CEN/BT WG173

CEN TC228/WG4 N332_rev5

prEN 15203 / 15315

CEN/TC BT/WG173
Secretariat: NEN

Energy performance of buildings — Overall energy use, CO_2 emissions and definition of energy ratings

Energetische Verhalten von Gebäuden — Gesamtenergieverbrauch, CO_2 Emissionen und Definition der Energieleistungsindikatoren

Performance énergétique des bâtiments — Consommation énergétique totale, émissions de CO_2 et définition des indices de performance énergétique

ICS:

Descriptors:

Document type: European Standard
Document subtype:
Document stage: Formal Vote
Document language: E

M:\Commissies projecten\commissies europees\00 BTWG 173 EPBD\drafts for WI's\WI 02+04 TC-approval version prEN 15203-15315.doc STD Version 2.1c

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Foreword

This document prEN 15203 has been prepared by Technical Committee CEN/TC BT/WG173 “Energy performance in buildings direective”, the secretariat of which is held by NNI.

This document is currently submitted to the Formal Vote.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

Introduction

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) 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 technical building systems;

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

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

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 on 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 methodology to obtain equivalent results from different sets of data is presented in this standard. A methodology 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 standard also provides a methodology to assess the energy effectiveness of possible improvements

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

1) The **calculated energy rating**;

2) The **measured energy rating.**

Because of the differences in the way these two ratings are obtained, they cannot be compared directly. 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.

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

NOTE Basically, energy is not produced, but only transformed. In this standard however, according to common sense, 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 (heating, cooling, ventilation, hot water, lighting, etc.).

1 Scope

The purpose of the standard is to:

- collate results from other standards that calculate energy consumption for specific uses within a building;
- account for energy generated in the building, some of which may be exported for use elsewhere;
- present a summary of the overall energy use of the building in tabular form;

— provide energy ratings based on primary energy consumption carbon dioxide emission or an other parameter defined by national energy policy;

— establish general principles for the calculation of primary energy factors and carbon emission coefficients.

This standard defines the uses of energy to be taken into account for setting energy performance ratings for planned and existing buildings, and provides for this:

a) 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;

b) A method to assess the measured energy rating, based on the delivered and exported energy;

c) A methodology to improve confidence in the building calculation model by comparison with actual energy use;

d) A method to assess the energy effectiveness of possible improvements.

This international standard is applicable to a part of a building (e.g. flat), buildings, 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.

2 Normative references

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

EN ISO 7345, *Thermal insulation – Physical quantities and definitions*

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

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

prEN 15193-1, *Energy performance of buildings – Energy requirements for lighting — Part 1: Lighting energy estimation*

prEN 15217, *Energy performance of buildings — Methods for expressing energy performance and for energy certification of buildings*

prEN 15232, *Calculation methods for energy efficiency improvements by the application of integrated building automation systems*

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

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

prEN 15316-1, *Heating systems in buildings – Method for calculation of system energy requirements and system efficiencies – Part 1: General*

prEN 15316-2-1 *Heating systems in buildings – Method for calculation of system energy requirements and system efficiencies Part 2-1 Space heating emission systems* prEN 15316-4, *Heating systems in buildings – Method for calculation of system energy requirements and system efficiencies Part 4: Space heating generation systems*

prEN 15316-2-3, *Heating systems in buildings – Method for calculation of system energy requirements and system efficiencies Part 2-3: Space heating distribution systems*

prEN 15316-3, *Heating systems in buildings – Method for calculation of system energy requirements and system efficiencies – Part 3: Domestic hot water systems*

EN ISO 12569, *Thermal insulation in buildings – Determination of air change in buildings - Tracer gas dilution method*

ISO 13600, *Technical energy systems – Basic concepts*

3 Terms and definitions

For the purposes of this European Standard, the terms and definitions given in EN ISO 7345 and the following apply.

Buildings

3.1
building
construction as a whole, including its envelope and all technical building systems, for which energy is used to condition the indoor climate

NOTE The term can refer to the building as a whole or to parts thereof that have been designed or altered to be used separately

3.2
new building
building at design stage or under construction or (for measured energy rating) too recently constructed to have reliable records of energy use

3.3
existing building
building that is erected and (for measured energy rating) for which actual data necessary to assess the energy use are known or can be measured

3.4
technical building system
technical equipment for heating, cooling, ventilation, domestic hot water, lighting and electricity production

NOTE A technical building system is composed of different subsystems

3.5
technical building sub-system
part of a technical building system that performs a specific function (e.g. heat generation, heat distribution, heat emission)

3.6
building automation and control
products, software, and engineering services for automatic controls, monitoring and optimization, human intervention, and management to achieve energy-efficient, economical, and safe operation of building services equipment.

3.7
conditioned space
part of building which is heated or cooled

3.8
conditioned zone
part of a conditioned space with a given set-point temperature or set-point temperatures, throughout which the internal temperature is assumed to have negligible spatial variations and which is controlled by a single heating system, cooling system and/or ventilation system

Technical building systems

3.9
auxiliary energy
electrical energy used by heating, cooling, ventilation and/or domestic water systems to transform and transport the delivered energy into the useful energy

NOTE 1 This includes energy for fans, pumps, electronics, etc., but not the energy that is transformed. Pilot flames are considered as part of the energy use by the system.

NOTE 2 In EN ISO 9488, *Solar energy – Vocabulary*, the energy used for pumps and valves is called "parasitic energy".

3.10
cogeneration
simultaneous generation in one process of thermal energy and electrical or mechanical energy.

NOTE Also known as combined heat and power

3.11
dehumidification
process of removing water vapour from air to reduce relative humidity

3.12
humidification
process of adding water vapour to air to increase relative humidity

3.13
ventilation
process of supplying or removing air by natural or mechanical means to or from any space. Such air is not required to have been conditioned

3.14
technical system thermal losses
thermal losses from a technical building system for heating, cooling or domestic hot water (not including lighting) to its surroundings

NOTE The system losses can become an internal heat gain if it is recovered

3.15
recoverable system thermal losses
part of the technical system thermal losses from a heating, cooling, ventilation, cooling, domestic hot water and lighting system which can be recovered to lower the energy need for heating or cooling

3.16
recovered system thermal losses
part of the recoverable system thermal losses which has been utilised to lower the energy need for heating or cooling

Energy and energywares

3.17
energy source

source from which useful energy can be extracted or recovered either directly or by means of a conversion or transformation process (e.g. solid fuels, liquid fuels, solar energy, biomass, etc.)

3.18
energy carrier
substance or phenomenon that can be used to produce mechanical work or heat or to operate chemical or physical processes [ISO 13600:1997].

NOTE The energy content of fuels is given by their gross calorific value.

3.19
energyware
tradable commodity used mainly to produce mechanical work or heat, or to operate chemical or physical processes, and listed in Annex A of ISO 13600. [ISO 13600]

NOTE Examples are oil, gas, coal, grid electricity, district heating. Energywares form a proper subset of energy carriers. The set of energy carriers is open. Solar radiation is an energy carrier that is not an energyware.

3.20
system boundary
boundary that includes within it all areas associated with the building (both inside and outside the building) where energy is consumed or produced

3.21
delivered energy
total energy, expressed per energy carrier, supplied to the building through the system boundary, to satisfy the uses taken into account (heating, cooling, ventilation, domestic hot water, lighting, appliances etc.) or to produce electricity

NOTE 1 For active solar and wind energy systems the incident solar radiation on solar panels or the kinetic energy of wind 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 panel) to the building are taken into account in the energy balance and hence in the delivered energy.

NOTE 2 Delivered energy can be calculated or it can be measured.

3.22
exported energy
energy, expressed per energy carrier, delivered by the building through the system boundary and used outside the system boundary

Note: Exported energy can be calculated or it can be measured.

3.23
net
delivered minus exported

3.24
resource energy
energy taken from a source which is depleted by extraction (e.g. fossil fuels).

3.25
renewable energy
energy from sources that are not depleted by extraction, such as solar energy (thermal and photovoltaic), wind, water power, renewed biomass

NOTE In ISO 13602-1:2002, renewable resource is defined as "natural resource for which the ratio of the creation of the natural resource to the output of that resource from nature to the technosphere is equal to or greater than one".

3.26
renewable energy produced on the building site
energy produced by technical systems directly connected to the building, using renewable energy sources

NOTE The electricity produced by on-site cogeneration is considered in the same way as renewable energy because the associated thermal losses and fuel used is taken into account in the heat production.

3.27
primary energy
energy that has not been subjected to any conversion or transformation process

NOTE 1 Primary energy includes resource energy and renewable energy. If both are taken into account it can be called total primary energy.

NOTE 2 For a building, it is the energy used to produce the energy delivered to the building. It is calculated from the delivered and exported amounts of energy carriers, using conversion factors.

3.28
total primary energy factor
resource and renewable primary energy divided by delivered energy, where the primary energy is that required to supply one unit of delivered energy, taking account of the energy required for extraction, processing, storage, transport, generation, transformation, transmission, distribution, and any other operations necessary for delivery to the building in which the delivered energy will be used

NOTE The total primary energy factor always exceeds unity

3.29
primary resource energy factor
primary resource energy divided by delivered energy, where the resource energy is that required to supply one unit of delivered energy, taking account of the resource energy required for extraction, processing, storage, transport, generation, transformation, transmission, distribution, and any other operations necessary for delivery to the building in which the delivered energy will be used.

NOTE The primary resource energy factor can be less than unity if renewable energy has been used.

3.30
CO_2 emission coefficient
quantity of CO_2 emitted to the atmosphere per unit of delivered energy

3.31
energy use for space heating or cooling or domestic hot water
energy input to the heating, cooling or hot water system to satisfy the energy need for heating, cooling or hot water respectively. It is the sum of the energy needs and the non-recovered technical system thermal losses.

3.32
energy need for heating or cooling
heat to be delivered to or extracted from a conditioned space by a heating or cooling system to maintain the intended temperature during a given period of time, not taking into account the technical building systems

NOTE The energy need is calculated and cannot easily be measured.

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

3.33
energy need for domestic hot water
heat to be delivered to the needed amount of domestic hot water to raise its temperature from the cold network temperature to the prefixed delivery temperature at the delivery point, not taking into account the technical building systems

3.34
grid electricity
energy delivered to the building from the public electricity network.

3.35
gross calorific value
quantity of heat released by a unit quantity of fuel, when it is burned completely with oxygen at a constant pressure equal to 101 320 Pa, and when the products of combustion are returned to ambient temperature. This quantity includes the latent heat of condensation of any water vapour contained in the fuel and of the water vapour formed by the combustion of any hydrogen contained in the fuel.

NOTE 1 According to ISO/DIS 13602-2, the gross calorific value is preferred to the net calorific value.

NOTE 2 The net calorific value does not take account of the latent heat.

Energy ratings and certification

3.36
energy rating
evaluation of the energy performance of a building based on the weighted sum of the calculated or measured use of energywares

3.37
calculated energy rating
energy rating based on calculations of the energy used by a building for heating, cooling, ventilation, domestic hot water and lighting

NOTE National bodies decide whether other energy uses resulting from occupants' activities such as cooking, production, laundering, etc. are included or not. If included, standard input data shall be provided for the various types of building and uses. Lighting is always included except (by decision of national bodies) for residential buildings.

3.38
tailored energy rating
energy rating calculated with actual data for the building, climate and occupancy

3.39
standard energy rating
energy rating calculated with actual data for the building and standard use data set

NOTE 1 It represents the intrinsic annual energy use of a building under standardised conditions. This is particularly relevant to certification of standard energy performance.

NOTE 2 It can also be termed "asset energy rating".

3.40
design energy rating
energy rating with design data for the building and standard use data set

NOTE It represents the calculated intrinsic annual energy use of a designed building under standardised conditions. This is particularly relevant to obtain a building permit at the design stage.

3.41
standard use data set
standard input data for internal and external climates, use, and occupancy

NOTE 1 This set may also include information on surroundings (such as shading or sheltering by adjacent buildings).

NOTE 2 Such data sets are defined at national level.

3.42
measured energy rating
energy rating based on measured amounts of delivered and exported energy.

NOTE The measured rating is the weighted sum of all energy carriers used by the building, as measured by meters or other means. It is a measure of the in-use performance of the building. This is particularly relevant to certification of actual energy performance.

NOTE Also known as "operational rating".

3.43
confidence interval
interval that has a high probability (e.g. 95 %) to include the actual value

Energy calculation

3.44
building calculation model
mathematical model of the building, used to calculate its energy use

3.45
validated building data set
data used as input to a building calculation model in which one or more input data have been adjusted on the basis of actual data so that the results from a calculation using the model do not significantly differ from the measured reality

NOTE The quality of the validated data set is a balance between reasonable costs for gathering data and reasonable accuracy.

3.46
heating or cooling season
period of the year during which a significant amount of energy for heating or cooling is needed

NOTE The lengths of the heating and cooling season are determined in different ways, depending on the calculation method. The season lengths are used to determine the operation period of the technical systems in order to calculate the auxiliary energy.

4 Symbols, units and subscripts

For the units only the basic units without the prefixes are indicated. All prefixes are allowed (e.g. J, kJ, MJ, GJ).

Table 1 —Symbols and units

Symbol	Quantity	Unit
A	area	m²
E	Energy in general (including primary energy, all energy carriers, energywares and energy needs, except heat and work,)	kg, m^3, Wh, J, [b)]
I	Irradiation	J/m², kWh/m²
f	Primary energy or policy factor	-
H_L	heat transfer coefficient	W/K
K	CO_2 emission coefficient	kg/J; g/kWh
m	mass (e.g. quantity of CO_2-emissions)	kg
O	occupancy	persons
Q	quantity of heat	J, Wh [a)]
t	time, period of time	s [a)]
V	volume	m³
η	efficiency, utilisation factor	-
θ	Celsius temperature	°C

a): Hours (h) may be used as the unit of time instead of seconds for all quantities involving time (i.e. for time periods as well as for air change rates), but in that case the unit of energy is Wh instead of J

b) The unit depends on the type of energy carrier

Table 2 — Subscripts

c	cooling	del	delivered	gen	generation, generator
e	electricity	ex	exported	an	annual
h	heating	n	need	per	for a time period
l	lighting	ls	loss	e	external
v	ventilation	gn	related to gains	i	internal
w	hot water	rb	recoverable	in	input
CO2	related to CO_2 emissions	sys	system	out	output
prim	primary	dis	distribution system	sol	solar
pol	related to policy	aux	auxiliary	*i,j,k*	dummy subscripts
calc	calculated	pr	produced		

5 Assessment of energy performance of buildings

5.1 Energy uses

The assessment of the energy used by the building shall comprise the annual energy use for the following purposes:

— heating;
— cooling and dehumidification;
— ventilation systems and humidification;
— hot water;
— lighting (optional for residential building)
— other uses (optional).

This includes auxiliary energy and losses of all systems.

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

NOTE: Energy uses for other uses are by nature included in the measured energy rating.

5.2 Assessment boundaries

The boundaries 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, etc). It includes all inside and outside areas associated with the building, where energy is consumed or produced. Inside the system boundary the system losses are detailed, outside the system boundary they are taken into account in the conversion factor.

Energy can be imported or exported through the building boundary. Some of these energy streams can be quantified by meters (e.g. gas, electricity, district heating and water) in case the system devices (boiler, chiller, cooling tower, etc.) are located outside the building envelope.

The building 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 wares.

If a part of a technical building system (e.g. boiler, chiller, cooling tower, etc.) is located outside the building envelope, it is nevertheless considered to be inside the boundaries, and its system losses are taken into account.

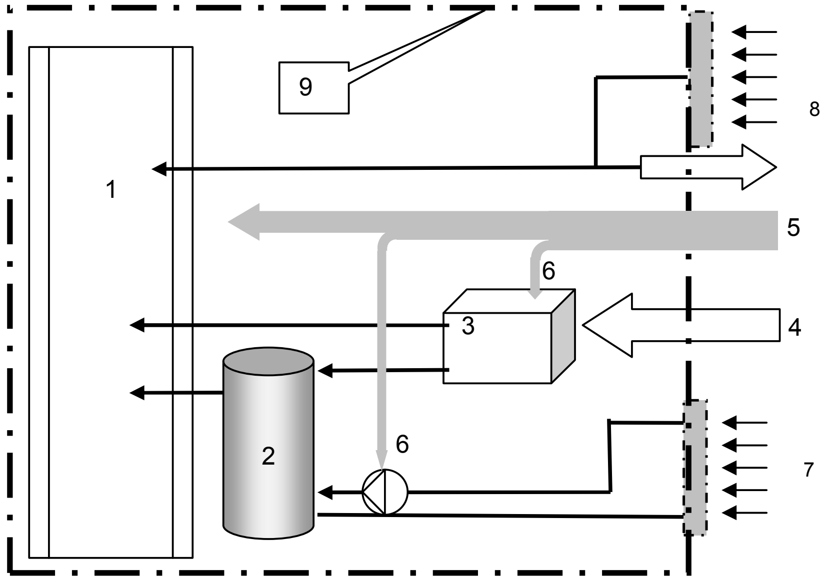

Figure 1 —Boundary: Examples of energy streams across the building boundary.

Key: 1: user, 2: storage, 3: boiler; 4: Fuel; 5: Electricity; 6: Auxiliary energy; 7: thermal solar panels; 8: photovoltaic panels, 9: boundary.

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 panel) to the building are taken into account in the energy balance.

The assessment can be made for a group of similar buildings, e.g. if they are on the same lot or served by the same technical system. 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 standard proposes two principal options for energy rating of buildings:

— the calculated energy rating,

— the measured energy rating.

NOTE The calculated energy ratings includes energy use for heating, cooling, ventilation, hot water and lighting when appropriate. It does not includes energy for other uses unless so decided at national level. Therefore, both ratings cannot be compared without special caution, mentioned in **clause 9**.

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

and can be either calculated for planned buildings (design rating) or for actual buildings.

National bodies determine under what conditions the design energy rating can be considered as or converted to a calculated energy rating for the actually realised building.

The assessment method of the measured energy rating is given in Clause 6.

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 realised building.

The types of rating are summarised in **Table 3**.

Table 3 — 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	Optimisation, validation, retrofit planning
Measured	Operational	Actual	Actual	Actual	Energy performance certificate, regulation

6 Calculated energy rating

6.1 Calculation procedure and reporting

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

Specific electrical uses (lighting, auxiliary) and thermal uses are reported separately inside the building boundaries.

The building on site energy production based on locally available renewable resources and the building energy use are considered separately.

6.1.1 Calculation period

The objective of the calculation is to determine the annual overall energy use, primary energy and CO_2 emission. This may be done in one of the following two different ways:

— for some energy use such as lighting the calculation are performed using annual average values;

— for others, such as heating and cooling, the calculation is performed by dividing the year into a number of calculation periods (e.g. months, hours, etc.), performing the calculations for each period using period-dependent values and suming up the results for all the periods over the year.

NOTE The use of annual values is unsatisfactory in many cases, especially when talking about CO2 emissions of seasonal energy uses.

6.1.2 Calculation principles of the recovered gains and losses

The interactions between the different energy uses (heating, cooling, lighting, …) are taken into account by the calculation of recovered heat sources or sinks which can have a positive or negative impact on the energy performance of the building.

Two approaches are allowed:

— **a holistic approach** adding up the totality of the heat sink and sources from the building and system that are recoverable in the building, for the calculation of the building energy need. As the systems losses depends on the building energy use, which itself depends on the recovered system sources, iteration may be required.. The calculation procedure is the following, for each calculation period.

1) calculate the building heat losses when heating, $Q_{h,ls}$, and cooling, $Q_{c,ls}$, according to prEN 13790,
2) calculate the solar and internal heat gains $Q_{h,gn}$, and cooling, $Q_{c,gn}$, according to prEN 13790, and consider them as the recoverable building gains ;
3) do the sub-system calculation according to prEN 15241, prEN 15243 and prEN 15316-1, using $Q_{h,ls}$ $Q_{c,ls}$, and determine the recoverable system losses;
4) add these to the recoverable building gains when heating, $Q_{h,gn}$, and cooling, $Q_{c,gn}$;
5) calculate the utilisation factors $\eta_{h,gn}$ and $\eta_{c,gn}$ according to prEN ISO 13790 using the total recoverable gains to compute the heat balance ratio;
6) determine the energy need for heating and for cooling using:

$$Q_{h,n} = Q_{h,ls} - \eta_{h,gn} Q_{h,gn} \quad \text{and} \quad Q_{c,n} = Q_{c,gn} - \eta_{c,ls} \cdot Q_{c,ls} \qquad (1)$$

7) iterate at step 3 on the base of these needs until changes of $Q_{h,gn}$, and $Q_{c,gn}$ between two iterations are less a defined limit (e.g. 1%).

— **a simplified approach** in which the recovered system heat losses are directly subtracted from the loss of each considered sub-system at the system level. This will avoid iterations. The calculation procedure is the following:

  — calculate the building energy need for heating and cooling according to prEN 13790, leaving out as heat sources the recoverable system losses,
  — do the sub-system calculation according to prEN 15241, prEN 15243 and prEN 15316-1, and determine the recoverable system losses,
  — determine the recovered system losses by multiplying the recoverable system losses by a recovery factor,
  — subtract the recovered system losses from the system energy use.

  Conventional values of the recovery factor are given on a national level.

NOTE 1 For complex systems (e.g. heating and cooling installation) the holistic approach is recommended.

NOTE 2 Heat recovery (e.g. preheating of the combustion air) is treated in a simplified approach.

6.1.3 Effect of integrated control

The impact of integrated controls, combining the control of several systems may be taken into account according to prEN 15232.

6.2 Building thermal needs and lighting

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

Table 4 — Building energy needs

		C1	C2	C3	C5
		Heating	Cooling	Domestic hot water	Lighting
L1	Building recoverable gains and losses	$Q_{h,gn,rb}$	$Q_{c,ls,rb}$	-	-
L2	Building thermal losses	$Q_{h,ls}$	$Q_{c,ls}$	--	-
L3	Building thermal needs	$Q_{h,n}$	$Q_{c,n}$	$Q_{w,n}$	E_l

The annual energy needs are calculated according to:

$Q_{h,n}$	Thermal need for space heating (without humidification)	prEN ISO 13790
$Q_{c,n}$	Thermal need for space cooling, (without dehumidification)	prEN ISO 13790
$Q_{w,n}$	Thermal need for domestic hot water	prEN 15316-3.-1
E_l	Energy use for lighting	prEN 15193
$Q_{h,ls}$	Heat losses of the building	prEN ISO 13790
$Q_{c,ls}$	Cooling losses of the building	prEN ISO 13790
$Q_{h,gn,rb}$	Recoverable internal and solar heat gains of the building according to	prEN ISO 13790
$Q_{c,ls,rb}$	Recoverable thermal loss of the building according to	prEN ISO 13790

NOTE 1 Table 4 intends to present the needs of the building. Since lighting need cannot be easily defined, it is expressed here by the energy use for lighting.

NOTE 2 The hourly method of prEn 13790 does not distinguish between losses and recovered losses. In this case, only $Q_{H,n}$ and $Q_{C,n}$ are reported in line 3 of table 4.

6.3 Building energy systems

6.3.1 Technical system thermal losses and auxiliary energy without building generation devices

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

Table 5 — System thermal losses and auxiliary energy without generation

		C1	C2	C3	C4	C4
		Heating	Cooling	Domestic Hot water	Ventilation	Total
L1	Auxilary energy	$E_{h,aux}$	$E_{c,aux}$	$E_{w,aux}$	$E_{v,aux}$	$\Sigma E_{i, aux}$
L2	System thermal losses	$Q_{h,s,ls}$	$Q_{c,s,ls}$	$Q_{w,s,ls}$	$Q_{v,s,ls}$	$\Sigma Q_{I,s,ls}$
L3	Recoverable system thermal losses	$Q_{h,s,rb}$	$Q_{c,s,rb}$	$Q_{w,s,rb}$	$Q_{v,s,rb}$	$\Sigma Q_{I,s,rb}$
L4	Thermal input	$Q_{h,s,in}$	$Q_{c,s,in}$	$Q_{w,s,in}$	$Q_{v,s,in}$	$\Sigma Q_{i,s,in}$

The thermal input to each distribution systems i is calculated with:

$$Q_{i,s,in} = Q_{i,n} + Q_{i,s,ls} \quad (3)$$

Where:

$Q_{i,n}$ thermal needs for use i

$Q_{i,s,ls}$ system thermal losses for use i

The necessary inputs are calculated according to the referenced prENs as indicated below.

6.3.1.1 Systems thermal losses

The annual systems thermal losses are calculated according to:

$Q_{h,s,ls}$ System thermal losses of the heating prEN 15316-1

$Q_{v,s,ls}$	System thermal losses of the ventilation system (including heat use for humidification)	prEN 15241
$Q_{c,s,ls}$	System thermal losses of the cooling system (including dehumidification)	prEN 15243/15241
$Q_{W,s,ls}$	System thermal losses of the domestic hot water	prEN 15316-1

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.

6.3.1.2 Recoverable systems thermal losses

The annual recoverable system thermal losses are calculated according to

$Q_{h,s,rb}$	Recoverable system thermal losses of the heating system	prEN 15316-1
$Q_{v,s,rb}$	Recoverable system thermal losses loss of the ventilation system	prEN 15241
$Q_{c,s,rb}$	Recoverable system thermal losses of the cooling system	prEN 15243
$Q_{w,s,rb}$	Recoverable system thermal losses of the domestic hot water system	prEN 15316-1

6.3.1.3 Electricity use of systems as auxiliary energy (fans, pumps, controls, etc.)

The annual auxiliary energy use is calculated according to:

$E_{h,aux}$	Auxiliary energy of the heating system	prEN 15316
$E_{c,aux}$	Auxiliary energy of the cooling system (including dehumidification)	prEN 15243
$E_{v,aux}$	Auxilairy energy of the ventilation system, including humidification	prEN 15241
$E_{w,aux}$	Auxiliary energy of the hot water distribution system	prEN 15316-3.2

6.3.2 Building energy generation systems

The thermal energy input of 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.

At this stage, the energy carriers are taken into account (oil, gas, biomass, district heating, etc).

NOTE In the building, energy is not only consumed but also produced (e.g. boilers, combined heat and power). A generation device may supply energy for different uses (e.g. heating, domestic hot water, electricity production). Therefore the system losses and the recoverable thermal losses are not associated to the specific building energy use but to the generation device.

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

The building on site energy production based on locally available renewable resources includes on site combined heat and power devices (CHP).

NOTE In calculation method for CHP (prEN 15316-4.4) the energy input and all system losses are related to the thermal output. The electricity is counted as a bonus (power bonus method).

If a heat pump is used to generate heat for heating or domestic hot water <u>and</u> cold for cooling the required cold and heat is indicated in line 1.

The energy production system losses are reported according to Table 6 The necessary inputs are calculated according to the referenced prENs.

Table 6 — Energy generation systems

		C1 Generator 1	C2 Generator 2	C3 Generator *i*	C4 **Total**
	Distribution systems supplied[a)]				
L1	Thermal output	$Q_{h,gen,ot,1,l}$	$Q_{h,gen,ot,2l}$	$Q_{h,gen,ot,i}$	$\Sigma Q_{h,gen,ot,l}$
L2	Auxiliary energy	$E_{gen,aux,1l}$	$E_{gen,aux,2l}$	$E_{gen,aux,i}$	$\Sigma E_{gen,aux,l}$
L3	System (generator) thermal losses	$Q_{gen,ls,1l}$	$Q_{sgen,2l}$	$Q_{sgen,i}$	$\Sigma Q_{sgen,l}$
L4	Recoverable system thermal losses	$Q_{gen,rb,1,l}$	$Q_{gen,rb,2l}$	$Q_{gen,rb,i}$	$\Sigma Q_{gen,rb,i}$
L5	Energy input	$E_{gen,in,1}$	$E_{gen,in,2}$	$E_{gen,in,i}$	
L6	Electricity production	$E_{el,pr,1l}$	$E_{el,pr,2l}$	$E_{el,pr,il}$	$\Sigma E_{el,pr,i}$
L7	Heat production (building)	$Q_{pr,1l}$	$Q_{pr,2l}$	$Q_{pr,il}$	$\Sigma Q_{pr,i}$
L8	Energy carrier [b)]				-

a) name of the supplied system, for example heating, cooling, heating and hot water, etc.

b) name of the energyware used by the generator (oil, gas, etc.)

The annual thermal output and auxiliary energy use of the generation devices are calculated according to the appropriate part of prEN 15316 for heating systems and according to prEN15243 for cooling systems:

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

$Q_{gen,ls,j}$ *S*ystem thermal losses of the generation device *j*

$Q_{gen,rb,j}$ Recoverable system thermal losses of the generation device *i*

$E_{gen,aux,j}$ Auxiliary energy of the generation device *j*

$E_{gn,el,i}$ Electricity production of the generation device *j*

$E_{gen,in,j}$ Energy input to the generation device *j*

NOTE it is equal to the heat output and the electricity output plus the system losses minus – in the simplified approach – the recovered system thermal losses.

The energy uses of the building to enter in Table 8 are calculated as follows:

$$Q_h = Q_{h,s,in} + Q_{w,s,in} \quad (1)$$

$$Q_c = Q_{c,s,in} \quad (2)$$

$$E_{el} = E_l + \sum_i E_{i,aux} \quad (3)$$

7 Measured energy[1]

7.1 Assessment period

7.1.1 General requirements

Energy use for all energywares shall be assessed as closely as possible for the same period.

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[1] Also called "operational rating"

The time period is an integer number of years. It is recommended to take the average over several most recent full years, as long as the building and its use pattern do not change.

If the assessment period is not an integer number of years, the annual energy use shall be obtained by extrapolation according to 7.1.2.

If the time period is shorter than three years, a correction for weather according to 7.3 shall be performed

No modifications to the building that may change its energy performance should happen during the assessment period. If such a change occurs, a new assessment period shall be started after it, to get the new energy rating.

NOTE It is recommended that the first one or two years after the building construction are 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;
- the adjustment of control system may not be perfect from the first day of use;
- there may be some faults that are corrected during the first year.

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

7.1.2 Extrapolation methods to an integral number of years

The appropriate method depends on the use of the energyware. Energywares used for several purposes, or for purposes 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. prEN 13790 for heating and cooling) can be used to extrapolate measurements assessed during a too short 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, include:

7.1.2.1 Energywares used at constant average power

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

$$E = \frac{t_{\mathrm{an}}}{t_{per}} E_{per} \qquad (4)$$

where

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

t_{an} is the duration of the year;

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

NOTE 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.

7.1.2.2 Energywares used for heating or cooling only

For energywares used for heating or cooling, the extrapolation can be performed either by using the energy signature (see informative Annex B) or using the simplified calculation according to EN 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 energyware used either for heating or for cooling for a whole year is:

$$E_{an} = \frac{Q_{an,calc}}{Q_{per,calc}} E_{per} \quad (5)$$

where

$Q_{an,calc}$ is the calculated heating or cooling energy need for the whole year

$Q_{per,calc}$ is the calculated heating or cooling energy need for the assessment period;

E_{per} is the amount of energyware used for heating or cooling during the assessment time period.

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

$$Q_{H,calc}(t) = H_L(\bar{\theta}_i - \bar{\theta}_e)t - \eta(A_{sol}E_{sol} + Q_{i,gn}) \quad (6)$$

$$Q_{C,calc}(t) = (A_{sol}E_{sol} + Q_{i,gn}) - \eta H_L(\bar{\theta}_i - \bar{\theta}_e)t \quad (7)$$

where

t is the assessment time period, i.e one full heating or cooling season to calculate $Q_{an,calc}$ and the measurement period for $Q_{per,calc}$

H_L is the heat transfer coefficient of the building calculated according to prEN ISO 13789;

$\bar{\theta}_i$ is the heating or cooling set point temperature, averaged over the building;

$\bar{\theta}_e$ is the mean external temperature, averaged over the time period *t;*

η is the utilisation factor calculated according to EN ISO 13790;

A_{sol} is a effective solar collecting area representative of the whole building

E_{sol} is the solar irradiation during time period *t* on the area A_{sol}

$Q_{i,gn}$ are the internal gains of the whole building during time *t*;

7.1.2.3 For energywares used at a rate depending on occupancy

For these, the extrapolation method is:

$$E_{an} = \frac{O_{an}}{O_{per}} E_{per} \quad (8)$$

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 energyware used during the assessment time period.

7.1.2.4 Limits of application

In any case, 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.

7.2 Assessing the used amounts of all energywares

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

Energywares that are not metered shall be assessed by calculation according to clause **6**.

If it is intended to compare the measured rating with a tailored calculated rating, the energy used for other purposes 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.

7.2.1 Metered fuels (Electricity, gas, district heating and cooling)

The 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 energywares. In this case, use always 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, the 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.

7.2.2 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 use 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, the 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, the 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 used is obtained by multiplying this amount by its gross calorific value.

7.2.3 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. The 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 weigh 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.

7.2.4 Energy monitoring

Periodic measurement of energy use allows quantifying 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 B provides more information.

7.3 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 local weather.

To achieve this, the measured energy use for heating and cooling shall be adjusted to the average weather for the building location.

The general method to perform this correction is to use the calculation model described in Clause 6 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 weather data.

Simpler correction methods, such as the method defined in 7.1.2 and their limits of application can be defined on a national basis, taking account of the climate and the building types and uses.

8 Energy rating

8.1 Types of ratings

Note: A building generally 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 standard, the aggregation methods are based on the following impacts the use of energy carriers have:

— Primary energy;

— Production of carbon dioxide

— A parameter defined by national energy policy.

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

8.2 Types of factors or coefficients

The aggregation needs factors and coefficients determined at a national level according to the rules given below. Local values for factors needed to calculate the primary energy consumption and/or CO2 emissions should be defined in a national annex. Annex E (informative) provides such factors and coefficients.

No confidence interval is associated to these factors.

NOTE The reason is that these factors are defined in a national annex.

In a multi-plant generation system (e.g. electricity, district heating) the weighting factor at any time depends on which generation plants are actually operating at any point in time 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.

8.2.1 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, CO2 production) during a year and divided by the total energy delivered.

8.2.2 Marginal factor or coefficient

If energy consumption is reduced (or increased), not all power stations are affected equally: the operation of "base load" stations is unchanged - the change in demand is met by reduced operation of other plants.

The marginal factor or coefficient takes into account only production units that are affected by the change in energy demand. For example, the marginal new plant factor or coefficient relate to a new plant that should be built if the energy demand increases.

8.2.3 End use factor or coefficient

Different end-uses produce demands at different times - lighting, heating, air-conditioning, for example, each having very different demand patterns - and this might justify the use of specific demand-weighted factors for different end-uses.

8.3 Primary energy rating

The primary energy approach makes possible the simple addition from different types of energies (e.g. thermal and electrical) because this approach integrate 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.

If a building A exports heat to the building B which is located outside the assessment boundaires, this case is taken into account in the same way as a district heating. The primary energy factor used for building B shall include the system losses (generation, heat losses between building A an B, etc).

8.3.1 Primary energy

Primary energy is calculated from the delivered and exported energy for each energy carrier:

$$E_{\text{prim}} = \sum \left(E_{\text{del},i} \; f_{\text{prim,del},i} \right) - \sum \left(E_{\text{ex},i} \; f_{\text{prim,ex},i} \right) \qquad (9)$$

where:

$E_{\text{del},i}$ is the delivered energy for energy carrier i;

$E_{\text{ex},i}$ is the exported energy for energy carrier i;

$f_{\text{prim,del},i}$ is the primary energy factor for the delivered energycarrier i,

$f_{\text{prim,ex,i}}$ is the primary energy factor for the exported energycarrier *i.*

These two factors can be the same.

The primary energy calculations are reported in Table 7. The energy used for different purposes and by different fuels is recorded separately.

8.3.2 Primary energy factors

Concerning the primary energy factors two conventions apply:

e) **total primary energy factor:** The conversion factors represent all the energy overheads of delivery (production outside the building system boundary, transport, extraction). In this case the primary energy conversion factor always exceeds unity.

f) **primary resource energy factor:** The conversion factors represent the energy overheads of delivery 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.

NOTE Giving the results of the calculations with the two primary energy conversion factors is a way to underline the positive influence of renewable energies on the integrated energy performance of a building.

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 utilisation site,
- Energy used for processing, storage, generation, transmission, distribution, and any other operations necessary for delivery to the building in which the delivered energy will be used.

The primary energy factors may also include:

- Energy to build the transformation units,
- Energy to build the transportation system,
- Energy to clean up or dispose the wastes.

National annexes may be inserted containing tables of values to represent local conditions for electricity generation and fuel supply, and such tables shall give values for primary energy factors or primary resource energy factors, depending on which are to be used on the national level. Examples of such factors are given in **Annex E**.

Any national annex that define primary energy factors and primary resource 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. This annex shall also clearly state which type of coefficient defined in **8.2** is used.

8.4 Carbon dioxide rating

8.4.1 Carbon dioxide emissions

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

$$m_{\mathrm{CO2}} = \sum\left(E_{\mathrm{del},i}\ K_{\mathrm{del},i}\right) - \sum\left(E_{\mathrm{ex},i}\ K_{\mathrm{ex},i}\right) \tag{6}$$

where

$E_{\mathrm{del},i}$ is the delivered energy for energy carrier i;

$E_{\mathrm{ex},i}$ is the exported energy for energy carrier i;

$K_{del,I}$ is the CO_2 emission coefficient for delivered energy carrier *i* and $K_{ex,i}$ is the CO_2 emission coefficient for the exported energy carrier *i.* These two coefficients can be the same.

The CO_2 emission calculation is reported in Table 7.

8.4.2 CO2 emission coefficients

The CO2 emission coefficients shall include all CO_2-emissions associated with the primary energy used by the building, as defined in 8.3. It shall be defined on the national level, if the CO_2-emission coefficients include also the equivalent emissions of other climate active emissions e.g. methane.

Any national annex that defines CO_2 emission coefficients shall state which of the additional overheads mentioned in **8.2** 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 clearly state which type of coefficient defined in **8.2** is used.

8.5 Policy energy rating

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

$$E_{pol} = \sum \left(E_{del,i} \; f_{pol,del,i} \right) - \sum \left(E_{ex,i} \; f_{pol,ex,i} \right) \qquad (10)$$

where

$E_{del,i}$ is the delivered energy for energycarrier *i*;

$E_{ex,i}$ is the exported energy for energycarrier *i*;

$f_{pol,i}$ is the policy factor for energycarrier *i*..

$f_{pol,ex,i}$ is the policy factor for exported energy.

The policy rating calculation is reported in Table 7.

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. It is recommended, but not mandatory, to use this method for existing building, in particular 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

9.2.1 Validation of the building calculation model

Obtain the measured energy rating according to Clause 7.

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 C for energy for other uses. The confidence intervals of all data shall be estimated. Input data that cannot be assessed are taken from inference rules, national references or 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 energywares used for other purposes 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 normative method defined in this standard to compute the "other uses". 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 C.

Compare the results of 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 0,5 K and 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 are:.

— 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.

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[2] For example in Duffie and Beckmann, Solar energy thermal processes, John Wiley & sons, 1974

- In many large buildings, a central computer controls all the systems, and records the internal temperature at several places, see prEN 15232 § 5.8..
- 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;

b) use of the tracer gas dilution method as described in EN 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 at best assessed from electricity bills where there are no heating or cooling systems on the same meter. prEN 15193-1 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.)

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 prEN 15316-3 from the number of occupants, use of the building and local habits, or data found in national documentation may 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 lighting is estimated by calculation according to prEN 15193-1.

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 uses”, 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 of retrofit measures for existing buildings

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 for the tailored rating, according to 9.2.1, or the model validated according to Clause 9.

The validated calculation model is recommended.

NOTE 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) The 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 or 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 utilisation 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 is used.

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

11 Report

This clause defines the content of the report on assessment of energy use of a building according to this standard. The content of a certificate is defined in prEN 15217.

The report shall include the following information:

a) reference to this standard;

b) the purpose of the energy rating

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

d) the type of rating;

e) the rating itself together with its confidence interval (when available), using Table 7and Table 8.

These tables are used for ratings based on final energy, CO_2 production or policy.

Table 7 — Calculation of ratings (example: CO_2 rating)

Row		C1	C2	C3
		Delivered energy		
		Energy carrier 1	Energy carrier *i*	
L1	Energy delivered (unweighted)	$E_{del,1}$	$E_{del, i}$	
L2	Weighting factor or coefficient	$K_{del,,1}$	$K_{del,i}$	
L3	Weighted delivered energy or CO_2	$m_{CO2,del,1}$	$m_{CO2,del,\ i}$	$\Sigma m_{CO2,del,\ i}$
		Exported energy		
		thermal	electrical	
L4	Energy exported (unweighted)	$Q_{exp,\ th}$	$E_{exp,el}$	
L5	Weighting factor	$K_{exp,th}$	$K_{exp,el}$	
L6	Weighted exported energy or CO_2	$m_{CO2,exp,th}$	$m_{CO2,exp,el}$	$\Sigma m_{CO2,exp,\ i}$
L7	**Rating**			$\boldsymbol{m_{CO2}}$

The reporting shall monitor the energy performance of the building, the technical building system and the influence of the choice of the energy carrier. It should be as explicit as possible, including tables 4 to 9 above. As a miniumum, the report shall include at least Table 7 and Table 8.

Table 8 — Reporting of the overall energy use or CO2 emission

ONLY CALCULATED ENERGY RATING		INSIDE BUILDING		OUTSIDE BUILDING
Building thermal needs and lighting	**Building use**	**Energy delivered** (Unweighted energywares)	BUILDING BOUNDARY	**Energy rating** (Weighted Energywares)
Heating $Q_{h,n}$ Cooling: $Q_{c,n}$ Hot water: $Q_{w,n}$ Lighting: E_l	Heat use Q_h Cooling: Q_c Electricity: E_{el}	Gas $E_{del,\ gas}$ Oil $E_{del,\ oil}$ Electricty $E_{\ del,\ el}$ District heating $E_{\ del,\ dh}$ Wood $E_{\ del,\ wd}$ Energyware (i) $E_{\ del,\ i}$		$\Sigma\ E_{prim,del,i}$ or $\Sigma\ E_{pol,del,i}$ or $\Sigma\ m_{CO2,del,\ i}$
	Renewable energy produced on site	**Energy exported** (Unweighted energycarriers)		$\Sigma\ E_{prim,exp,i}$ or $\Sigma\ E_{pol,exp,i}$ or $\Sigma\ m_{CO2,exp,\ i}$
	Thermal $Q_{h,pr}$	Thermal: $Q_{th,\ exp}$		
	Electrical $E_{el,prd}$	Electrical $E_{el,\ exp}$		
				E_{prim}; m_{CO2}, , or E_{pol}

NOTE This reporting is in line with the objectives of the European Performance Building Directive.

f) Climate parameters used for the calculated energy rating or as known - average external temperature, solar irradiance, etc. for the measured energy rating).

In addition, depending on the rating method, the following information is included:

g) Calculated rating:

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

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

   3) the energy use for heating, cooling, ventilation, hot water and lighting, together with their confidence intervals (when available) as shown in tables 4 to 6.

h) Measured energy rating, for each energyware:

   1) the assessment time period;

   2) the method used to assess the energy use;

   3) the amount used, in units used when assessing it (e.g. litres, cubic meters, kilograms, kWh);

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

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

i) 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.

j) 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 standard.

Annex A
(informative)

Methods for collecting building data

A.1 References

EN 410, *Glass in building – Determination of luminous and solar characteristics of glazing*

EN 673, *Glass in building – Determination of thermal transmittance (U value) – Calculation method*

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

EN 13187, *Thermal performance of buildings – Qualitative detection of thermal irregularities in building envelopes – Infrared method*

EN ISO 10077-2, *Thermal performance of windows, doors and shutters – Calculation of thermal transmittance – Part 2: Numerical method for frames*

EN ISO 12567 (all parts), *Thermal performance of windows and doors – Determination of thermal transmittance by hot box method*

EN ISO 6946, *Building components and building elements – Thermal resistance and thermal transmittance – Calculation method*

ISO 9869, *Thermal insulation – Building elements – In-situ measurement of thermal resistance and thermal transmittance*

prEN 15232, *Calculation methods for energy efficiency improvements by the application of integrated building automation systems*

prEN 15241, *Ventilation for buildings – Calculation methods for energy requirements due to ventilation systems in buildings*

prEN 15242, *Ventilation for buildings - Calculation methods for the determination of air flow rates in buildings including infiltration*

prEN 15243, *Ventilation for buildings - Calculation of room temperatures and of load and energy fir buildings with room conditioning systems.*

prEN ISO 10077-1, *Thermal performance of windows, doors and shutters – Calculation of thermal transmittance – Part 1: General*

prEN ISO 10211:2005, *Thermal bridges in building construction – Heat flows and surface temperatures – Detailed calculations*

A.2 Data on building envelope

A.2.1 General

Information on the building envelope, such as dimensions, thermal transmittance or structure and areas of envelope components, characteristics of thermal bridges, solar energy transmittance of glazed envelope components, is collected from drawings, local surveys and measurements, 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.

A.2.2 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 EN 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 EN ISO 6946.

If the building has a known typology, the thermal transmittance of envelope components can be taken from a building typology prepared at a national level.

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

A.2.3 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. This includes not only windows but also any transparent or translucent element such as skylights, glass block, transparent insulation, etc.

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 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 slightly differs 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. The thermal transmittance of complete windows is calculated according to prEN ISO 10077-1:2004 or EN ISO 10077-2. EN ISO 12567-1. EN ISO 12567-2 and EN 12412-2 can also be used for the determination of the thermal transmittance of windows and frames by measurement.

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

The transmission coefficient to solar radiation can be measured on site using simultaneously 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 characteristics 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 manufacturer's data are not known.

A.2.4 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 energy balance 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 indoors may also indicate the location of thermal bridges.

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

A.2.5 Assessment of air flow rates and infiltration

Air flow rates are determined according to prEN 15241 or prEN 15242. Infiltration through the building envelope can be measured according to EN 13829.

See also A.5.1

A.3 Thermal capacity

For calculation of annual energy use for heating or cooling according to prEN 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 1000 J/(kg·K), which is a rough estimate of the heat capacity of most mineral building materials. For massive wood or wood frame structure, multiply by 1700 J/(kg·K).

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

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

Building typology	C [kJ/(m²·K)]
All walls, floor and ceiling of stone or concrete, no wall coverings, wooden floor, carpets, or false ceiling, relatively small rooms about 20 m²	500
The same for very large rooms	250
Rooms about 20 m², 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 about 20 m² 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	

A.4 Heating systems

If sufficient detailed information on the heating system is available, the calculation of the heating system is undertaken according to prEN 15316-1 to 10. 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 prEN 15378 *Heating systems in buildings – Inspection of boilers and heating systems*.

A.5 Ventilation systems

A.5.1 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.

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

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

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

4) Use tracer gas dilution techniques.

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

A.5.2 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 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.

A.5.3 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 prEN 15241. For other cases typical amounts of auxiliary energy used by systems, can be given at national level, based on ventilation system typology.

A.6 Cooling systems

If sufficient detailed information on the cooling system is available, the calculation of the cooling system is undertaken according to prEN 15243. 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.

A.7 Building operation

The actual operation of the building is assessed using the list of functions defined in prEN 15232.

Annex B
(informative)

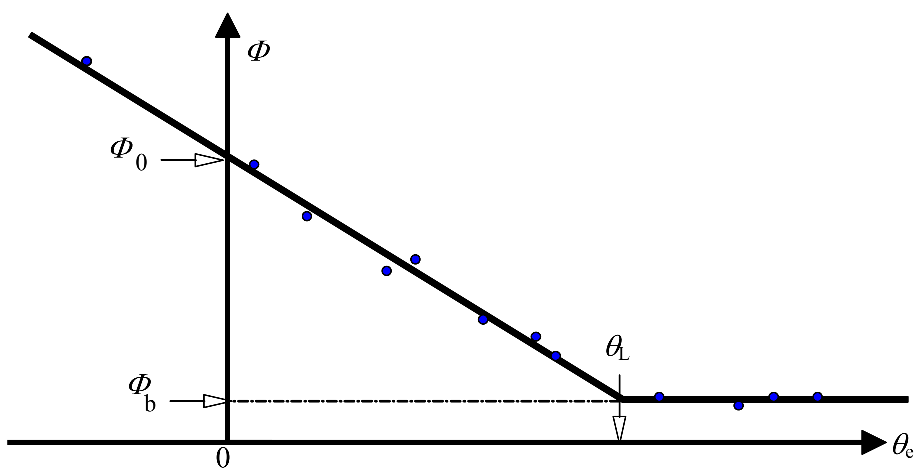
Energy monitoring

B.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 average external temperature or accumulated temperature difference is recorded at regular intervals. These intervals can be as small as one hour, 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 B.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 B.1).



Key

H slope

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 B.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 uses other than heating and cooling (e.g. hot water).

The line drawn during the heating (or cooling) season is characterised by a power P_0 at 0 °C and a slope H:

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

where

Φ is the average power;

θ_e is the average external temperature.

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

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

where

H' is the heat transfer coefficient of the building;

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

Φ_a includes system loss and average power for uses 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 utilisation factor and I_S is the solar irradiance.

Comparing equations (G.1)and (G.2), we get $H' = H$ and:

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

Seasonal energy use for heating can be estimated from P_0 and H, the seasonal average of the external temperature $\overline{\theta}_e$ and the duration *t* of the heating season:

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

This estimate can be obtained without waiting for the whole heating season. However a large range of external temperatures is necessary to obtain a good accuracy for H and P_0.

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

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

The dispersion of the individual measurements above or below the line characterising the signature can result from several causes:

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

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

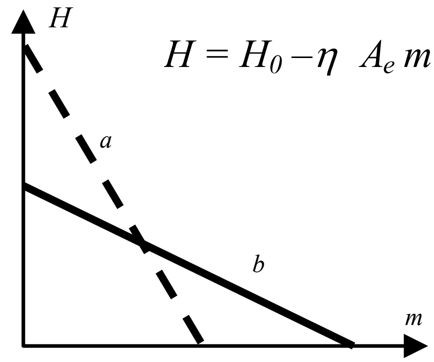
The analysis of possible explanations to significant differences between a particular record and the line allows detection of system malfunctions.

B.2 H-m method

In passive solar buildings, the dispersion of the points around the line becomes important and the method described above 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:

$$H = \frac{\Phi - \Phi_a}{\Delta\theta} = H_0 - \eta A_e \frac{I_S}{\Delta\theta} = H_0 - \eta A_e m \qquad \text{(G.6)}$$

where m is a "meteorological" variable. The slope of the regression line is the equivalent solar collecting area multiplied by the utilisation 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

The line a is that of a highly glazed buildings with large losses and large gains, better performing in mild climates, and line b is for a well insulated building with relatively small passive solar gains, better in Nordic climates.

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

Annex C
(informative)

Other uses of energy

C.1 General

In order to compare the calculated rating with the measured energy rating for the purposes of validation, the amounts of energywares used for other purposes 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 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, say ± 50 %.

C.2 Residential buildings

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

Number of rooms **Number of occupants**	**1** **1**	**2** **1,5**	**3** **2**	**4** **3**	**5** **4**	**6** **5**
Refrigerator	250*	250*	270*	270*	170+	170+
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

*: with freezer + without freezer

C.3 Office buildings

When no other information is available, the following equipment can be assumed in office buildings: 1 PC with flat screen and 1 telephone per work place; 1 printer per 10 work places, and, per office room, 1 telefax, 1 photocopier, 1 scanner and 1 coffee machine. The table below is calculated with this equipment.

Table C.2 — Annual use of electricity for office equipment per work place in kWh and per conditioned area in kWh/m^2

	Per work place	**Per m^2 conditioned area**		
Floor area per person		10 m^2	15 m^2	20 m^2
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 this table, it is calculated with external building dimensions.

Annex D
(informative)

Calorific values of fuels

D.1 General

The energy use during a specific time period is calculated by multiplying the consumed amount of energyware, E, by the gross calorific value, GCV:

$$Q_i = E_i \; GCV_i \tag{F.1}$$

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 get Q_i in appropriate units (kWh or J), the units of GCV_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 of them being mixes of pure chemicals. Indicative values are given in this annex.

D.2 Solid and liquid energywares

For solid and liquid energywares, the calorific values (in MJ/kg) can be calculated using the following formula (Brandt 1981). The input is given as the mass of the energyware:

Gross calorific value: $GCV = 34{,}8*c + 93{,}8*h + 10{,}46*s + 6{,}28*n – 10{,}8*o$

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;

Net calorific value: $NCV = GCV – 2{,}5*w$

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

The second term is the energy that can be recovered by condensing the water vapour resulting from combustion of hydrogen.

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

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

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

	Fuel	Density kg/l	Gross calorific value MJ/kg
Oil	Heating oil, light	0,84 - 0,85	44,8
	Heating oil, heavy	0,96	50,2 - 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

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

D.3 Gaseous Fuels

See ISO 6976, *Natural gas – Calculation of calorific values, density, relative density and Wobbe index from composition*.

If the gaseous energyware amount is given in normal cubic metre (at 0 °C and 101,3 kPa), the following factors can be used. The confidence interval for the pure gases is smaller than 0,1 MJ/m³.

Table D.3 — Gross calorific values of some gaseous energywares

Fuel	Density	Gross calorific value
	kg/m³	MJ/m³
Natural gas L	0,64	35,2 - 35,2
Natural gas H	0,61	41,1 - 41,3
Methane	0,55	39,8 - 39,9
Propane	1,56	100,9
Butane	2,09	133,9
Biogas	1,2	4 to 8*

* Depending on its methane content

The actual calorific power of common fuel gases depend on their chemical composition. If this is known, the figure can be more accurate that those given in the table.

Annex E
(informative)

Factors and coefficients

	Primary energy factors		CO_2 production
	Ressource	Total	[kg/MWh]
Fuel oil	1.35	1.35	330
Gas	1.36	1.36	277
Anthracite	1.19	1.19	394
Lignite	1.40	1.40	433
Coke	1.53	1.53	467
Wood shavings	0.06	1.06	4
Log	0.09	1.09	14
Beech log	0.07	1.07	13
Fir log	0.10	1.10	20
Electricity from hydraulic power plant	0.50	1.50	7
Electricity from nuclear power plant	2.80	2.80	16
Electricity from coal power plant	4.05	4.05	1340
Electricity Mix UCPTE	3.14	3.31	617

Source: Oekoinventare für Energiesysteme - ETH Zürich (1996)
These factors include the energy to build the transformation and transportation systems for the transformation of the primary energy to delivered energy.

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 is not known, but an interval can in most cases be defined, that has a high probability (e.g. 95 % or 99 %) to contain the actual value. This is the confidence interval.

F.2 Assessment of confidence interval

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

8) From the dispersion of several measurements of the same data. If the distribution is Gaussian, the confidence interval of the mean value $\bar{x}$ at probability P when N measurements are performed is:

$$\delta x = \frac{s(x)}{\sqrt{N}} T(P, N-1) \qquad \text{(G. 1)}$$

where $s(x)$ is the estimate of the standard deviation of the measurements x:

$$s_x = \sqrt{\frac{\sum_i \left(x_i - \bar{x}\right)^2}{(N-1)}} = \sqrt{\frac{\sum_i \left(x_i^2\right) - N\,\bar{x}^2}{(N-1)}} \qquad \text{(G. 2)}$$

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, the number of degree of freedom being N. The values of the two-sided Student distribution are given in the table below.

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

	$T(P, N - 1)$ for probability P =					
	0,8	0,9	0,95	0,99	0,995	0,999
	3,078	6,3138	12,706	63,657	127,32	636,619
	1,886	2,9200	4,304,3=27	9,9248	14,089	31,598
	1,638	2,3534	3,1825	5,8409	7,4533	12,924
	1,533	2,1318	2,7764	4,6041	5,5976	8,610
	1,476	2,0150	2,5706	4,0321	4,7733	6,869
	1,440	1,9432	2,4469	3,7074	4,3168	5,959
	1,415	1,8946	2,3646	3,4995	4,0293	5,408
	1,397	1,8595	2,3060	3,3554	3,8325	5,041
	1,383	1,8331	2,2622	3,2498	3,6897	4,781
	1,328	1,7291	2,0930	2,8609	3,1737	3,8837
	1,2858	1,6525	1,9719	2,6006	2,8386	3,3400

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:

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

where

x_i is for all variables on which y depends;

δx_i is for the confidence interval of the variable $x_{i.}$

d) 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 1000 runs (depending on the complexity and sensitivity of the calculation model), a good estimate of the statistical distribution of the results is obtained (Figure G.1).

F.3 Examples

F.3.1 General

In a building, measured annual energy uses for successive years are 251; 267; 245; 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 ± 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 Equation (D.3) for two simple examples gives:

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

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

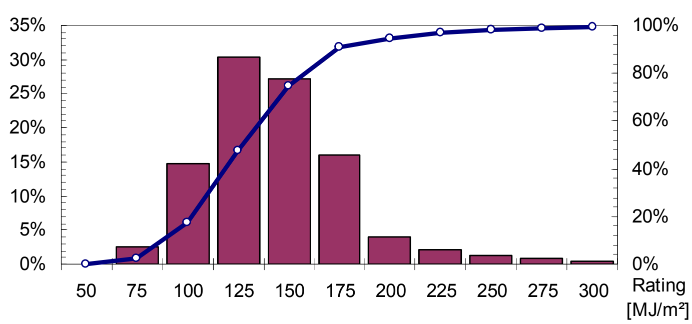
F.3.2 Indications on confidence intervals

Table G.2 — gives indications on 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 G.2 — Standard deviations and distribution type approximately sorted by order of importance for residential buildings

Variable	Standard deviation: Calculated energy rating	Standard deviation: Tailored rating	Distribution
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
Utilisation 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 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



The energy use was calculated with EN ISO 13790 using the Monte-Carlo method and standard deviations of Table G.2, for a tailored rating. The line is the normalised cumulative distribution.

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

Annex G
(informative)

Example

(This annex will be adapted to the new tables 4 to 8 once their form is accepted)

G.1 Building description

This example addresses a public building 38378 m² office space. This building is well insulated, with large glazed area facing south. A gas powered cogeneration plant produces heat and electricity. An adsorption chiller, heated by the cogeneration plant, produces cold in Summer. District heating from waste treatment plant is used for very cold periods.

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

G.1.1 Standard calculated rating

G.1.2 Measured rating

G.1.3 Comparison