INTERNATIONAL STANDARD

ISO 23045

First edition
2008-12-15

Building environment design — Guidelines to assess energy efficiency of new buildings

Conception de l'environnement des bâtiments — Lignes directrices pour l'évaluation de l'efficacité énergétique des bâtiments neufs

Reference number
ISO 23045:2008(E)

Contents

Page

Foreword

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

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 23045 was prepared by Technical Committee ISO/TC 205, *Building environment design*.

Introduction

The world's energy resources are being consumed at a significant rate that will result in the depletion of non-renewable resources. It is imperative that energy be conserved. The building sector, through its use of energy, can represent up to 40 % of the total energy consumption (in mild climates, where heating and cooling correspond to the major energy demand in buildings). Conservation of energy in buildings can result in a slowing down of non-renewable resource usage and consequently of the build-up of greenhouse gases.

This International Standard gives guidelines to introduce energy requirements in the design process or to achieve the designed values of energy efficiency for new buildings. As most buildings are designed to last for a long period (80 y to 100 y), reducing energy consumption can also be considered a means of preserving the financial resources of owners and occupants if energy prices rise due to depleted energy resources or in the event of competition with other non-renewable energy resources.

Data and requirements are introduced in the design process, as described in ISO 16813.

Methods to express energy efficiency are also presented.

Building environment design — Guidelines to assess energy efficiency of new buildings

1 Scope

This International Standard gives guidelines related to energy efficiency in buildings as introduced in ISO 16813.

The objectives of this International Standard are to assist designers and practitioners when collecting and providing the useful data that are required at different stages of the design process and to fulfil the definitions of the building as prepared by building designers.

This International Standard applies to new buildings and is applicable to space air-conditioning equipment and the heating plant in new buildings.

It is assumed that the conditions of indoor spaces are maintained within a comfort range with regard to temperature, humidity, air quality, acoustics and light, or conditions maintained to provide freeze protection for piping or stored materials.

Systems to be considered when assessing the energy efficiency of the building are heating, cooling, lighting, domestic hot water, service water heating, ventilation and related controls.

2 Normative references

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

ISO 16813, *Building environment design — Indoor environment — General principles*

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

3 Terms and definitions

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

3.1
calculation period
period of time over which assessment is carried out, considered as one year

3.2
practitioner
person engaged directly or indirectly in building design activity

EXAMPLE Architects, technical manager, owner, investor.

3.3
systems
processes undergoing assessment

EXAMPLE Heating, cooling, domestic hot water, lighting, ventilation and relevant automation or control.

3.4
surface reference
air-conditioned surface in square metres

4 Fundamentals on energy efficiency

4.1 General

Designing and constructing a building to a specified level of efficiency, starting with the global approach and progressing to the utilization of passive behaviour, shall ensure that the highest process standards are involved (such as HVAC[1]) , lighting, hot water systems and associated controls) and that the highest specifications of the HVAC system and structure are met.

A global approach in designing a system shall consider the interrelationship of how energy used in a process influences the gains or losses in other systems (e.g. the thermal influence of micro-computers on heating or air-conditioning).

The flowchart in Figure A.1 provides a summary of the process, with cross-references to works giving general principles that simplify the conception of the building (see ISO 16813).

Energy efficiency definition is the result of an iterative process from project information up to the final design.

This International Standard will assist in:

— collecting and providing information regarding the energy efficiency of the building under consideration;

— conducting the iterative process to ensure improved energy efficiency of buildings;

— obtaining the target values for energy efficiency ratios used in labelling or information to public or/and consumers.

The design process leads to a reduction in energy demand through a global approach to the building including analysis of the building location, definition of the building envelope, energy systems and products.

4.2 Project information in relation to energy efficiency

4.2.1 Location of the building

The elevation of the building (i.e. ground height above sea level) shall be given in addition to the longitude and latitude. Configuration of the surroundings shall be identified as they might cast shadows on the buildings. Other information about position and orientation of the building shall be given to increase the possibility of recovering energy from the sun, from ground sources (water), and from wind.

4.2.2 Building specification

Building dimensions: global dimensions and ratio of volumes versus external surfaces or windows, and transparent surfaces versus overall external surfaces shall be specified.

1) Heating, ventilation and air conditioning.

Zone dimensions: when calculations are made for each room or zone, all dimensions for the building frame and any dimensions required for zone calculation concerned shall be specified.

Appearance: the nature of outside materials (glass, concrete) with respect to daylight influence shall be specified.

4.2.3 Weather data

Hour by hour data of the following items shall be prepared for a full year:

a) external air temperature in degrees centigrade;

b) relative humidity as a percentage, humidity ratio (dimensionless) or absolute humidity in grams per kilogram;

c) direct solar radiation on each normal surface in watts per square metre;

d) diffuse solar radiation on horizontal surface in watts per square metre;

e) nocturnal radiation on a horizontal surface in watts per square metre;

f) wind speed in metres per second;

g) wind direction in degrees or presentation on a wind rose;

h) precipitation in millimetres;

i) other element with appropriate units, if necessary.

4.2.4 Occupancy

The schedule of building occupancy shall be specified in hours when the space is occupied, as a percentage of full number of occupants. The designed number of occupants shall be taken into consideration.

Set-points for temperature and humidity for the space or zone during the occupied period shall be specified.

Bandwidth acceptability for deviation of set-points shall be specified.

Thermal load and indoor air quality (IAQ) will vary depending on whether the design values used refer to an adapted or a non-adapted person. The category of persons (and related activity, see Annex C) shall be defined for the design.

4.2.5 Identification of site factors for reduction of energy load

Global passive behaviour: reducing energy demand where thermal protection (insulation) is adapted to external climate and local opportunities.

Solar gains: building orientation, windows, solar protection, solar capitation (solar collectors or solar cells).

Water/ground source: input for heat pump inlet.

Wind: natural ventilation.

Daylight: lighting systems and/or solar shading.

Annexes C, D and E provide information about thermal loads due to human activity, lighting and equipment.

4.2.6 Commissioning and operation information

Commissioning occurs at the end of the construction stage. The aim of commissioning is to ensure that the energy performance target values of the building are achieved.

4.3 Introducing the energy efficiency framework

The purpose of the energy efficiency framework is to introduce the correct parameters at any of the four stages of the design in progress.

The flowchart in Figure A.1 provides a summary of the processes, with cross-referencing to works giving general principles that simplify the conception of the building. It shall be completed with respect to the progress of the project as defined in the flowchart in ISO 16813.

Table 1 gives a more detailed description of the requirements that are necessary to meet the energy requirements according to the progress of the design.

Table 1 — Correspondence between different stages of the design and energy requirements

Stage	Building	"System" + "Process"	Products
Project definition	Identify requirements and constraints. Labelling target for energy-efficient building or maximum values for energy delivered should be considered at this stage.	—	—
Stage I Conceptual design	From global approach to passive behaviour of the building Checklist of input and output minimum and maximum level grades for energy requirements Choice of rating (possible or not possible) Information of the optional solutions for design Definition of the systems that directly connect to the energy performance and are linked to the definition of the building. → Highlight design performance of the envelope of the building (solar protection, insulation).	Select the building performance/systems under consideration and analyse the potential for reducing energy demand, then check the possibility of combining it with renewable energy. Some specific guidelines can be introduced at this stage to optimize the use of solar active systems: inclination, orientation conditions and comparison of integration strategies (wall, roof, etc.) in terms of efficiency. { heating/cooling ventilation air conditioning lighting electric power service water } Process: laundry, kitchen, storage	Not under consideration at this stage
Stage II Schematic design	Acceptance of the choice for design of the energy systems after the trade-off between systems	Basic design of the systems Simplified calculation of energy consumption should be available at this stage.	Not under consideration at this stage
Stage III Detail design	—	Detailed design of the system. Calculation of energy consumption available at this stage.	—
Stage IV Final design	Validation of the target (versus energy consumption)	Complete the design of the system by defining the products. Introduce commissioning and operation requirements.	Sizing/labelling of product refer to energy efficiency requirements of the products.

4.4 Renewable energy integration

4.4.1 General

Integration of solar systems into the HVAC systems, lighting and the building envelope is important to reduce the energy load (demand) used to achieve the target value for energy efficiency of the building.

Daylighting and solar gains shall be considered for both positive and negative aspects. Positive aspects are considered to balance lighting and heat load.

4.4.2 Passive solar heating (to be considered at Stage I)

Direct solar heat gain through ordinary windows in winter is automatically taken into account in the procedure, as it will reduce space-heating load.

Solar heat gain through sunny spaces, winter gardens, greenhouses, atria and other sunny spaces shall also be included.

Passive solar components and systems of various designs shall be incorporated using the appropriate procedures, such as Trombe walls and ventilated façades.

Balance between lighting and cooling shall appear in the discussion; the use of passive masks to reduce cooling demand in the summer (hot) season may contribute to increased energy for lighting.

Natural ventilation and complex insulation of the envelope (double coating) are also solutions that can achieve summer thermal comfort with reduced thermal load for the HVAC systems.

4.4.3 Active solar heating and cooling

When the active solar heating and cooling systems are included in the system design, heating and cooling loads may be reduced by the amount supplied by the solar heating and cooling system. If the active solar heating and cooling systems are provided separately from the conventional air cooling system, the refrigeration load and the boiler load are to be reduced accordingly.

Solar systems are considered in two stages:

- calculation of the solar contribution ➔ (energy demand reduced);
- calculation of the energy consumption of the supply system, necessary to achieve thermal comfort and other scheduled objectives.

4.4.4 Photovoltaic integration

Integration of a photovoltaic system is considered to reduce of the electrical energy delivered.

A distinction shall be made between a photovoltaic system that is connected to the electricity grid and that used internally to the building to reduce electrical energy demand, as conception and components of the system may be different.

Hourly scenarios of solar radiation and electricity demand are necessary to identify clearly the real amount of photovoltaic energy produced.

Photovoltaic systems that are only connected to the electrical network shall not be considered as a way to reduce the energy demand (and increase energy performance) of the building.

NOTE When the photovoltaic system of a grid-connection type is provided, a certain amount of electricity to drive refrigeration machines and lighting can be reduced to the extent that the diurnal profile of electricity demand and power generation by photovoltaic system are balanced.

4.4.5 Other systems to be considered

Biomass furnaces, including wood furnaces and biogas furnaces shall also be considered.

Heat pumps utilizing external sources (air, water, ground) help to reduce the electric consumption (regarding the seasonal coefficient of performance of the heat pump system) as part of the energy delivered to the building is used for HVAC and domestic hot water.

Wind power and small-scale hydroelectric power units shall also be considered if the site location offers the possibility to use such facilities for local energy production.

5 Expression of efficiency indicators

5.1 General

The indicators presented in 5.2 to 5.4 are relevant when identifying energy target(s) for the designed building. The choice of indicators shall be made at the earliest stage when the project is defined. Other indicators may be used with respect to any labelling schemes or regulations that apply.

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

The area considered for the expression of efficiency and performance factors is the air-conditioned area as defined in ISO 16818. If this is not applicable, the definition of the floor area shall be given as most factors can be related to this area.

NOTE Normally, all indicators relate to a year.

5.2 Indicators related to the performance of the building envelope

Indicators are relevant to identifying the energy performance of the building envelope, including passive devices such as solar protection or building insulation.

— Indicator 1a: energy use, in kilowatt hours;

— Indicator 1b: energy use/area unit, in kilowatt hours per square metre.

Indicators are relevant to identifying the energy performance of the building envelope, including passive devices such as solar protection.

When local building codes require minimum energy performance of the building envelope as a reference value, a relative indicator represents the ratio between reference energy demand and designed building.

— Indicator 1c: energy use/reference energy use.

NOTE Total reference energy use can be calculated for the same building with thermal envelope performance according to reference building codes at local level.

5.3 Indicators related to integrated energy performance of the building including systems

Indicators 1a, 1b and 1c may be completed with the building performance factors which represent the capacity of the building to fulfil the requirement.

Indicators 2a, 2b and 2c take into account the global performance of the building related to the energy use and efficiency of the systems considered.

The global efficiency ratio of the building is defined as the ratio between total energy delivered to the building, E_D, and energy use, E_R. The total energy delivered, E_D, is the sum of all the energy delivered (gas, fuel oil, electricity) as they are expressed in kilowatt hours[2)] on the basis of an annual energy consumption.

Indicator 2a represents the quantity of energy delivered to the building and is related to annual variation of the building's energy consumption. Indicator 2b represents the density of energy delivered and can be used for comparison for buildings of the same category. Indicator 2c represents the global efficiency of the energy systems considered to operate at design indoor conditions.

— Indicator 2a: energy delivered, in kilowatt hours;

— Indicator 2b: integrated intensity of energy used = 2a/area unit, in kilowatt hours per square metre;

— Indicator 2c: building (active) efficiency = energy use (E_R)/energy delivered(E_D).

5.4 Secondary indicators

5.4.1 Indicators related to primary (or weighted) energy performance

As buildings are connected to energy providers to supply energy, it shall be relevant to assess the performance of the building, including the overall energy performance of energy providers. Primary energy definition has been introduced in that way. In that case, any quantity of energy delivered, E_D, to (or from) the building has to be weighted according to regional values devoted to each energy carrier.

$$E_{\text{D primary energy1}} = E_{\text{D energy1}} \times C_{\text{P energy1}} \tag{1}$$

where $C_{\text{P energy1}}$ is the conversion factor for the energy considered.

— Indicator 3a: total weighted energy delivered $= \sum_I E_{\text{D primary energy}I}$, in kilowatt hours;

— Indicator 3b: integrated intensity of total weighted energy used = 3a/floor unit, in kilowatt hours per square metre;

— Indicator 3c: energy efficiency of the building expressed through primary energy concept, P_{EERB}.

$$P_{\text{EERB}} = \frac{\sum_I E_{\text{R}}}{\sum_I E_{\text{D primary\_energy}I}} \tag{2}$$

5.4.2 Indicators related to global warming contribution (CO_2 emission)

Indicators such as those that identify the pollution impact of buildings shall also be introduced; CO_2 is an identified indicator relevant to global warming considerations, and can be added to main indicators. All greenhouse gases have an equivalent value represented with their GWP (global warming potential) conversion factor to CO_2.

2) Some systems (as cogeneration) may generate energy that is delivered outside the building. Two possibilities are offered. If the system has been sized and designed to fit with the energy demand of the building, energy output reduces the energy consumption of the building. If the system has been designed to deliver energy to different buildings or is not connected to the energy system of the building (e.g. photovoltaic systems directly connected to the electricity grid), the energy provided to the generation system is considered separately; in this case, the system will be considered a separate energy provider if part of the energy is delivered to the building.

Annex F provides information on CO_2 emissions of different fuels.

CO_2 emission is expressed in grams per year or in grams per square metre per year.

NOTE 1 [tonne] unit representing 10^6 g is a more relevant unit.

— 4a: total CO_2 emission per year, in kilograms per year;

— 4b: relative CO_2 emission 4b = 4a/area unit, in grams per square metre per year.

NOTE 2 Other pollutants such as sulfur oxide gases (SO_x) could be also considered for their impact on air acidity.

6 Design process

6.1 General

ISO 16813 describes a framework that allows building designers to progress from the basic requirements to the final design through a step-by-step approach and evaluation of specification and design choices at every stage.

Energy efficiency is part of the input of this iterative framework and input and output are described in this clause for every stage of the design process.

6.2 Stage I — Conceptual design

6.2.1 Inputs

— constraints placed on the design by the client;

— data that will influence the efficiency of the building [i.e. climate, natural resources for water, position of the building to emphasize solar gains or solar protection, wind situation to benefit from natural ventilation and thermal gains (solar, activity, process)];

— the global reason regarding efficiency (i.e. target for rating, certificate of the building or of specified process) with respect to indicators defined in this clause;

— local regulations and codes that apply;

— use of the building.

6.2.2 Outputs

— check the consistency between constraints and objectives;

— define calculation tools and systems considered for the calculation;

— determine the issues that optimize the passive behaviour of the building envelope.

6.3 Stage II — Schematic design

6.3.1 General

The objective of Stage II is to determine the schematic framework of the building and the building environment systems. Once a design problem is defined, the following processes concentrate on the solution. Stage II focuses on the concepts and scheme concerning the building and building environment systems whose structure will determine the following process (i.e. Stage III).

The framework defining how the design problem, formalized in the previous step, is solved shall be determined. The framework is expressed in terms of the building scheme (i.e. the zoning, the circulation, the prospected use and the diagrams to describe the building environment systems such as HVAC, lighting, water service, etc.). The building environment systems that are employed shall be determined in this process.

6.3.2 Inputs

— building dimensions and thermal zone;

— validation of main construction principles (insulation, ventilation, heating and cooling, lighting).

6.3.3 Outputs

— basic definition and thermal characteristics of the building envelope;

— basic design of systems including the balance of energy per system (see Figure B.1);

— relationship between systems;

— main assumptions for systems;

— optimization of the control and functions to be used (taking into account the building occupancy);

— energy calculation (simplified method).

6.4 Stage III — Detail design

6.4.1 General

Stage III is the main stage of the design process where a detailed design is performed. The structure of the building (expressed in terms of the shape, the dimension and the material of the building elements, the characteristics of the building envelope and the spatial and/or functional relations among them and the components of the building environment system) shall be specified. System design shall be included.

6.4.2 Inputs

— validation of schematic design and/or modifications to be taken into account.

6.4.3 Outputs

— sizing and definition of building envelope characteristics (insulation, thermal performance of windows and doors, definition of solar/wind protection);

— design of system and drawings completed;

— energy consumption calculated for each system;

— set-points and target value for control system definition (temperature, humidity, etc.).

6.5 Stage IV — Final design

6.5.1 Inputs

- select the appliances and the products that will be part of the systems;
- check the energy consumption of the building and calculate the efficiency ratio;
- conform to the commissioning process.

6.5.2 Outputs

- sizing and definition of products (power, performance level, control accuracy, etc.);
- design of system and drawings completed;
- energy consumption calculated for each system;
- energy efficiency indicators as expressed in this clause;
- information on energy labelling;
- information regarding commissioning and maintenance.

7 Influential parameters

7.1 General

The parameters listed in 7.2 to 7.5 may influence the calculation of the energy delivered to the building.

7.2 Building environment

- orientation of the building;
- local climate.

7.3 Building characteristics

- building shape (i.e. the ratio between the surface of the envelope and the air-conditioned surface);
- energy efficiency of the building envelope [related to the energy demand or energy required (E_R)].

7.4 Building use

- comfort levels, indoor air quality levels, occupancy, indoor temperature;
- definition of the functionality of the control system [e.g. manual control, timer control, occupancy control, direct control using multi parameters (indoor air, occupancy) with or without any supervisor system];
- correct sizing of all items used in the building operation.

7.5 Calculation tools

The calculation tool used to calculate the energy used shall be determined.

8 Uses for energy performance indicators

8.1 General

Energy performance indicators may be used for labelling buildings with respect to their global energy consumption with a view to prividing labelling or ranking.

Energy indicators can be used for all systems involved in the building construction in order to optimize aggregation.

8.2 Standard assets

As a basis, standard assets shall be considered for new buildings (i.e. standard climate and usage regarding the category of building and its location).

8.3 Other parameters

If others parameters are adapted to climate or usage, these indicators shall be considered to be customized.

Annex A
(normative)

Energy efficiency flowchart

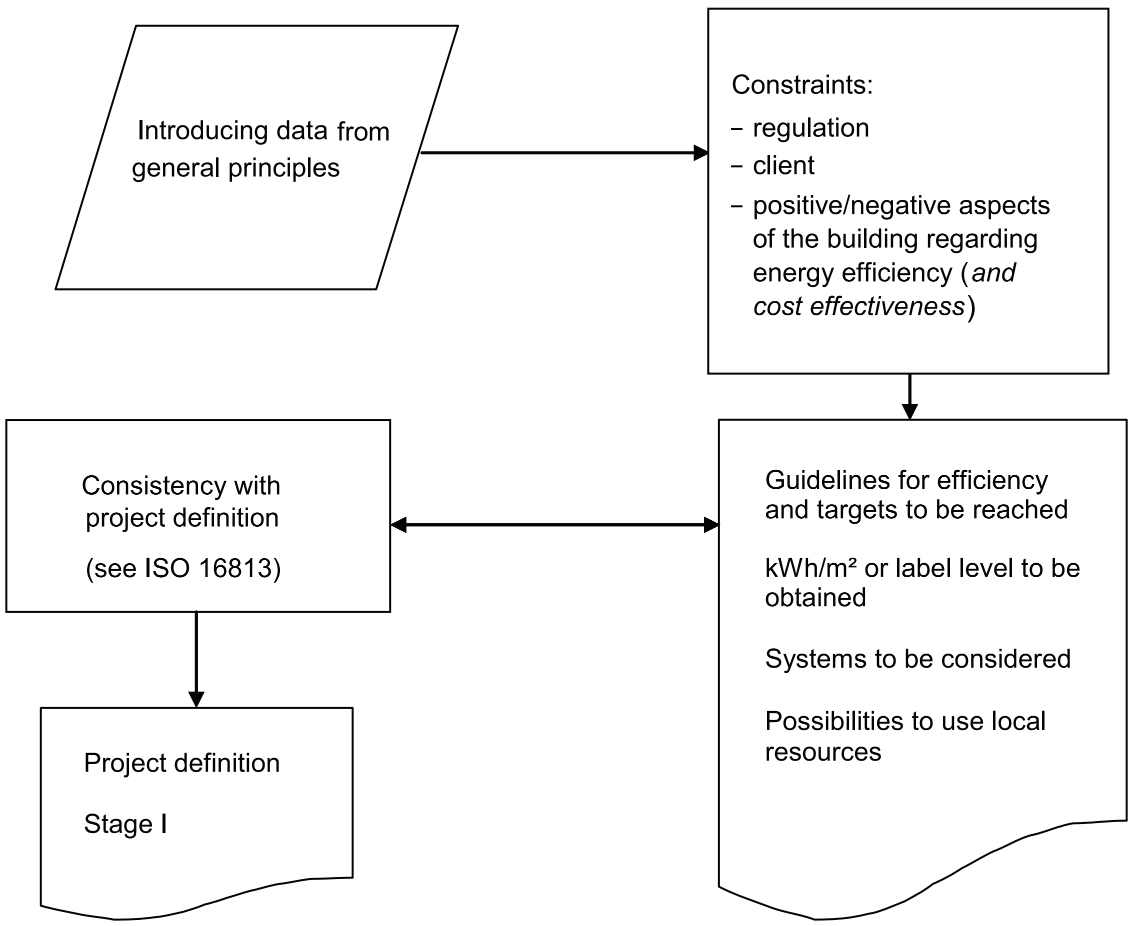
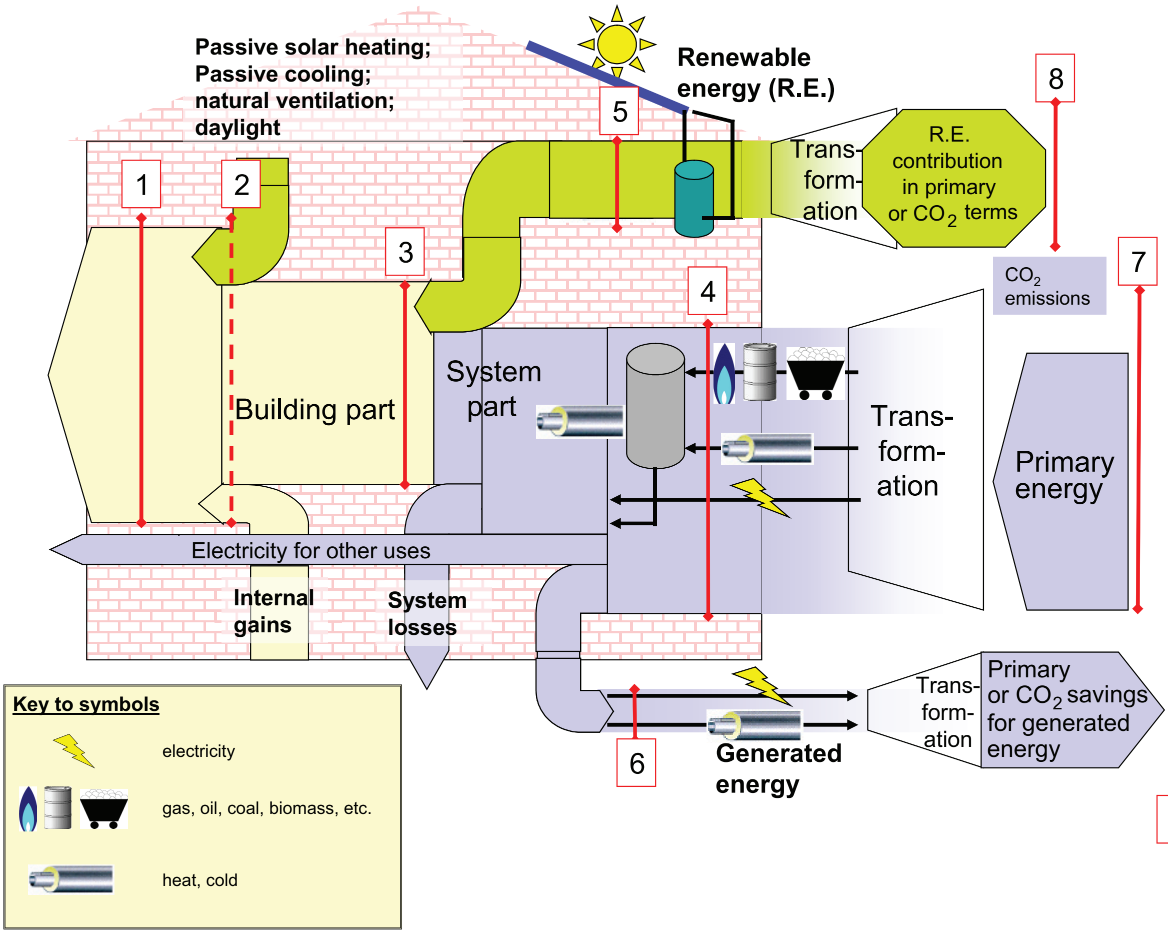


Figure A.1 — Flowchart of design process involving the efficiency of the building

Annex B
(informative)

Global basic energy scheme



Key

1 energy required to fulfil the user's requirements for heating, lighting, cooling, etc. according to levels that are specified for the purposes of the calculation

2 “natural” energy gains — passive solar, ventilation cooling, daylighting, etc. — together with internal gains (occupants, lighting, electrical equipment, etc.); these “gains” reduce energy demand in winter season but increase energy demand in summer season

3 building's net energy use, obtained from [1] and [2] along with the characteristics of the building itself (in winter season [2] is lower than [1] but in summer [2] is greater than [1])

4 delivered energy, represented separately for each energy carrier, inclusive of auxiliary energy, used by heating, cooling, ventilation, hot water and lighting systems, taking into account renewable energy sources and co-generation; this may be expressed in energy units or in units of the energy ware (kg, m^3, kWh, etc.)

5 renewable energy produced on the building premises

6 generated energy, produced on the premises and exported to the market; this can include part of [5]

7 represents the primary energy usage or the CO_2 emissions associated with the building

8 represents the primary energy or emissions associated with on-site generation that is used on-site and is therefore not subtracted from [7]

9 represents the primary energy or CO_2 saving associated with exported energy, which is subtracted from [7]

NOTE The overall calculation process involves following the energy flows from the left to the right of Figure B.1.

Figure B.1 — Global energy scheme (from CEN TR 15615)

Annex C
(informative)

Thermal load due to persons

The heat production of persons consists of a sensible part (radiation plus convection) and a latent part (emission of vapour). For the temperature rise, only the sensible part is relevant.

Table C.1 contains values for the heat production of occupants, which are based on an air temperature of 24 °C that represents the equilibrium value for a sedentary activity.

At higher temperatures the total heat production remains the same, but the sensible heat values decrease.

Table C.1 — Heat production of persons with different activities (air temperature 24 °C)

Activity	Total heat		Sensible heat
	met [a]	$W \cdot person^{-1}$ [b]	$W \cdot person^{-1}$
Reclining	0,8	80	55
Seated, relaxed	1,0	100	70
Sedentary activity (office, school, laboratory)	1,2	125	75
Standing, light activity (shopping, laboratory, light industry)	1,6	170	85
Standing, medium activity (shop assistant, machine work)	2,0	210	105
Walking on the level:			
2 km/h	1,9	200	100
3 km/h	2,4	250	105
4 km/h	2,8	300	110
5 km/h	3,4	360	120

[a] 1 met = 58 $W \cdot m^{-2}$.

[b] Rounded values for a human body with a surface of 1,8 $m^2 \cdot person^{-1}$.

Annex D
(informative)

Thermal load due to lighting

The air conditioning (HVAC) system shall be designed to take into consideration the internal heat load produced by the proposed lighting system.

Typical design values for lighting are given in Table D.1. The given figures are averaged over the area of the room.

Table D.1 — Design lighting level

Kind of use	Typical range of lighting level lux
Office room with window	300 to 750
Office room without window	300 to 750
Department store	300 to 500
Classroom	300 to 500
Hospital ward	200 to 300
Hotel bedroom	200 to 300
Restaurant	200 to 300
Non-habitable room	50 to 100

The electrical power required for a given lighting level depends on the technical solution. Typical values for energy-efficient systems are given in Table D.2.

Table D.2 — Design values for lighting power of energy-efficient lighting systems

Lighting level lux	Specific lighting power $W \cdot m^{-2}$	
	Typical range	Maximum value for low-efficiency lighting systems
50	2,5 to 3,2	6
100	3,5 to 4,5	8
200	5,5 to 7,0	12
300	7,5 to 10,0	16
400	9,0 to 12,5	20
500	11,0 to 15,0	24

Annex E
(informative)

Thermal load due to equipment

As a basis for the design of the HVAC system, all the equipment with relevant emissions in the ventilated space shall be defined.

In office buildings, the heat load due to the equipment is usually between 25 $W \cdot person^{-1}$ and 200 $W \cdot person^{-1}$ averaged over the time period for use. A default value for office buildings is 100 $W \cdot person^{-1}$ during 8 $h \cdot d^{-1}$.

Annex F
(informative)

Default net energy value for fuels

Table F.1 — Default value for delivered energy fuels

Fuel considered	Unit	Energy value MJ	Energy value kWh	CO_2 g/kWh
Natural gas	Nm^3	36,3	10,0	205
Propane/butane	kg	46,0	12,8	205
Light oil/diesel oil	l	42,0	10,0	266
Heavy oil	l	40,2	11,2	282
Coke	kg	29,3	8,1	343
Lignite	kg	8,4	2,3	360
Wood	m^3	7 800,0	2 150	331
Electricity	kWh	3,6	1,0	[a]

[a] For electricity, the value of CO_2 emitted per unit depends on the different fuels used for electricity production. The environmental profile of the electricity distributed shall be available for national information sources or from the electricity supplier.

Bibliography

General standards related to indoor and outdoor conditions

[1] ISO 7730, *Ergonomics of the thermal environment — Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria*

[2] ISO 15927-1, *Hygrothermal performance of buildings — Calculation and presentation of climatic data — Part 1: Monthly means of single meteorological elements*

[3] ISO 15927-2, *Hygrothermal performance of buildings — Calculation and presentation of climatic data — Part 2: Hourly data for design cooling load*

[4] ISO 15927-3, *Hygrothermal performance of buildings — Calculation and presentation of climatic data — Part 3: Calculation of a driving rain index for vertical surfaces from hourly wind and rain data*

[5] ISO 15927-4, *Hygrothermal performance of buildings — Calculation and presentation of climatic data — Part 4: Hourly data for assessing the annual energy use for heating and cooling*

[6] ISO 15927-6, *Hygrothermal performance of buildings — Calculation and presentation of climatic data — Part 6: Accumulated temperature differences (degree-days)*

Standards for design and energy demand related to systems

Heating

[7] EN 12828, *Heating systems in buildings — Design of water-based heating systems*

[8] EN 14337, *Heating systems in buildings — Design and installation of direct electrical room heating systems*

[9] EN 15450, *Heating systems in buildings — Design of heat pump heating systems*

Cooling

[10] ISO 13791, *Thermal performance of buildings — Calculation of internal temperatures of a room in summer without mechanical cooling — General criteria and validation procedures*

[11] EN 15255, *Energy performance of buildings — Sensible room cooling load calculation — General criteria and validation procedures*

Heating and cooling

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

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

Ventilation

[14] ISO 16814, *Building environment design — Indoor air quality — Methods of expressing the quality of indoor air for human occupancy*

[15] ASHRAE 62.1, *Ventilation for Acceptable Indoor Air Quality*

[16] ASHRAE 62.2, *Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings*

[17] EN 13465, *Ventilation for buildings — Calculation methods for the determination of air flow rates in dwellings*

[18] EN 13779, *Ventilation for non-residential buildings — Performance requirements for ventilation and room-conditioning systems*

[19] EN 15240, *Ventilation for buildings — Energy performance of buildings — Guidelines for inspection of air-conditioning systems*

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

Lighting

[21] EN 12464-1, *Light and lighting — Lighting of work places — Part 1: Indoor work places*

[22] EN 12665, *Light and lighting — Basic terms and criteria for specifying lighting requirements*

[23] EN 15193, *Energy performance of buildings — Energy requirements for lighting*

Standards for calculation of delivered energy

Overall building

[24] ASHRAE 90.1, *Energy Standard for Buildings Except Low-Rise Residential Buildings*

[25] ASHRAE 90.2, *Energy-Efficient Design of Low-Rise Residential Buildings*

[26] EN 15232, *Energy performance of buildings — Impact of Building Automation, Controls and Building Management*

[27] EN 15603, *Energy performance of buildings — Overall energy use and definition of energy ratings*

[28] ASHRAE 140, *Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs*

Heating

[29] EN 15316-1, *Heating systems in buildings — Method for calculation of system energy requirements and system efficiencies — Part 1: General*

[30] EN 15316-2-1, *Heating systems in buildings — Method for calculation of system energy requirements and system efficiencies — Part 2-1: Space heating emission systems*

[31] EN 15316-2-3, *Heating systems in buildings — Method for calculation of system energy requirements and system efficiencies — Part 2-3: Space heating distribution systems*

[32] EN 15316-4-3, *Heating systems in buildings — Method for calculation of system energy requirements and system efficiencies — Part 4-3: Heat generation systems, thermal solar systems*

[33] EN 15316-4-5, *Heating systems in buildings — Method for calculation of system energy requirements and system efficiencies — Part 4-5: Space heating generation systems, the performance and quality of district heating and large volume systems*

[34] EN 15316-4-6, *Heating systems in buildings — Method for calculation of system energy requirements and system efficiencies — Part 4-6: Heat generation systems, photovoltaic systems*

[35] EN 15377-3, *Heating systems in buildings — Design of embedded water based surface heating and cooling systems — Part 3: Optimizing for use of renewable energy sources*

Domestic hot water

[36] EN 15316-3-1, *Heating systems in buildings — Method for calculation of system energy requirements and system efficiencies — Part 3-1: Domestic hot water systems, characterisation of needs (tapping requirements)*

[37] EN 15316-3-2, *Heating systems in buildings — Method for calculation of system energy requirements and system efficiencies — Part 3-2: Domestic hot water systems, distribution*

[38] EN 15316-3-3, *Heating systems in buildings — Method for calculation of system energy requirements and system efficiencies — Part 3-3: Domestic hot water systems, generation*

Economic performance

[39] ISO 15686-5, *Building and constructed assets — Service-life planning — Part 5: Life-cycle costing*

[40] EN 15459, *Energy performance of buildings — Economic evaluation procedure for energy systems in buildings*

[41] CEN/TR 15615, *Explanation of the general relationship between various European standards and the Energy Performance of Buildings Directive (EPBD) — Umbrella Document*

ICS 91.040.01

Price based on 20 pages