (e.g. CHP, PV, or wind power).

The part of the annual thermal energy produced on site by system *i* (e.g. heat or cold) that is exported, $E_{exp;T;i}$, is

$$E_{exp;T;i} = ... \tag{18}$$

NOTE 10 Not taken into account; attention needed for the difference between thermal energy that is already implicitly taken into account in the assessment of the energy use at the system level (see one of the other notes above, like thermal solar systems) and other thermal energy producing systems.

7.2.2 Formulae per energy use

The formulae can be grouped per energy use. For example, for heating (H):

The annual energy used for space heating (H), in the form of energy carrier *ci*, is equal to the sum over all periods of the year *mi* of the energy that is delivered per period to all generators *gi* obtaining energy from the energy carrier *ci*, for all involved systems *si*:

$$E_{\mathrm{H},ci} = \sum_{mi}\sum_{si}\sum_{gi} E_{\mathrm{H},si,gi,ci,mi} \tag{19}$$

With associated (electric) auxiliary energy over the involved systems *si* (system part excluding generator $_{\mathrm{ngen}}$) and, per system, all involved generators *gi* (generator part $_{\mathrm{gen}}$),

$$W_{\mathrm{H,aux}} = \sum_{mi}[\sum_{si}(W_{\mathrm{H,aux,ngen},si,mi}) + \sum_{gi} W_{\mathrm{H,aux,gen},si,gi,mi}] \tag{20}$$

NOTE 1 Each heating system may service one or more calculation zones.

where:

Generator part:

$$E_{\mathrm{H},si,gi,ci,mi} = \frac{Q_{\mathrm{H,dis,si},mi} \cdot F_{\mathrm{H,gen},si,gi,mi}}{\eta_{\mathrm{H,gen},si,gi,mi}} \tag{21}$$

NOTE 2 The efficiency can be replaced by the ratio of the energy out and energy going into the generator; the difference between these quantities being the losses not recovered within the system.

Distribution part:

$$Q_{\mathrm{H,dis},si,mi} = \frac{\sum_{zi} Q_{\mathrm{H,em},si,zi,mi} + \sum_{ahi} Q_{\mathrm{H,AHU},si,ahi,mi}}{\eta_{\mathrm{H,dis},si,mi}} - Q_{\mathrm{H,ren},si,mi} \tag{22}$$

NOTE 3 The efficiency can be replaced by the ratio of the energy out and energy going into the distribution part; the difference between these quantities being the losses not recovered within the system.

Emission part:

$$Q_{\mathrm{H,em},si,zi,mi} = \frac{Q_{\mathrm{H,nd},zi,mi}}{\eta_{\mathrm{H,em},si,zi,mi}} \tag{23}$$

NOTE 4 The efficiency can be replaced by the ratio of the energy out and energy going into the emission part; the difference between these quantities being the losses not recovered within the system where:

$E_{\mathrm{H},si,gi,ci,mi}$	is the annual energy used for space heating (H), for period *mi*, system *si*, and, from this system, the generator *gi*, obtaining energy from energy carrier *ci*, in MJ or kWh;
$Q_{\mathrm{H,dis},si,mi}$	is the energy for space heating, for period *mi*, delivered to the distribution part of the system *si*, in MJ or kWh;
$F_{\mathrm{H,gen},si,gi,mi}$	is the fraction with which generator *gi* delivers heat to the heating system *si*, for period *mi*, to be determined according to the relevant standard for heating systems (see Annex A). The sum over all generators delivering heat to the system *si* is 1;
$\eta_{\mathrm{H,gen},si,gi,mi}$	is the generator efficiency for space heating, for period *mi*, for generator *gi* in the system *si*, determined according to the relevant standard for heating systems (see Annex A);
$Q_{\mathrm{H,em},si,zi,mi}$	is the energy for space heating, for period *mi*, delivered to the emission part of the system *si*, in calculation zone *zi*, in MJ or kWh, determined according to the relevant standard for heating systems (see Annex A);
$Q_{\mathrm{H,AHU},si,ahi,mi}$	is the energy for space heating, for period *mi*, delivered to the air handling unit *ahi* of system *si*, in MJ or kWh, determined according to the relevant standard for ventilation systems (see Annex A); NOTE 5 In these formulae, an air handling unit is assumed to be coupled with one calculation zone.
$Q_{\mathrm{H,ren},si,mi}$	is the energy for space heating, for period *mi*, delivered by a thermal renewable energy system, to system *si*, in MJ or kWh, determined according to the relevant standard for heating systems (see Annex A);
$\eta_{\mathrm{H,dis},si,mi}$	is the distribution efficiency for space heating, for period *mi*, for system *si*, determined according to the relevant standard for heating systems (see Annex A);
$Q_{\mathrm{H,nd},zi,mi}$	is the net energy needs for space heating, for period *mi*, in calculation zone *zi*, in MJ or kWh, determined according to ISO 13790, and taking into account 7.3;
$\eta_{\mathrm{H,em},si,zi,mi}$	is the emission efficiency for space heating, for period *mi*, of system *si*, in calculation zone *zi*, determined according to the relevant standard for heating systems (see Annex A).

7.3 Building thermal needs

The building thermal needs, building thermal transfers, and building heat gains and recoverable thermal losses are reported using Table 4. The rows and columns of this table should be adapted to the building concerned.

Table 4 — Building energy needs

		C1	C2	C3	C3	C4
		Heating		Cooling		Domestic hot water
		Sensible heat	Latent heat (humidification)	Sensible heat	Latent heat (dehumidification)	
L1	Building heat gains and recoverable thermal losses[a]	$Q_{H,gn}$[a] $Q_{H,ls,rbl}$	—	$Q_{C,gn}$ + $Q_{C,ls,rbl}$	—	—
L2	Building thermal transfers	$Q_{H,ht}$	—	$Q_{C,ht}$	—	—
L3	Building thermal needs	$Q_{H,nd}$	$Q_{H,hum,nd}$	$Q_{C,nd}$	$Q_{C,dhum,nd}$	$Q_{W,nd}$

[a] If applicable.

The necessary inputs are calculated according to the International Standards listed below.

$Q_{H,nd}$	energy need for space heating (without humidification)	ISO 13790
$Q_{C,nd}$	energy need for space cooling (without dehumidification)	ISO 13790
$Q_{W,nd}$	energy need for domestic hot water	EN 15136-3-1/See Annex A
$Q_{H,ht}$	heat transfer by transmission and ventilation of the building when heated	ISO 13790
$Q_{C,ht}$	heat transfer by transmission and ventilation of the building when cooled	ISO 13790
$Q_{H,gn}$	internal and solar heat gains of the building when heated	ISO 13790
$Q_{C,gn}$,	internal and solar heat gains of the building when cooled	ISO 13790
$Q_{H,ls,rbl}$	recoverable thermal losses of technical building systems when heated	ISO 13790
$Q_{C,ls,rbl}$,	recoverable thermal losses of technical building systems when cooled	ISO 13790
$Q_{H,hum,nd}$	thermal energy for humidification	EN 15241/See Annex A
$Q_{C,dhum,nd}$	thermal energy for dehumidification	EN 15243/See Annex A

7.4 Technical building systems

7.4.1 Technical system thermal losses, electrical and auxiliary energy without building generation devices

The system losses and the electrical and auxiliary energy without generation are reported using Table 5.

Table 5 — System thermal losses and auxiliary energy without generation

		C1	C2	C3	C4	C5
		Heating	**Cooling**	**Domestic hot water**	**Ventilation**	**Lighting**
L4	Electrical energy	$W_{H,ngen}$	$W_{C,ngen}$	$W_{W,ngen}$	E_V	E_L
L5	System thermal losses	$Q_{H,ngen,ls}$	$Q_{C,ngen,ls}$	$Q_{W,ngen,ls}$		
L6	Recoverable system thermal losses	$Q_{H,ngen,ls,rbl}$	$Q_{C,ngen,ls,rbl}$	$Q_{W,ngen,ls,rbl}$	$Q_{V,ls,rbl}$	$Q_{L,ls,rbl}$[a]
L7	Thermal input to distribution system	$Q_{H,dis,in}$	$Q_{C,dis,in}$	$Q_{W,dis,in}$		

[a] $Q_{L,ls,rbl}$ is the recoverable heat dissipated by the lighting system.

NOTE The values in this table are the presentation of the results of other International Standards. It is not possible to calculate missing values by arithmetic in this table.

The system thermal losses without the building generation devices include the emission, distribution, and storage losses (if not included in the generation part) of the respective system.

The thermal output of the cooling distribution system includes the thermal need for dehumidification.

The thermal output of the ventilation system includes the thermal need for humidification.

The necessary inputs are calculated according to the International Standards listed below.

$Q_{H,ngen,ls}$ $Q_{H,ngen,ls,rbl}$ $W_{H,ngen}$	thermal losses, auxiliary energy of the heating systems without generation	EN 15316-1/ See Annex A
$Q_{C,ngen,ls}$ $Q_{C,ngen,ls,rbl}$ $W_{C,ngen}$	thermal losses, auxiliary energy of the cooling system without generation (including dehumidification)	EN 15243/15241/ See Annex A
$Q_{W,ngen,ls}$ $Q_{W,ngen,ls,rbl}$ W_W	thermal losses, auxiliary energy of domestic hot water system without generation	EN 15316-3-2/ See Annex A
E_V $Q_{V,ls,rbl}$	energy use for ventilation (including humidification) and system thermal losses	EN 15241/ See Annex A
E_L $Q_{L,ls,rbl}$	energy use for lighting and heat dissipated by the lighting system	EN 15193/ See Annex A

7.4.2 Thermal energy generation systems

The thermal energy input to the distribution systems has to be supplied by the thermal energy output of the building heat generation systems or energy supplied from outside the building (e.g. district heating).

The heat input to the distribution system is dispatched according to the system design to the different building generation devices and the energy supplied directly from outside the building.

NOTE 1 Information about the dispatch is given in EN 15316–1 and the EN 15316–4 series or the relevant International Standards listed in Annex A.

Table 6 has one column for each generation system, including cogeneration, heat pumps, refrigeration units, thermal solar, PV, etc. Energy delivered directly to the distribution systems without energy transformation (e.g. district heating, electricity, etc.) is also taken into account in these columns.

Table 6 — Energy generation systems

	Type of generator	C1 Generator 1	C2 Generator 2	C3 Generator *i*
	Distribution systems supplied[a]			
L8	Thermal output	$Q_{,gen,out,1}$	$Q_{,gen,out,2}$	$Q_{,gen,out,i}$
L9	Auxiliary energy	$W_{gen,1}$	$W_{gen,2}$	$W_{gen,i}$
L10	System (generator) thermal losses	$Q_{gen,ls,1}$	$Q_{gen,ls,2}$	$Q_{gen,ls,i}$
L11	Recoverable system thermal losses	$Q_{gen,ls,rbl,1}$	$Q_{gen,ls,rbl,2}$	$Q_{gen,ls,rbl,i}$
L12	Energy input	$E_{gen,in,1}$	$E_{gen,in,2}$	[c]
L13	Electricity production	$E_{el,gen,out,1}$	$E_{el,gen,out,2}$	$E_{el,gen,out,i}$
L14	Energy carrier[b]			

[a] Name of the supplied system, (heating, cooling, hot water, etc.)

[b] Name of the energy carrier used by the generator (oil, gas, solar heat, etc.).

[c] For renewable energy produced at the building site or energy coming from other generators situated inside the system boundary, there is no energy input taken into account.

In the case that a generator provides the input to another generator (e.g. cogenerator for absorption chiller), it is distinguished between the thermal output to the distribution system and the thermal output for generation. The thermal output, the thermal losses, and the energy input of the second generator are only given for information but not counted in the energy balance of the generation systems.

NOTE 2 In the calculation method for combined heat and power (EN 15316–4-4 or the relevant International Standard listed in Annex A), the energy input and all system losses are related to the thermal output. The electricity is counted as a bonus (power bonus method).

For a heat pump, the difference between the energy input and the thermal output plus the thermal losses is taken into account in the building energy balance either as heat recovery (inside the system boundary) or as renewable energy produced at the building site if the heat is collected through the system boundary (e.g. heat pump with an earth heat exchange).

If a heat pump is used to generate heat for heating or domestic hot water and to extract heat for cooling, the required heat supply and extraction are indicated in row L8 of Table 6 as separate quantities.

If a generator provides energy for heating and cooling, then the generator thermal losses and the auxiliary energy are dispatched between these two services according to the thermal outputs.

The generator system losses and the auxiliary energy uses are calculated according to the appropriate part of EN 15316 or the relevant International Standards listed in Annex A for heating systems and according to EN 15243 or the relevant International Standards listed in Annex A for cooling systems, and reported in accordance with Table 6.

$Q_{gen,out,i}$ thermal output of the generation device i (thermal input required by the distribution systems fed by this generator);

$Q_{gen,ls,\,i}$ system thermal losses of the generation device i;

$Q_{gen,ls,rbl,i}$ recoverable system thermal losses of the generation device i;

$W_{gen,i}$ auxiliary energy of the generation device i;

$E_{el,gen,out,i}$ electricity production of the generation device i;

$E_{gen,in,i}$ energy input to the generation device i;

$E_{gen,in,j}$ equal to the heat output and the electricity output plus the system losses minus, in the simplified approach, the recovered system thermal losses.

In the simplified approach, the recovered thermal system losses are deducted from the thermal system losses. Therefore, the total recovered thermal system losses have to be dispatched among the different generators in order to continue the calculation until the energy rating is measured by taking into account each energy carrier. For this purpose, the recoverable thermal losses are calculated as follows:

$$Q_{gen,ls,rvd,i} = Q_{Tot,sys,ls,rvd} \bullet \frac{Q_{gen,out,i}}{\sum_i Q_{gen,out,i}} \tag{24}$$

where

$Q_{gen,ls,rvd,i}$ is the recovered thermal system loss of generator i;

$Q_{Tot,sys,ls,rvd}$ is the total recovered thermal system loss;

$Q_{gen,out,i}$ is the thermal output of generator i.

At this stage, the energy carriers are taken into account (oil, gas, biomass, district heating, heat from solar systems, PV electricity, etc). They are indicated in row L14 of Table 6.

The input to the building generation system (sum of thermal and electrical output of the energy generation systems, the generator thermal losses) has to be supplied by the energy input of the different energy carriers and the renewable energies produced at the building site.

The building on-site energy production is divided according to the system design between the energy used in the building and the exported energy. The results are included in Table 8.

The thermal technical building system performances to enter in Table 8 are calculated as follows:

$$Q_{HW,ls,nrvd} = Q_{H,ngen,ls} + \sum_i Q_{H,gen,ls,i} + Q_{W,ngen,ls} + \sum_i Q_{W,gen,ls,i} - Q_{HW,ls,rvd} \tag{25}$$

$$Q_{C,ls,nrvd} = Q_{C,ngen,ls} + \sum_i Q_{C,gen,ls,i} - Q_{C,ls,rvd} \tag{26}$$

$$W_{\mathrm{HW}} = W_{\mathrm{H,ngen}} + \sum_i W_{\mathrm{H,gen},i} + W_{\mathrm{W,ngen,}} + \sum_i W_{\mathrm{W,gen},i} \tag{27}$$

$$W_{\mathrm{C}} = W_{\mathrm{C,ngen,}} + \sum_i W_{\mathrm{C,gen},i} \tag{28}$$

8 Measured energy rating[1)]

8.1 General requirements

The amounts of all energy carriers delivered to the building and exported by the building shall be measured and reported in a table based on Table 7.

Table 7 — Accounting energy carriers for measured energy rating

Row	R1	R2	R3	R4
	Units (l, kg, m^3, kWh, MJ or kWh, etc.)	**Energy delivered** (Quantities)	**Gross calorific value**	**Energy delivered** (Energy content in kWh or MJ)
L1		Gas, Oil, Electricity District heating, Wood Energy carrier (*i*)		
Units (kWh, MJ, etc.)		**Energy exported** (Quantities)		**Energy exported** (Energy content in kWh or MJ)
L2		Thermal: Electrical:		
Units (kWh, MJ, etc.)		**Renewable energy produced on site**		
L3		Thermal: Electrical:		

NOTE The columns in Table 7 should be adapted to the building concerned.

The annual delivered energy (row R2, line L1) corresponds to the total delivery of each energy carrier, as measured according to 8.3. The exported energy (row R2, line L2) is measured by an export meter or its surrogate. The delivered and exported amounts of energy carriers are indicated in the units as measured. The amount for each energy fuel is multiplied by its gross calorific value to obtain the energy content (row R4).

8.2 Assessment period

8.2.1 General

The amounts in Table 7 shall be assessed as closely as possible for the same period.

The time period is an integer number of years. It should take the average over several most recent full years, as long as the building and its use pattern have been the same.

If the assessment period is not an integer number of years, the annual energy use shall be obtained by extrapolation according to 8.2.2.

If the time period is shorter than three years, a correction for weather according to 8.4 shall be performed

1) Also called “operational rating”.

No modifications to the building that may have changed its energy performance should have taken place during the assessment period. If such a change has occurred, a new assessment period shall be started after it to get the new energy rating.

It is recommended that the first or second year after the erection of the building is discarded. The energy use during the first years is often larger than during the following years for several reasons:

— some additional energy is used to dry the building fabric,

— adjustment of control system may not be perfect from the first day of use, and

— there may be some faults that are corrected during the first year.

It is recommended that the meters are read, or stored quantities of fuel are measured, at a time when the use of the energy carrier concerned is low. The errors resulting from metering for not exactly a full number of years will then be reduced.

8.2.2 Extrapolation to an integral number of years

8.2.2.1 General

The appropriate method depends on the use of the energy carrier. Energy carriers used for several services or for services for which none of the extrapolation methods listed below can be applied shall be assessed for an integer number of years.

An appropriate building model (input data and calculation method, e.g. ISO 13790 for heating and cooling) can be used to extrapolate measurements assessed during too short a period. In this case, the building model, validated according to Clause 9, is used to obtain a calculated energy rating.

Possible simpler extrapolation methods, applicable under limited conditions only, are given in 8.2.2.2 to 8.2.2.4.

8.2.2.2 Energy carriers used at constant average power

For energy carriers used at constant average power, the extrapolation is linear:

$$E = \frac{t_{\text{an}}}{t_{\text{per}}} E_{\text{per}} \qquad (29)$$

where

t_{an} is the duration of the year;

t_{per} is the assessment time period, which shall be much larger than the time averaging period;

E_{per} is the amount of energy carrier used during the assessment time period.

For example, if the daily average power is approximately constant, t shall be several days. If the weekly average is constant, the assessment time period shall be several weeks.

8.2.2.3 Energy carriers used for heating or cooling only

For energy carriers used for heating or cooling, the extrapolation can be performed either by using the energy signature (see Annex D) or using the simplified calculation according to ISO 13790 described below.

These extrapolation methods are valid for heating in cold climates where heating is an important part of the energy rating and for cooling in warm climates where the climate is the main reason for cooling.

If the assessment is done by energy signature, the assessment period shall encompass a wide range of values of the average external temperature.

The simplified calculation for extrapolation is as follows. The amount of energy carrier used either for heating or for cooling for a whole year is

$$E_{\text{an}} = \frac{Q_{\text{an,calc}}}{Q_{\text{per,calc}}} E_{\text{per}} \tag{30}$$

where

$Q_{\text{an,calc}}$	is the calculated heating or cooling energy need for the whole year;
$Q_{\text{per,calc}}$	is the calculated heating or cooling energy need for the assessment period;
E_{per}	is the amount of energy carrier used for heating or cooling during the assessment time period.

$Q_{\text{an,calc}}$ and $Q_{\text{per,calc}}$ are calculated according to ISO 13790 in a simplified way, i.e. averaging internal temperature and gains over the building (no zoning) and using mean input values, as follows:

$$Q_{\text{H,calc}}(t) = (H_{\text{tr}} + H_{\text{ve}})\left(\overline{\theta}_{\text{int}} - \overline{\theta}_{\text{e}}\right)t - \eta_{\text{H,gn}}\left(A_{\text{sol}} I_{\text{sol}} + Q_{\text{int}}\right) \tag{31}$$

$$Q_{\text{C,calc}}(t) = \left(A_{\text{sol}} I_{\text{sol}} + Q_{\text{int}}\right) - \eta_{\text{C,ls}}(H_{\text{tr}} + H_{\text{ve}})\left(\overline{\theta}_{\text{int}} - \overline{\theta}_{\text{e}}\right)t \tag{32}$$

where

t	is the assessment time period, i.e. one full heating or cooling season to calculate $Q_{\text{an,calc}}$ and the measurement period for $Q_{\text{per,calc}}$;
H_{tr}, H_{ve}	are the heat transfer coefficients of the building by transmission and ventilation, calculated according to ISO 13789;
$\overline{\theta}_{\text{int,H,set}}$	is the heating and cooling set point temperatures, averaged over the building;
$\overline{\theta}_{\text{int,C,set}}$	is the heating and cooling set point temperatures, averaged over the building;
$\overline{\theta}_{\text{e}}$	is the mean external temperature, averaged over the time period t;
$\eta_{\text{H,gn}}$	is the gain utilization factor for heating, calculated according to ISO 13790;
$\eta_{\text{C,ls}}$	is the loss utilization factor for cooling, calculated according to ISO 13790;
A_{sol}	is an effective solar collecting area representative of the whole building, defined for a specific reference orientation (usually: south vertical);
I_{sol}	is the solar irradiation during time period t on the area A_{sol};
Q_{int}	are the internal gains of the whole building during time t; including recoverable technical system thermal losses, if applicable.

8.2.2.4 For energy carriers used at a rate depending on occupancy

For these, the extrapolation method is

$$E_{an} = \frac{O_{an}}{O_{per}} E_{per} \quad (33)$$

where

O_{an} is the occupancy (e.g. average number of occupants in the building) during the whole year;

O_{per} is the occupancy during the assessment time period;

E_{per} is the amount of energy carrier used during the assessment time period.

8.2.2.5 Limits of application

The confidence interval of the result shall be estimated.

If the confidence interval is too large because of a too short assessment period or because the assessment period is not appropriate (e.g. swing seasons), the assessment period shall be extended.

8.3 Assessing the used amounts of all energy carriers

8.3.1 General

The amount of all energy carriers shall be assessed as accurately as reasonably practicable from recorded data, energy bills, or measurements.

Energy carriers that are not metered shall be assessed by calculation according to Clause 7.

If it is intended to compare the measured rating with a tailored calculated rating, the energy used for other services than heating, cooling, ventilation, hot water, or lighting (i.e. energy use for cooking, washing, production units, etc.) should be assessed separately as accurately as reasonably practicable, by separate metering or by estimation of power and operating time.

8.3.2 Metered fuels (electricity, gas, district heating, and cooling)

Energy use is the difference of two readings of the meter taken at the beginning and the end of the assessment period.

Electricity, gas, district heating, and cooling bills can be used for assessing the use of these energy carriers. In this case, always use full years as the assessment period. Care should be taken in cases where such bills take account of the electricity or heat produced on site.

If electricity used by rented premises is metered and billed separately, energy use may not be accessible because of data protection. In this case, estimated or conventional values can be used, provided that this electricity is a small part of the energy use of this building.

8.3.3 Liquid fuels in tanks

Fuel bills or records of bought fuel are collected.

The fuel level in the tank is measured at the beginning and the end of the assessment period using a calibrated scale. The fuel used during the assessment period is then

E = content of the tank at the beginning of the assessment period
− content of the tank at the end of the assessment period
+ quantity of fuel bought during the assessment period

If delivered in small containers, gas use is assessed by counting the number of used containers. If this number is small, the containers used first and last in the assessment period should be weighed to assess the remaining stock.

If the burner operates at fixed power (not modulating) and is equipped with a burning time counter, fuel use is the difference of two readings taken at the beginning and the end of the assessment period, multiplied by the fuel flow rate of the burner. This flow rate shall be measured before the first reading and after each adjustment or cleaning of the burner.

The energy use corresponding to the amount of fuel use is obtained by multiplying this amount by its gross calorific value.

8.3.4 Solid fuels

The energy content of solid fuels (coal, wood, etc.) depends on their quality and density. The most accurate way of assessing it is to weigh the fuel. Solid fuel use is then:

E = fuel weight in stock at the beginning of the assessment period
− fuel weight in stock at end of the assessment period
+ fuel weight bought during the assessment period

The energy use corresponding to the amount of fuel used is obtained by multiplying this amount by its gross calorific value.

If volume is measured, it is multiplied by the fuel density to get the mass of solid fuel. When calculating the confidence interval of the mass, the uncertainty of its density shall be taken into account.

8.3.5 Energy monitoring

Periodic measurement of energy use allows the quantification of building-related properties such as effective boiler efficiency, apparent heat loss coefficient, or equivalent solar collecting area. Annual energy use for heating can be calculated from these data.

NOTE Annex D provides more information.

8.4 Correction for weather

If the measured energy rating is not based on energy use over at least three full years, a correction of the measured energy use for weather is necessary to ensure that the energy consumed during the period of measurement is representative of the average weather for the building's location or region.

To achieve this, the measured energy use for heating and cooling shall be adjusted to the average weather for the building's location, i.e. the regional climate.

The general method to perform this correction is to use the calculation model described in Clause 7 to calculate and validate a tailored energy rating according to Clause 9 and to use the validated calculation model to re-calculate the energy use with average local or regional weather data.

Simpler correction methods, such as the method given in 8.2.2.2 and their limits of application can be defined on a national basis, taking account of the purpose of the assessment, the climate, and the building type and usages.

9 Validated building calculation model

9.1 Introduction

The method given in this clause enables the attainment of a higher confidence level in the building calculation model and input data used for calculations by comparing the calculated result with the actual energy use. This method should be used for an existing building, particularly for assessing the energy effectiveness of possible improvement measures.

It is the general method to make corrections or extrapolations to the measured energy use.

9.2 Procedure — Validation of the building calculation model

Obtain the measured energy rating according to Clause 8.

Collect information such as actual climatic data, air permeability of the envelope, ventilation rate, heating system efficiencies, actual internal conditions (occupancy, intermittent heating, temperatures, ventilation, etc.) from building technical documentation, or through surveys, measurements, and monitoring, as far as they are available at a reasonable cost. See 9.3 for ways of collecting climatic data, 9.4 for occupancy data, and Annex D for energy for other services. The confidence intervals of all data shall be estimated. Input data that cannot be assessed are taken from inference rules, national references, or International Standards.

The assessment period for collecting all data (energy use and input data for the calculation) should be, as far as reasonably possible, the same.

Calculate a tailored rating using data as close to reality as reasonably possible not only for the building but also for climate and occupancy data. Estimate the confidence interval of the rating, resulting from uncertainties of input data.

The amount of energy carriers used for purposes other than heating, cooling, ventilation, hot water, or lighting shall be added to the tailored rating. If these are not metered separately, they shall be estimated. The part of this energy used within the conditioned space shall also be taken into account as internal heat sources in the calculation of the tailored rating.

NOTE There is no method defined in this International Standard to compute the “other services”. A list of typical energy use for cooking, washing, and electrical equipment including computers or production processes, etc. can be provided at national level for various types of buildings. Some information is given in Annex D.

Compare the results of the measured energy rating and of this tailored rating for all energy carriers.

If the confidence intervals do not overlap significantly, or if they are unacceptably large, further investigations shall be made in order to verify the data or to introduce new influencing factors that may have been previously ignored and the calculation shall be repeated with the new set of input data. If necessary, adjust input data (in a credible way, e.g. within their confidence interval) so that the calculated energy rating does not differ significantly from the measured energy rating.

When both confidence intervals are acceptable and overlap significantly, it is assumed that the calculation model of the building, including estimated input data, is plausible and the procedure can be continued further.

9.3 Climatic data

Obtain values of external temperature and solar irradiance from the meteorological station that is most representative of the location of the building and of the time period used for energy metering.

Solar irradiance shall be available for all main orientations of the building envelope that include transparent elements or elements covered with transparent insulation.

NOTE 1 Ways of calculating irradiance on any orientation from solar irradiance on a horizontal surface are found in literature[2)].

If the altitude of the meteorological station significantly differs from that of the building, external temperatures shall be corrected for altitude according to local average temperature gradients.

NOTE 2 Depending on the climate, the correction is between a 0,5 K and a 1 K decrease per 100 m altitude difference.

9.4 Occupancy data

9.4.1 Internal temperature

The actual internal temperature should be assessed since it often differs from design temperature and has a significant influence on the energy use for cooling or heating. Possible methods include the following:

— In buildings with mechanical ventilation, the air temperature in the exhaust duct upwind of the fan can give an estimate of the average temperature of the ventilated zone when exhaust fan is on.

— In many large buildings, a Building Automation and Control System controls all the energy systems and records the internal temperature and other energy-related characteristics at several places (see Annex A of EN 15232:2007 or relevant standard in Annex A).

— The temperature can be measured or monitored (using small single-channel data loggers) at some representative places during representative days, i.e. days that have meteorological characteristics that represent the corresponding month or season.

— If the heating or cooling systems are controlled by thermostats, their set points could be used, provided that the calibration of the thermostat is checked.

9.4.2 Air infiltration and ventilation

External airflow rate shall be estimated as well as reasonably possible. Ways to do this include

a) assessments of the airflow rates of air handling units where appropriate, and

b) use of the tracer gas dilution method as described in ISO 12569.

9.4.3 Internal heat sources

The occupancy (number of occupants) and presence time should be assessed from a survey or from the building management.

The internal sources from artificial lighting and electrical appliances are best assessed from electricity bills where there are no heating or cooling systems on the same meter or from a submeter. EN 15193 or the relevant International Standard listed in Annex A can also be used when no field data are available for lighting.

NOTE Not all the electricity used becomes an internal heat source (e.g. lights can be placed externally or the heat can be partly exhausted).

2) For example in Duffie and Beckmann, Solar energy thermal processes, John Wiley & Sons, 1974.

9.4.4 Hot water use

Where a separate meter is installed, hot water use is obtained from the difference of two readings at the beginning and end of the assessment period.

NOTE In this case, meters are generally used to include hot water use in bills, from which the information can be obtained without looking at the meters.

Where hot water use is not metered, it shall be estimated using EN 15316-3 or the relevant International Standard listed in Annex A from the number of occupants, use of the building and local habits, or data found in national documentation can be used.

9.4.5 Artificial lighting

Electricity bills may be useful to assess energy use for lighting, provided there are no other systems (cooking, heating, cooling systems, or other appliances) on the same meter.

Otherwise, energy use for fixed built-in lighting is estimated by calculation according to EN 15193 or the relevant International Standard listed in Annex A.

9.5 Ratings based on the validated calculation model

In order to get a standard calculated energy rating based on the validated model, perform the calculated rating once more using the same calculation model but with standard input data set according to 5.3 instead of actual data.

If the standard calculated energy rating is without “other services”, subtract the values which have been added to the tailored energy rating (see above).

To make weather or climate corrections to the measured energy rating, perform the calculated rating once more using the same calculation model but with the appropriate climate instead of the actual one.

10 Planning retrofit measures for existing buildings

The scope for energy saving measures is defined by the energy used by the technical building systems which is the combination of all the net delivered energy carriers and the active renewable energy produced on site.

The assessment of the energy saving obtained by retrofit measures is carried out using a building calculation model. This can be the same calculation model as the tailored rating, according to the relevant International Standards mentioned in Annex A (measured energy rating, validation of calculated energy rating).

The validated calculation model is recommended.

NOTE 1 If the measured energy rating is used to validate the building calculation model and input data by aligning its predictions with measured values, there is increased confidence that predicted measures will, in practice, deliver their anticipated benefits.

When preparing the calculation model, the following issues are taken into account.

a) Model used for standard calculated energy rating can only predict the effects of improvements related to heating, cooling, hot water, ventilation, or lighting. It cannot be used to predict the effects of better management system or different user behaviour, since it is based on standard input data.

b) Specific calculation models that can be used to predict savings of specific measures (such as calculating the energy savings when improving the thermal performance of a window by multiplying the thermal transmittance by area and degree-hours) do not take account of interactions (such as a low solar transmittance of the same window, which reduces the solar gains and thus changes the utilization factor) and shall therefore not be used.

When a building is sold, used for another purpose, or used by another occupant, standard data set shall be used for planning retrofit measures.

If the building is used in the same way as before, climatic and occupancy data according to the tailored rating are used.

NOTE 2 This allows assessing the effects of adjusting building management or occupant behaviour.

Prepare one or more retrofit scenarios, each containing a list of compatible retrofit measures.

Since some measures may interact (e.g. increased thermal insulation or passive solar gains might decrease boiler efficiency), the effect of individual measures cannot be added. Combined measures shall be calculated as one package.

Then, for each scenario, the input data are modified according to the planned retrofit measures and the calculation performed again. The difference between the ratings without and with the retrofit measures is the effect of these measures on the energy use.

When a final set of retrofit measures is chosen, a standard calculated energy rating of the retrofitted building may be performed using the building calculation model with a set of input data taking account of the retrofit measures and using standard input data set.

NOTE 3 The actual effectiveness of measures depends on how the building is actually used.

11 Test report

This clause defines the content of a report on the assessment of the energy use of a building according to this International Standard. The content of a certificate is defined in ISO 16343.

The report shall include the following information:

a) a reference to this International Standard (i.e. ISO 16346:2013);

b) the purpose of the energy rating;

c) a description of the building and its location, its activities, equipment and occupancy, and other relevant assumptions;

d) the type of rating;

e) the rating itself together with its confidence interval (when available). The minimum amounts of data to be reported are listed in Table 8 for the calculated and measured rating.

Table 8 is used for ratings based on primary energy, CO_2 production, or policy.

For buildings with active renewable energy systems, it is recommended to report as a supplementary value the rating as if the renewable energy systems were not present.

Table 8 — Reporting of the overall energy use or CO_2 emission for the calculated and measured energy rating

For calculated rating only			
Building thermal needs (without technical building systems)	**Technical building system performance** (thermal system losses-recovered losses)	**Energy delivered** (content of energy carriers)	**Energy rating** (weighted Energy carriers)
Heating: $Q_{H,nd}$ $Q_{H,hum,nd}$ Hot water: $Q_{W,nd}$ Cooling: $Q_{C,nd}$ $Q_{C,dhum,nd}$	Heat (H+W): $Q_{HW,ls,nrvd}$ Cooling: $Q_{C,ls,nrvd}$ Electricity[a]: Heat auxiliary W_{HW} Cooling auxiliary W_C Lighting W_L Ventilation E_V	Gas $E_{gas,del}$ Oil $E_{oil,del}$ Electricity $E_{el,del}$ District heating $E_{dh,del}$ Wood $E_{Wd,del}$ Energy carrier (i) $E_{i,del}$	$\sum E_{P,del,i}$ or $\sum E_{pol,del,i}$ or $\sum m_{CO_2,del,i}$
		Energy exported (unweighted energy carriers)	$\sum E_{P,exp,i}$ or $\sum E_{pol,exp,i}$ or $\sum m_{CO_2,exp,i}$
		Thermal $Q_{T,exp}$	
		Electrical $E_{el,exp}$	
			E_P, m_{CO_2} ,or E_{pol}
		Renewable energy produced on site	
		Thermal $Q_{H,gen,out}$	
		Electrical $E_{el,gen,out}$	

[a] Includes electricity for ventilation, lighting, and the auxiliary energy for the thermal technical systems; it does not include electricity for heating, cooling, domestic hot water, humidification, and dehumidification.

In addition, depending on national documents, the following information could be included:

a) climate parameters used for the calculated energy rating or as known — average external temperature, solar irradiance, etc. — for the measured energy rating;

b) calculated rating:

1) content of the report according to the relevant standards;

2) assumptions used to compute the energy use for hot water and lighting;

3) energy use for heating, cooling, ventilation, hot water, and lighting, together with their confidence intervals (when available), as shown in Tables 4, 5 and 6;

c) measured energy rating, for each energy carrier:

1) assessment time period;

2) method used to assess the energy use;

3) amount used, in units used when assessing it (e.g. litres, cubic metres, kilograms, kilowatt hour);

4) methods used for extrapolation and weather correction, if any;

5) delivered and exported energy of each energy carrier in kWh or MJ or multiples of them, together with their confidence intervals, when available;

d) validated rating:

1) report on the measured energy rating with confidence intervals;

2) assumptions used to fit the tailored rating to the measured energy rating;

3) result of the calculated rating including confidence intervals;

4) if required, validated standard calculated energy rating including confidence intervals;

e) improvement measures:

1) list of measures, grouped by packages when appropriate;

2) effect of each measure or package of measures on the energy performance;

3) if required, cost effectiveness of the measures or packages.

NOTE The cost effectiveness of measures is not within the scope of this International Standard.

12 Standard operating assumptions

12.1 Introduction

In this clause, standard operating assumptions are given when comparing the energy performance of buildings between countries or regions, e.g. within the same climatic zone but with different standard operating assumptions.

The drawback of comparing the energy performance of buildings with different operating assumptions is that the comparison is more a comparison of the operating assumptions than a comparison of the performance of the buildings.

On the other hand, the disadvantage of comparing the energy performance of buildings under the assumption of the same operating assumptions which significantly differ from the national or regional situation (culture, building tradition, type, and level of energy saving provisions) may be misleading too.

NOTE Because of different primary energy factors, different climate conditions, and different operation assumptions, international comparisons are often difficult and can mislead. The design of a building should follow the concrete conditions and not average international values.

12.2 Input data

The following table contains default values in case of the absence of national values.

Table 9 — Standard operating assumptions — Default input data

Building type	a	b	c	d	e	f	g	h	i Other types				Unit
Building category / Input data	Single-family houses	Apartment blocks	Offices	Education buildings	Hospitals	Restaurants	Trade services	Sports facilities	Meeting halls	Industrial buildings	Warehouses	Indoor swimming pools	
Internal set-point temperature in winter	20	20	20	20	22	20	20	18	20	18	18	28	°C
Internal set-point temperature in summer	26	26	26	26	26	26	26	26	26	26	26	28	°C
Area per person (occupancy)	60	40	20	10	30	5	10	20	5	20	100	20	m^2/person
Average heat flow per person	70	70	80	70	80	100	90	100	80	100	100	60	W/person
Metabolic gain per conditioned floor area	1,2	1,8	4,0	7,0	2,7	20,0	9,0	5,0	16,0	5,0	1,0	3,0	W/m^2
Presence time per day (monthly average)	12	12	6	4	16	3	4	6	3	6	6	4	h
Annual electricity use per conditioned floor area[a]	20	30	20	10	30	30	30	10	20	20	6	60	kWh/m^2
Part of electricity use within conditioned part of building	0,7	0,7	0,9	0,9	0,7	0,7	0,8	0,9	0,8	0,9	0,9	0,7	—
Airflow rate with external air per conditioned floor area[a]	0,7	0,7	0,7	0,7	1,0	1,2	0,7	0,7	1,0	0,7	0,3	0,7	$m^3/(h \cdot m^2)$
Airflow rate with external air per person	42	28	14	7	30	6	7	14	5	14	30	14	$m^3/(h \cdot person)$
Heating need for hot water per conditioned floor area [a]	10	20	10	10	30	60	10	80	10	10	1,4	80	kWh/m^2

[a] These figures refer to the gross conditioned area, calculated with external building dimensions. This area includes all conditioned space contained within the thermal insulation layer. For example, an internal unheated (but indirectly heated) staircase is included, but a cellar is not.

Annex A
(normative)

Parallel routes in normative references

This International Standard contains specific parallel routes in referencing to other International Standards in order to take into account existing national and/or regional regulations and/or legal environments while maintaining global relevance.

The International Standards that shall be used, as called for in the succeeding clauses, are given in Table A.1.

NOTE 1 This annex intends to take into account that the "CEN area" requires links to specific CEN standards where ISO standards may be different or (at the moment) absent.

NOTE 2 An example of a similar annex can be found in ISO 13790:2008, (Annex A).

Table A.1 — Normative references

Clause (in this International Standard)	Subject	CEN area[a]	Elsewhere
1	Heating, cooling and ventilation systems	Heating: EN 15316 (all parts) Ventilation: EN 15241 Cooling: EN 15243	National standards or other appropriate documents
...	...	...	...
7.1, 7.2, 7.3, 7.4 Annex C	Energy balance, system losses, and auxiliary energy use: — Heating system — Cooling system or combined heating and cooling system, including dehumidification — Ventilation system, including humidification — Energy use for ventilation air transport — Energy use for central pre-heating and/or pre-cooling	If applicable: EN 15316 (all parts) EN 15243 EN 15241 Otherwise: national standards If applicable: EN 15241 Otherwise: national standards EN 15316 (all parts) EN 15243	ISO <in preparation> ISO <in preparation> ISO <in preparation> ISO <in preparation> National standards or other appropriate documents

[a] CEN area = Countries whose national standards body is a member of CEN. Attention is drawn to the need for observance of EU Directives transposed into national legal requirements. Existing national regulations with or without reference to national standards, may restrict for the time being the implementation of European Standards

Annex B
(informative)

Methods for collecting building data

B.1 Data on building envelope

B.1.1 General

Information on the building envelope, such as dimensions, thermal transmittance or structure, areas of envelope components, characteristics of thermal bridges, and solar energy transmittance of glazed envelope components, is collected from drawings, local surveys, and measurements and calculated or measured according to appropriate standards or inference rules based on typology.

The preference shall be given to appropriate standards. Most of these are referred to in the text below.

B.1.2 Assessment of thermal transmittance of opaque building elements

If the structure of the element is known (e.g. from drawings or inference rules), the thermal transmittance is calculated according to ISO 6946.

The structure of the element can be assessed by boring a small hole in it and inspecting it using an endoscope. Materials of each layer are identified and their thicknesses are assessed. The thermal transmittance is calculated according to ISO 6946.

If the building is covered by a building typology, e.g. prepared on a national or regional level, the thermal transmittance of envelope components can be taken from a building typology prepared at national level.

Thermal transmittances of building elements can also be measured according to ISO 9869.

For a new building, ISO 8990 (HotBox) can be considered.

B.1.3 Assessment of thermal transmittance and total solar energy transmittance of transparent elements

The dimensions of all components of the transparent element are measured or estimated and the material of the frame and the type of glazing are identified. These include not only windows but also any transparent or translucent elements such as skylights, glass block, transparent insulation.

The type of glazing (simple, double, or triple glazing, tinted or not, with or without one or more infrared radiation reflecting coatings) can be used to estimate its thermal transmittance and total solar energy transmittance, either from manufacturers' data or from tables provided at national level.

The presence and location of an infrared reflecting coating on transparent glazing can be detected by directing a small white light source onto the glazing and looking at its reflections on all glass surfaces. The colour of the image reflected by the coated surface differs slightly from the others. If all reflections have the same colour, there is no coating.

The thermal transmittance of the glazing can be measured according to ISO 9869.

The thermal transmittance of the transparent element can also be calculated according to EN 673 or ISO 10292. The thermal transmittance of complete windows is calculated according to ISO 10077-1 or ISO 10077-2. ISO 12567-1, ISO 12567-2, and EN 12412-2 can also be used for the determination of the thermal transmittance of windows and frames by measurement in a hot box.

The total solar energy transmittance of glazing can be calculated according to EN 410 or ISO 9050.

The transmission coefficient of solar radiation can be measured on site simultaneously using two radiation pyrometers installed parallel to the window plane, one externally and one internally, so that the external pyrometer does not shade the internal one. This characteristic does not include the radiation absorbed by the glazing and transferred indoors as heat, but may be useful for atypical glazing, such as tinted or reflecting ones, when the manufacturers' data are not known.

B.1.4 Assessment of thermal characteristics of thermal bridges

Important thermal bridges (thermal bridges with high *Ψ*-value or with large length) shall be identified as they may significantly affect the thermal performance of the building. Thermal bridges are found by looking at building drawings, using building typologies provided at national level, or by infrared thermography according to EN 13187. Mould growth on internal surfaces may also indicate the location of thermal bridges.

The thermal transmittance of linear and point thermal bridges are then assessed either by calculation according ISO 10211 using an appropriate computer program, or found in a thermal bridge catalogue provided at national level or tables of default values such as ISO 14683.

NOTE In most cases, geometric thermal bridges, such as corners, can be neglected if external dimensions are used. On the other hand, conductive materials interrupting the thermal insulation layer (decks, balconies) cannot be neglected, especially when the thermal insulation layer is thicker than a few centimetres.

B.1.5 Assessment of airflow rates and infiltration

Airflow rates are determined according to EN 15241 or EN 15242 or relevant International Standards listed in Annex A. Infiltration through the building envelope can be measured according to EN 13829 or relevant International Standards listed in Annex A.

See also B.4.1.

B.2 Thermal capacity

For the calculation of annual energy use for heating or cooling according to ISO 13790, a rough estimate of the thermal capacity of the building is sufficient.

Estimate the internal mass of the building, e.g. the mass of materials that are inside the thermal insulation layer, and multiply this mass by 1 000 J/(kg·K), which is a rough estimate of the heat capacity of most mineral building materials. For massive wood or wood frame structures, multiply by 1 700 J/(kg·K).

This thermal capacity can also be given at national level, based on building typology. Table B.1 may be used where no other information is available.

Table B.1 — Thermal capacity per conditioned floor area for some typical constructions

Building typology	*C* [kJ/(m^2·K)]
all walls, floor and ceiling of stone or concrete, no wall coverings, wooden floor, carpets, or false ceiling, relatively small rooms of about 20 m^2	500
the same for very large rooms	250
rooms of about 20 m^2, concrete floor and ceiling, hollow brick walls	400
the same, with carpet on floor	350
the same, with carpet on floor and false ceiling	250
rooms of about 20 m^2 with carpeted floor, false ceiling, and plasterboard walls	150
thick, massive wood	200
frame wood construction	100
NOTE The thermal capacity, C, is normalised to conditioned floor area of the room calculated with external dimensions	

B.3 Heating systems

If sufficient detailed information on the heating system is available, the calculation of the heating system is undertaken according to EN 15316 series or relevant International Standards listed in Annex A. For other cases, the efficiency or coefficient of performance of systems representing the ratio of energy need to energy use and typical amounts of auxiliary energy used by systems can be given at national level based on heating system typology.

NOTE Examples of such national tables are given in Annex P of EN 15378:2007.

B.4 Ventilation systems

B.4.1 Assessment of airflow rates

Actual airflow rates in ventilation systems often differ from design values. They can be checked using one or more of the following methods.

a) Perform a velocity traverse using a suitable anemometer through a section of a straight duct.

b) Measure the pressure differentials across new filters and determine the airflow rate from filter characteristics.

c) Measure the pressure differential across the fan and the speed or power use of fans and determine the airflow rate from the fan characteristics.

d) Use tracer gas dilution techniques.

e) Measure the pressure drop in the inlet nozzle. This is a good way to assess the airflow rate through this nozzle, provided the characteristics of the nozzle are available.

B.4.2 Thermal efficiency of heat recovery systems

Actual global efficiency of such systems on site is smaller than the thermal effectiveness of the heat exchanger alone when measured in the factory. It could be assessed by measuring actual airflow rates in both channels, as well as upwind and downwind temperatures and humidity.

B.4.3 Assessment of auxiliary energy use

If sufficient detailed information on the ventilation system is available, the assessment of auxiliary energy use is undertaken according to EN 15241 or relevant International Standards listed in Annex A. For other cases, typical amounts of auxiliary energy used by systems can be given at national level based on ventilation system typology.

B.5 Cooling systems

If sufficient detailed information on the cooling system is available, the calculation of the cooling system is undertaken according to EN 15243 or relevant International Standards listed in Annex A. For other cases, the efficiency or coefficient of performance of systems representing the ratio of net energy to delivered energy and typical amounts of auxiliary energy used by systems can be given at national level based on cooling system typology.

B.6 Building operation

The actual operation of the building is assessed using the list of functions defined in EN 15232 or relevant International Standards listed in Annex A.

B.7 Bibliography for this annex

[1] EN 410, *Glass in building — Determination of luminous and solar characteristics of glazing*

[2] EN 673, *Glass in building — Determination of thermal transmittance (U value) — Calculation method*

[3] EN 12412-2, *Thermal performance of windows, doors and shutters — Determination of thermal transmittance by hot box method — Part 2: Frames*

[4] EN 13187, *Thermal performance of buildings — Qualitative detection of thermal irregularities in building envelopes - Infrared method*

[5] EN 15242, *Ventilation for buildings — Calculation methods for the determination of air flow rates in buildings including infiltration*

[6] ISO 6946, *Building components and building elements — Thermal resistance and thermal transmittance — Calculation method* (ISO 6946:2007)

[7] ISO 9869, *Thermal insulation — Building elements — In situ measurement of thermal resistance and thermal transmittance*

[8] ISO 10077-1, *Thermal performance of windows, doors and shutters — Calculation of thermal transmittance — Part 1: General* (ISO 10077-1:2006)

[9] ISO 10077-2, *Thermal performance of windows, doors and shutters — Calculation of thermal transmittance — Part 2: Numerical method for frames* (ISO 10077-2:2012)

[10] ISO 10211:2007 *Thermal bridges in building construction — Heat flows and surface temperatures - Detailed calculations* (ISO/DIS 10211:2005)

[11] ISO 12567 (all parts), *Thermal performance of windows and doors — Determination of thermal transmittance by hot box method*

[12] ISO 13600, *Technical energy systems — Basic concepts*

Annex C
(informative)

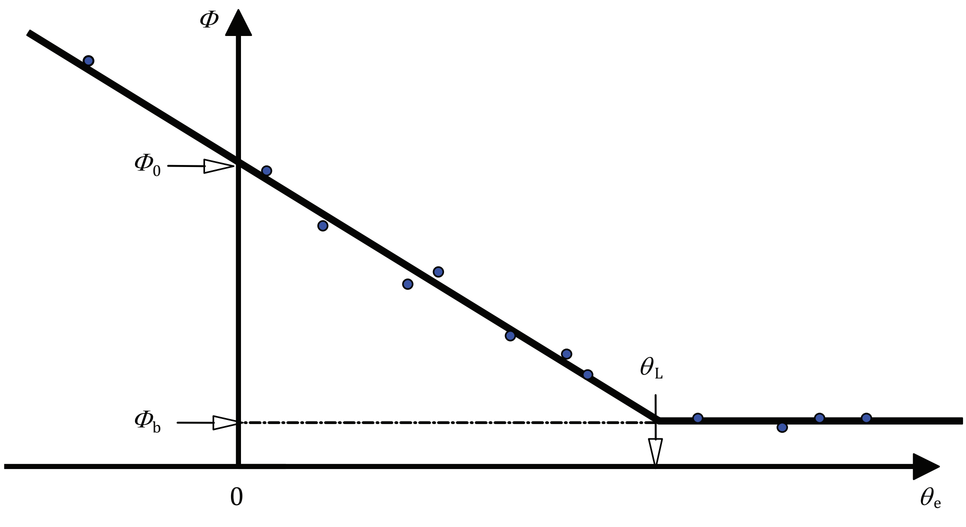
Energy monitoring

C.1 Energy signature

Heating and cooling energy use is correlated to climatic data over a suitable period. Plotting for several time periods the average heating or cooling power versus average external temperature allows a fast detection of malfunctions and provides useful information on the building energy performance. This monitoring method assumes constant internal temperature and that external temperature is the most influential parameter. It is useful in buildings with stable internal gains and relatively low passive solar gains.

Energy use for heating and cooling, as well as an average external temperature or accumulated temperature difference, is recorded at regular intervals. These intervals can be as short as 1 h, but for manual monitoring, a week is often used. The average external temperature can also be obtained from a neighbouring meteorological station. Average power is obtained by dividing the energy use by the duration of the time interval between successive records.

The average power is plotted versus the average external temperature or degree-days. For the heating season, a diagram as shown in Figure C.1 is obtained. Lines are drawn through the dots measured during the heating season (heating on, cooling off), the cooling season (cooling on, heating off), and intermediate season (both off) using a linear regression (see Figure C.1).



Key

Φ average power between two successive records

Φ_0 power at 0 °C

Φ_b base power, not dependant on external temperature (e.g. for system loss and hot water)

θ_L heating limit external temperature

θ_e external average temperature between two successive records

Figure C.1 — Energy signature, principle

The line drawn outside the heating (or cooling) season has, in general, a nearly-zero slope and represents the system loss and energy for services other than heating and cooling (e.g. hot water).

The line drawn during the heating (or cooling) season is characterized by a power Φ_0 at 0 °C and a slope H.

$$\Phi = \Phi_0 - H\theta_e \tag{C.1}$$

where

Φ is the average power;

θ_e is the average external temperature;

$$H = \frac{\Phi_0 - \Phi_b}{\theta_L}$$

The slope H reflects the sensitivity of the building to changes in external temperature. Formula C.1 can be compared to the global, simplified average energy balance of the building:

$$\Phi = H'\left(\bar{\theta}_i - \theta_e\right) + \Phi_a - \eta(A_e I_s) \tag{C.2}$$

where

H' is the heat transfer coefficient of the building;

$\bar{\theta}_i$ is the average internal temperature;

Φ_a includes system loss and average power for services other than heating. As a first approximation, this power does not depend on external temperature and, if the pattern of use of the building is constant, this power can be assumed to be the average power measured during the intermediate season;

ηA_e is the equivalent solar collecting area multiplied by the utilization factor;

I_S is the solar irradiance.

Comparing Formulae (C.1) and (C.2), $H' = H$, and

$$\Phi_0 = H\bar{\theta}_i + \Phi_a - \eta(A_e I_s) \tag{C.3}$$

Seasonal energy use for heating can be estimated from Φ_0 and H, the seasonal average of the external temperature, $\bar{\theta}_e$, and the duration, t, of the heating season:

$$Q_h = \left(\Phi_0 - H\bar{\theta}_e\right)t \tag{C.4}$$

This estimate can be obtained for a period less than the whole heating season. However, a large range of external temperatures is necessary to obtain a good accuracy for H and Φ_0.

An estimate of the confidence interval of the energy use for heating is calculated by:

$$\delta Q_h = \sqrt{t^2 \delta \Phi_0^2 + \theta_e^2 t^2 \delta H^2 + t^2 H^2 \delta \theta_e^2 + \left(\Phi_0 - H\theta_e\right)^2 \delta t^2} \tag{C.5}$$

The dispersion of the individual measurements above or below the line characterizing the signature can result from several causes, including the following:

a) variable solar or internal gains (which makes this method not suitable for buildings with large passive solar gains);

b) varying heat transfer coefficients, e.g. resulting from the effect of wind on a permeable building envelope or malfunctioning of the heating or cooling system.

The analysis of possible explanations to significant differences between a particular record and the line allows detection of system malfunctions.

C.2 *H-m* method

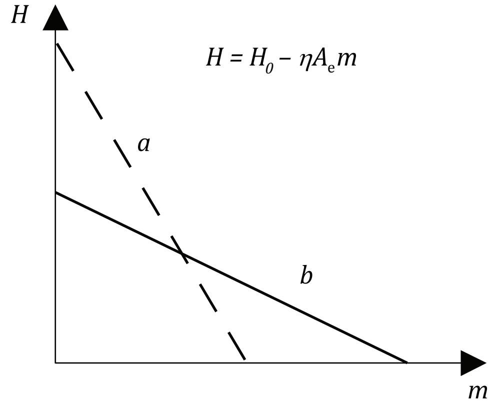
In passive solar buildings, the dispersion of the points around the line becomes important and the method described in C.1 does not apply well. Dividing the global heat balance by $\Delta\theta = (\bar{\theta}_i - \bar{\theta}_e)$ results in an expression for an apparent heat loss coefficient of the building:

$$H = \frac{\Phi - \Phi_a}{\Delta\theta} = H_0 - \eta A_e \frac{I_S}{\Delta\theta} = H_0 - \eta A_e m \tag{C.6}$$

where

m is a “meteorological” variable.

The slope of the regression line is the equivalent solar collecting area multiplied by the utilization factor, and the ordinate at origin is the effective heat loss coefficient.



Key

H apparent heat loss coefficient of the building

m meteorological variable, which is the ratio of the solar irradiance to the internal-external temperature difference

a highly glazed building with large losses and large gains, better performing in mild climates

b well-insulated building with relatively small passive solar gains, better in Nordic climates

Figure C.2 — Principle of the H-m method

Annex D
(informative)

Other uses of energy

D.1 General

In order to compare the calculated rating with the measured energy rating for the purposes of validation, the amounts of energy carriers used for purposes other than heating, cooling, ventilation, hot water, or lighting are added to the tailored rating. If these are not metered separately, they are estimated.

Figures for this estimation are best provided at the national level. When no other information is available, the information given in this annex can be used. Since these values strongly depend on the behaviour of the occupants, the confidence intervals of these values are rather large (± 50 %).

D.2 Residential buildings

Table D.1 — Annual use of electricity in dwellings with energy efficient equipment [kWh]

Number of rooms	**1**	**2**	**3**	**4**	**5**	**6**
Number of occupants	**1**	**1,5**	**2**	**3**	**4**	**5**
Refrigerator	250[a]	250[a]	270[a]	270[a]	170[b]	170[b]
Freezer	0	0	0	0	200	200
Dishwasher	110	150	210	260	320	330
Oven	30	40	80	80	80	80
Washing machine	70	100	130	200	270	330
Dryer	130	200	260	390	525	660
Cooker	220	240	260	300	340	380
Other equipment	130	150	180	220	270	290
Total in kWh	**690**	**880**	**1120**	**1450**	**2005**	**2270**
Floor area	40	60	80	110	140	170
Rounded total in kWh/m^2	24	19	17	16	16	14

[a] With freezer.

[b] Without freezer.

D.3 Office buildings

When no other information is available, the following equipment can be assumed to be in office buildings:

a) PC with flat screen and 1 telephone per workplace;

b) 1 printer per 10 workplaces;

c) 1 telefax, 1 photocopier, 1 scanner, and 1 coffee machine per office.

Table D.2 was calculated with this equipment.

Table D.2 — Annual use of electricity for office equipment per workplace in kWh and per conditioned area in kWh/m²

	Per workplace	Per m² conditioned area		
Floor area per person		10 m²	15 m²	20 m²
With energy efficient equipment	120	12	8	6
With typical equipment	230	23	15	12

NOTE The conditioned area includes all conditioned space contained within the thermal insulation layer. In Table D.2, it is calculated with external building dimensions.

Annex E
(informative)

Calorific values of fuels

E.1 General

The thermal energy use during a specific time period is calculated by multiplying the consumed amount of energy carrier, E, by the gross calorific value, H.

$$Q_i = E_i H_i \tag{E.1}$$

The calorific value is the quantity of heat produced by complete combustion, at a constant pressure equal to 101 320 Pa, of a unit amount of fuel. The gross calorific value includes the heat recovered when condensing the water vapour resulting from the combustion of hydrogen. The net calorific value does not take account of this latent heat.

In order to obtain Q_i in appropriate units (kWh or J), the units of H_i must be consistent with the units in which E_i is expressed.

The calorific values depend on the precise composition of the fuel, most fuels being mixes of pure chemicals. Indicative values are given in this annex.

E.2 Solid and liquid energy carriers

For solid and liquid energy carriers, the calorific values (in MJ/kg or kWh/kg) can be calculated using Formula (E.2) (Reference [10]). The input is given as the mass of the energy carrier.

The gross calorific value is given by

$$H = 34{,}8\, c + 93{,}8\, h + 10{,}46\, s + 6{,}28\, n - 10{,}8\, o \tag{E.2}$$

where

- c is the carbon content, in kg/kg;
- h is the hydrogen content, in kg/kg;
- s is the sulphur content, in kg/kg;
- n is the nitrogen content, in kg/kg;
- o is the oxygen content, in kg/kg.

The net calorific value is given by

$$H_{net} = H - 2{,}5\, w \tag{E.3}$$

where

- w is the water content of the combustion products, in kg/kg. $w = 18\, h$.

w = 18 h is the energy that can be recovered by condensing the water vapour resulting from the combustion of hydrogen.

Table E.1 — Gross calorific value of some common solid fuels

Fuel	Gross calorific value MJ/kg
Anthracite	32 to 35
Bituminous coal	17 to 25
Charcoal	29,6
Coke	28 to 31
Lignite	15 to 30
Peat	13 to 20
Wood (dry)	14 to 17

Table E.2 — Gross calorific value of some common liquid fuels

Fuel		Density kg/l	Gross calorific value MJ/kg
Oil	Heating oil, light	0,84 to 0,85	45,4
	Heating oil, heavy	0,96	50,2 to 42,3
Liquid gas	80 propane:20 butane	0,52	49,8
	70 propane:30 butane	0,53	49,8
	60 propane:40 butane	0,53	49,7
	50 propane:50 butane	0,55	49,6
	Commercial propane	0,51	50,0

The confidence interval for liquid gas is about ± 0,1 MJ/kg.

E.3 Gaseous fuels

See ISO 6976.

If the gaseous energy carrier amount is given in cubic metres at 0 °C and 101,3 kPa, the following factors can be used. The confidence interval for the pure gases is less than 0,1 MJ/m^3.

Table E.3 — Gross calorific values of some gaseous energy carriers

Fuel	Density	Gross calorific value
	kg/m^3	MJ/m^3
Natural gas L	0,64	35,2
Natural gas H	0,61	41,3
Methane	0,55	39,9
Propane	1,56	100,9
Butane	2,09	133,9
Biogas	1,2	4 to 8[a]

[a] Depending on its methane content.

The actual calorific value of common gaseous fuels depends on their chemical composition. If this is known, the figure can be more accurate that those given in Table E.3.

Annex F
(informative)

Confidence intervals

F.1 Definition

Only conventional input data are certain or exact, by definition. The actual value of any other data are not known, but an interval that has a high probability (e.g. 95 % or 99 %) to contain the actual value can be defined. This is the confidence interval.

F.2 Assessment of confidence interval

The confidence interval of a given data can be assessed in several ways.

a) Using the dispersion of several measurements of the same data when the distribution is Gaussian, the confidence interval of the mean value at probability P when N measurements are performed is

$$\delta x = \frac{s(x)}{\sqrt{N}} T(P, N-1) \tag{F.1}$$

where

s_x is the estimate of the standard deviation of the measurements x:

$$s_x = \sqrt{\frac{\sum_i \left(x_i - \bar{x}\right)^2}{(N-1)}} = \sqrt{\frac{\sum_i \left(x_i^2\right) - N\bar{x}^2}{(N-1)}} \tag{F.2}$$

where

$\bar{x}$ is the estimate of the mean;

$T(P, N)$ is the Student coefficient for having the actual value within the confidence interval with probability;

P, is the number of degrees of freedom being N.

The values of the two-sided Student distribution are given in Table F.1.

Table F.1 — Two-sided confidence limits *T*(*P*, *N* - 1) for a Student distribution

	T(P, N - 1) for probability P =					
N-1	0,8	0,9	0,95	0,99	0,995	0,999
2	3,078	6,313 8	12,706	63,657	127,32	636,619
3	1,886	2,920 0	4,304,3=7	9,927 8	14,089	31,598
4	1,638	2,353 4	3,182 5	5,840 9	7,453 3	12,924
5	1,533	2,131 8	2,776 4	4,604 1	5,597 6	8,610
6	1,476	2,015 0	2,570 6	4,032 1	4,773 3	6,869
7	1,440	1,943 2	2,446 9	3,707 4	4,316 8	5,959
8	1,415	1,894 6	2,364 6	3,499 5	4,029 3	5,408
9	1,397	1,859 5	2,306 0	3,355 4	3,832 5	5,041
10	1,383	1,833 1	2,262 2	3,249 8	3,689 7	4,781
20	1,328	1,729 1	2,093 0	2,860 9	3,173 7	3,883 7
∞	1,285 8	1,652 5	1,971 9	2,600 6	2,838 6	3,340 0

b) By assessing it from experience, common knowledge, accuracy of the used measuring instruments, etc.

c) By combining the confidence intervals of the variables x_i used to calculate the data of interest, *y*. Assuming that the measurements are affected by random and independent errors, the confidence interval of any result, *y*, is:

$$\left[y-\delta y; y+\delta y\right] \text{ with } \delta y=\sqrt{\sum_i \left(\frac{\partial y}{\partial x_i}\right)^2 \left(\delta x_i\right)^2} \quad \text{(F.3)}$$

where

x_i is for all variables on which *y* depends;

δx_i is for the confidence interval of the variable x_i.

The confidence interval of a calculated result can also be obtained using the Monte-Carlo method. For this, run the calculation model used for calculations many times, changing at each run all the variables at random, according to statistical distributions of each variable. Sort the results in classes in order to get its distribution. After 100 to 1 000 runs (depending on the complexity and sensitivity of the calculation model), a good estimate of the statistical distribution of the results is obtained (Figure F.1).

F.3 Examples

F.3.1 General

In a building, measured annual energy uses for successive years are 251 GJ, 267 GJ, 245 GJ, and 274 GJ. Since these are corrected for climatic data, the remaining variations from year to year are assumed to result from random-like causes. The average energy use is then 259 GJ with a standard deviation of 14 GJ. Since there are four measured data, the 95 % confidence interval of the mean is 14*T(0,95, 4-2)/2 = 14*4,3/2 = 30. A good estimate of the annual energy use is then 259 GJ ± 30 GJ.

If a scale graduated in millimetre is used to make measurements of length, then a confidence interval of about 1 mm should be given to each measurement of length.

Applying Formula (F.3) for two simple examples,

$$\text{if } y=\sum_i \left(a_i x_i\right) \text{, where } a_i \text{ are coefficients, then } \delta y=\sqrt{\sum_i \left(a_i^2 \delta x_i^2 + x_i^2 \delta a_i^2\right)} \quad \text{(F.4)}$$

$$\text{or if } y = ax \text{ then } \frac{\partial y}{y} = \sqrt{\left(\frac{\delta a}{a}\right)^2 + \left(\frac{\delta x}{x}\right)^2} \tag{F.5}$$

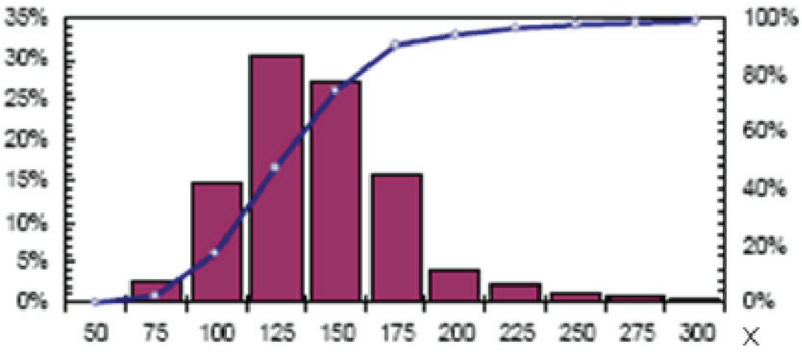
F.3.2 Indications on confidence intervals

Table F.2 gives indications on the typical absolute or relative standard deviations of several variables used in building calculation models and on the nearest type of statistical distribution.

The relative standard deviation is the ratio of the standard deviation to the mean value. It is given in percent.

Table F.2 — Standard deviations and distribution type approximately sorted by order of importance for residential buildings

Variable	Standard deviation		Distribution
	Calculated energy rating	Tailored rating	
Airflow rate from infiltration	0 %	50 %	log normal
Airflow rate from ventilation system	0 %	10 %	log normal
Area	2 %	2 %	log normal
Thermal transmittance (*U*-value)	10 %	10 %	log normal
System efficiency	5 %	5 %	log normal for *x* and 1-*x*
Internal temperature	0	1 K	normal distribution
Utilization time	0 %	25 %	log normal
Volume	3 %	3 %	log normal
Depth, height	1 %	1 %	log normal
Electricity use (recovered as internal heat gains)	0 %	10 %	log normal
Frame factor (fraction of frame area in a window)	5 %	5 %	log normal for *x* and 1-*x*
Length	1 %	1 %	log normal
Linear thermal transmittance (Ψ)	10 %	10 %	log normal
Number of occupants	0 %	10 %	log normal
Shaded fraction, shading factor	5 %	5 %	log normal for *x* and 1-*x*
Thickness	5 %	5 %	log normal
Absorption coefficient	5 %	5 %	log normal for *x* and 1-*x*
Emissivity	5 %	5 %	log normal for *x* and 1-*x*
Heating power increase per degree of external temperature decrease	20 %	20 %	log normal
Orientation (of collecting area for solar radiation)	5 °	5 °	normal distribution
Perimeter	2 %	2 %	log normal
Slope (of collecting area for solar radiation)	5°	5°	normal distribution
Thermal capacity	25 %	25 %	log normal



Key

X rating M·Vm2

NOTE 1 The energy use was calculated with ISO 13790 using the Monte-Carlo method and standard deviations of Table F.2, for a tailored rating.

NOTE 2 The line is the normalized cumulative distribution.

Figure F.1 — Example of the distribution of heating energy use of a low-energy single family house

Annex G
(informative)

Example

G.1 Building description

G.1.1 General

This example addresses a public building 38 378 m^2 office space. This building is well insulated with a large glazed area facing south. A gas-powered cogeneration plant produces heat and electricity. An absorption chiller, heated by the cogeneration plant, extracts heat in summer. District heating from waste treatment plant is used for very cold periods.

The purposes of the ratings are for certification and to have a base for energy retrofit.

In the following ratings, primary resource energy factors are used for the rating. Annual energy amounts are all given in MWh.

G.1.2 Standard calculated rating

G.1.2.1 Information coming from other standards

G.1.2.1.1 Building energy needs

Sources: ISO 13790, EN 15316-3-1, EN 15241, EN 15243.

Table G.1 — Building energy needs

		C1	C2	C3	C3	C4
		Heating		Cooling		Domestic hot water
		sensible heat	latent heat (humidification)	sensible heat	latent heat (dehumidification)	
L1	Building gains and losses	—	—	—	—	—
L2	Building thermal transfers	—	—	—	—	—
L3	Building thermal needs	5 346 ± 500	—	2 512 ± 300	—	220 ± 20

G.1.2.1.2 System thermal losses and auxiliary energy without generation

Sources: EN 15316-1, EN 15316-3-2, EN 15241, EN 15243, EN 15193.

Table G.2 — System thermal losses and auxiliary energy without generation

		C1	C2	C3	C4	C5
		Heating	**Cooling**	**Domestic hot water**	**Ventilation**	**Lighting**
	From Table G.1 (optional)	5 346 ± 500	2 512 ± 300	220 ± 20	—	—
L4	Electrical energy	37 ± 4	11 ± 1	11 ± 1	140 ± 10	1 680 ± 100
L5	System thermal losses	54 ± 5	51 ± 7	68 ± 7	70 ± 5	1 500 ± 100
L6	Recoverable system thermal losses	40 ± 4	0±0	10 ± 1	30 ± 3	500 ± 50
L7	Thermal input distribution	5 400 ± 500	2 563 ± 288	288 ± 30		

G.1.2.1.3 Energy generation systems

Sources: EN 15316 series, EN 15316-3-2, EN 15243.

Table G.3 — Energy generation systems

		C1	C2	C3	C4
	Type of generator	Cogenerator	District heat.	Absorb. chiller	Compressor
	Distribution systems supplied[a]	H + W	H	C	C
L8	Thermal output (distribution) (generation)	4 708 ± 410 4 219 ± 410	980 ± 10	1 932 ± 300	631 ± 30
L9	Auxiliary energy	179 ± 20	20 ± 2	39 ± 4	27 ± 1
L10	System (generator) thermal losses	3 245 ± 300	20 ± 2	2 287 ± 200	76 ± 15
L11	Recoverable system thermal losses	0	0	0	0
L12	Energy input	17 855 ± 1 700	1 000 ± 10	4 219 ± 500[c]	225 ± 20
L13	Electricity production	5 683 ± 600			
L14	Energy carrier[b]	Gas	District heat	Heat from cogenerator	Electricity from the grid

[a] Name of the supplied system (heating, cooling, hot water, etc.).

[b] Name of the energy carrier used by the generator (oil, gas, solar heat, etc.).

[c] For renewable energy produced at the building site or energy coming from other generators situated inside the system boundary, there is no energy input taken into account.

G.1.2.2 Verification of the energy balances

G.1.2.2.1 Thermal input to distribution system — Thermal output of the building thermal generation systems

The thermal energy input to the distribution systems shall be supplied by the thermal energy output from the building thermal generation systems or energy supplied from outside the building.

The thermal energy input of the distribution systems is

$$Q_{\text{HW,dis,in}} = 5\,400 + 288 = 5\,688;\ Q_{\text{C,dis,in}} = 2\,563;\ \boldsymbol{Q_{\text{dis,in}} = 8\,251} \tag{G.1}$$

The thermal energy output to the building generation systems or energy supplied from outside the building to the distribution systems is

$$Q_{\text{HW,gen,out}} = 4\,708 + 980 = 5\,688;\ Q_{\text{C,gen,out}} = 1\,932 + 631 = 2\,563;\ \boldsymbol{Q_{\text{gen,out}} = 8\,251} \tag{G.2}$$

The total energy output from the building generation system is 10 538 MWh because 4 219 MWh is provided from the cogenerator to the absorption chiller. The thermal output of the absorption chiller is not counted twice.

G.1.2.2.2 Input to building generation system — Energy carriers and renewables energies produced on site

The input to the building generation system (sum of thermal and electrical output from the energy generation systems, the generator thermal losses) is supplied by the energy input of the different energy carriers and the renewables energies produced at the building site.

$$Q_{\text{gen,int}} = 10\,538 + 5\,683 + 3\,341 = \mathbf{19\,562} \tag{G.3}$$

The difference between the thermal output plus the thermal losses of the compressor and the energy input is 482.

This energy is taken from the ground and counted as renewable energy produced at the building site.

$$Q_{\text{del}} = 19\,080 + 482 = \mathbf{19\,562} \tag{G.4}$$

G.1.2.2.3 Division between the energy used in the building and the exported energy

According to the system design, the building's on-site production is dispatched between the energy used in the building and the exported energy. In this example, only the surplus of electricity of the cogenerator is exported.

The electricity used in the building is the sum of the auxiliary energy with and without generation devices and the energy used for ventilation and lighting.

The cogenerator is producing, during the year more, electrical energy than the annual electrical use. According to the system design, only the electricity for the compressor is imported from the grid. The difference is exported.

$$E_{\text{el}} = 1\,879 + 265 + 225 = 2\,369 \tag{G.5}$$

$$E_{\text{el,del}} = 225 \tag{G.6}$$

$$E_{\text{el,exp}} = 5\,683 + 225 - 2\,369 = \mathbf{3\,539} \tag{G.7}$$

G.1.2.3 Calculation of the technical building system performances

The thermal technical building system performances to enter in Table 8 are calculated as follows:

$$Q_{HW,ls,nrvd} = Q_{\text{H,ngen,ls}} + \sum_i Q_{\text{H,gen,ls},i} + Q_{\text{W,ngen,ls}} + \sum_i Q_{\text{W,gen,ls},i} - Q_{\text{HW,ls,rvd}} \tag{G.8}$$

$$Q_{C,ls,nrvd} = Q_{\mathrm{C,ngen,ls}} + \sum_i Q_{\mathrm{C,gen,ls},i} - Q_{\mathrm{C,ls,rvd}} \quad \text{(G.9)}$$

$$W_{HW} = W_{\mathrm{H,ngen}} + \sum_i W_{\mathrm{H,gen},i} + W_{\mathrm{W,ngen,}} + \sum_i W_{\mathrm{W,gen},i} \quad \text{(G.10)}$$

$$W_C = W_{\mathrm{C,ngen,}} + \sum_i W_{\mathrm{C,gen},i} \quad \text{(G.11)}$$

The thermal losses and the auxiliary energy of the cogenerator are dispatched between heating and cooling according to the thermal outputs.

$Q_{\mathrm{C,gen,out,1}}$ = 4 219; $Q_{\mathrm{H,gen,out,1}} = 4\,708$

$Q_{C,gen,ls,1} = 3\,245 \dfrac{4\,219}{8\,927}$ = 1 533; $Q_{\mathrm{H,gen,ls,1}} = 1\,712$

$W_{C,gen,1} = 179 \dfrac{4\ 219}{8\ 927}$ = 85; $Q_{\mathrm{H,gen,ls,1}}$ = 94

$Q_{\mathrm{HW,ls,nrvd}}$ = 54 + (1 712 + 20) + 68 $= 1\,854$

$Q_{\mathrm{C,ls,nrvd}}$ = 51 + (1 533 + 76 + 2 287) $= 3\,947$

The thermal losses of the absorption chiller are added again.

W_{HW} = 37 + (94 + 20) + 11 = 162

W_{C} = 11 + (85 + 39 + 27) = 162

G.1.2.4 Calculation of the recovered gains and losses

The calculation of the recovered gains and losses is done with the simplified approach.

NOTE The energy uses for ventilation and lighting have been taken into account before the calculation of the thermal technical building systems. In this example, they are integrated in the building energy needs because the building energy needs are not used for building code requirements but only as a calculation intermediate result. If ventilation and lighting are not integrated in the building needs, the recovered thermal losses have to be subtracted before the calculation of the thermal technical building systems. If the holistic approach had been chosen, the recovered heat sources should be allocated to the appropriate building services in order to determine the impact of each on the building performance.

The recovered thermal losses are determined by multiplying the system thermal losses by a conventional recovery factor.

In this example, no system thermal losses for cooling are recoverable.

As the building generation devices are located outside the heated space, no system thermal losses are recoverable from the building generation devices for heating.

The recoverable system thermal losses of the technical building systems without building generation devices are

$$Q_{\mathrm{HW,sys,ls,rvd}} = Q_{\mathrm{HW,sys,ls,rbl}}\, f \quad \text{(G.19)}$$

$$Q_{Tot,sys,ls,rvd} = (40 + 10)\ 0{,}5 \ = 25 \tag{G.20}$$

The recovered system thermal losses are dispatched among the different generators.

$$Q_{gen,ls,rvd,i} = Q_{Tot,sys,ls,rvd} \frac{Q_{gen,out,i}}{\sum_{i} Q_{gen,out,i}} \tag{G.21}$$

$$Q_{gen,ls,rvd,1} = 25 \frac{4\ 708}{4\ 708 + 980} \ = 21 \tag{G.22}$$

$$Q_{gen,ls,rvd,2} = 25 - 21 = 4 \tag{G.23}$$

G.1.2.5 Weighted energy rating

Table G.4 — Calculation of ratings (example: primary energy rating)

Row		**C1**	**C2**	**C3**	**C4**
		Delivered energy			
		Gas	Electricity	District heating	Total
L1	Energy delivered (un-weighted)	17 831	225	996	
L2	Weighting factor or coefficient	1,5	3	0,5	
L3	Weighted delivered energy or CO_2	26 746	675	498	27 919
		Exported energy			
		Thermal	Electrical		
L4	Energy exported (un-weighted)	—	3 539		
L5	Weighting factor	—	3		
L6	Weighted exported energy or CO_2	—	10 617		10 617
L7	**Rating**				**17 302**

G.1.2.6 Test report

This clause defines the content of a report on the assessment of the energy use of a building according to this International Standard. The content of a certificate is defined in ISO 16343.

The report shall include the following information:

— a reference to this International Standard (i.e. ISO 16346:2013);

— the purpose of the energy rating;

— a description of the building and its location, its activities, equipment, and occupancy;

— the type of rating.

For buildings with active renewable energy systems, it is recommended to report as a supplementary value the rating if the renewable energy systems were not present.

G.1.2.7 Calculation specification

Gains and losses included in the building needs	*solar gains, ventilation and lighting losses*
Delivered energy	*renewable energy produced on site is not part of the delivered energy*
Weigthing factor	*primary non-renewable fraction factor*
Calculation of the recovered gains and losses	*simplified approach*

Table G.5 — Calculated rating – Reporting of the overall energy use and the primary energy rating

Building thermal needs (without techn. build. systems)	**Technical building system performance** (thermal system losses-recovered losses)	**Energy delivered** (content of energy carriers)	**Energy rating** (weighted energy carriers)
$Q_{H,n}$ = 5 346 ± 500 $Q_{W,n}$ = 220 ± 20 $Q_{C,n}$ = 2 512 ± 300	$Q_{HW,ls,nrvd}$ = 1 854 ± 180 -(21+4) $Q_{C,ls}$ = 3 947 ± 400 $E_{el:}$ = 2 144 ± 220 (W_{HW} = 162 ± 15) (W_{C} = 162 ± 15) (E_{L} = 1 680 ± 100) (E_{V} = 140 ± 10)	$E_{gas,del}$ = 17 855 ± 1 700 - 21 $E_{el,del}$ = 225 ± 0 $E_{dh,\ del,}$ = 10 00 ± 0 - 4	$\sum E_{exp;Pnren}$ = 27 919 ± 0 ($E_{gas,del,Pnren}$ = 26 746 ± 0) ($E_{el,del,Pnren}$ = 675 ± 0) ($E_{dh,del,Pnren}$ = 498 ± 0)
		Energy exported (unweighted energy carriers)	
		$E_{el,\ exp}$ =-3 539 ± 0	$\sum E_{exp;Pnren}$ = 10 617 ± 0
			E_{Pnren} = 17 302 ± 0
		Renewable energy produced on site	
		$E_{el,\ gen,out}$= 482 ± 0	

[a] Includes electricity for ventilation and lighting and the auxiliary energy for the thermal technical systems; it does not include electricity for heating, cooling, DHW, humidification, and dehumidification.

G.1.3 Flow diagram

NOTE The information in the draft flow diagram in Figure G.1 is from the draft spreadsheet validating/demonstrating the formulae in Clauses 6 and 7.

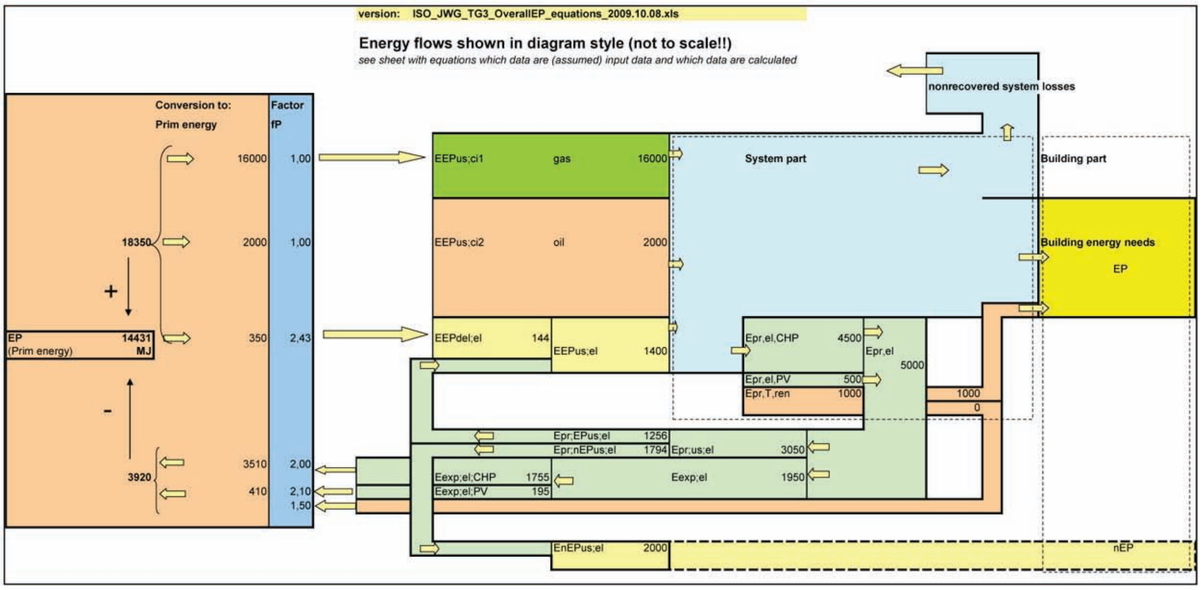


Figure G.1 — Flow diagram illustrating the energy flows

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