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Framework of the design process for energy-saving single-family residential and small commercial buildings

Cadre général d'un processus de conception d'habitations individuelles et de petits bâtiments commerciaux permettant d'économiser de l'énergie

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Foreword

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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.

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ISO 13153 was prepared by Technical Committee ISO/TC 205, *Building environment design*.

Introduction

This International Standard provides the framework for a design process for single-family residential and small commercial buildings, characterized by the “energy consumption ratio” as the key criterion. The design process, or design guidelines explaining the design process, is prepared by suppliers of the design guidelines for designers of buildings as a whole system, building envelopes or building equipment, all of which are deeply related to the energy performance of buildings. Designers play the most important role in the wide propagation of energy-saving technologies because they often make the final decisions on whether energy-saving technologies should be adopted or not, and which energy-saving technologies should be adopted in actual building projects.

Framework of the design process for energy-saving single-family residential and small commercial buildings

1 Scope

This International Standard specifies a framework of the design process for energy-saving single-family residential and small commercial buildings, with the energy consumption ratio as the key criterion. It is intended to assist in the development of design guidelines for practitioners who design energy-related parts of buildings.

This International Standard is applicable only to the design process for single-family residential and small commercial buildings.

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*

ISO 23045, *Building environment design — Guidelines to assess energy efficiency of new buildings*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 16813, ISO 16818 and ISO 23045 and the following apply.

3.1
analogical inference
prediction of energy consumption or effectiveness in energy saving of a certain specification of a certain elemental technology on the basis of a design process or design guidelines, where the prerequisite design condition does not agree completely with that of the building project of concern

3.2
design condition
condition which affects functions of energy-saving elemental technologies and is taken into account in order to design the building concerned

3.3
designer
general designer
practitioner who designs buildings and equipment, and does not necessarily have expertise in energy-related aspects of buildings

3.4
design guidelines
media which include information on how to design buildings and on the design process

3.5
design process
course of actions performed by designers to produce a set of specifications and drawings

3.6
energy consumption ratio
ratio of predicted energy consumption for a certain energy use to the reference energy consumption

3.7
elemental technology
energy-saving elemental technology
group of design methods or specifications which constitute a common function in buildings and are proved to reduce energy consumption when compared with a reference method and specification

3.8
energy use
purpose of the equipment for which energy is used

EXAMPLE Space heating, space cooling, ventilation, domestic hot water, lighting, cooking, consumer electronics, etc.

3.9
predicted energy consumption
energy consumption in primary energy for a particular energy use or a sum of energy uses, which is predicted by taking actual performance of building components and actual efficiency of equipment into consideration as much as possible

3.10
project definition
process of providing the relevant information for designers and others to define the scope of the work

NOTE The project definition lists the given constraints, which cannot be revised, and the project requirements, the theories and assumptions. All of these might not be completely defined at this stage. Some of these may be revised in response to feedback from later stages of the design process.

3.11
reference energy consumption
predicted energy consumption of a building with reference specifications for elemental technologies

3.12
reference specification for elemental technology
reference specification
specification whose energy performance is regarded as a reference standard

3.13
specification
information which specifies the construction of a part of buildings or the requirements for installed equipment

3.14
supplier of design guidelines
expert who produces and supplies design guidelines for designers by using his/her expertise on energy-related aspects of buildings

4 Symbols, units and abbreviations

Table 1 — Symbols, units and abbreviations

Symbol	Quantity	Unit
E_i	reference annual energy consumption in primary energy for energy use "i"	GJ/a
E_T	predicted annual energy consumption in primary energy taking power generation by photovoltaic cells into consideration	GJ/a
ET	elemental technology	
EU	energy use	
e_e	predicted annual electrical load	kWh/a
e_i	predicted annual energy consumption for energy use "i"	GJ/a
e_PV	predicted power generation by photovoltaic cells	GJ/a
e_T	predicted total annual energy consumption for energy use "1", "2", ⋯ , "N"	GJ/a
$e_{i,j,k}$	predicted annual energy consumption in primary energy for energy use "i", when the level of option "k" of the elemental technology "j" is adopted	GJ/a
$e_{i,j_1k_{j_1}+j_2k_{j_2}+\dots+j_nk_{j_n}}$	predicted annual energy consumption in primary energy for energy use "i", when the level of option "k_{j_1}" of the elemental technology "j_1", the level of option "k_{j_2}" of the elemental technology "j_2", ⋯ and the level of option "k_{j_n}" of the elemental technology "j_n" are adopted	GJ/a
L_dhw	predicted annual heat load for domestic hot water	GJ/a
L_h	predicted annual heat load for hot-water space heating	GJ/a
N	number of energy uses with which the design process deals	-
n	number of elemental technologies that are effective in saving each energy use	-
$r_{i,j,k}$	energy consumption ratio for energy use "i", when the level of option "k" of the elemental technology "j" is adopted	-
$r_{i,j_n,k_{j_n}}$	energy consumption ratio for energy use "i", when the level of option "k_{j_n}" of the elemental technology "j_n" is adopted	-
$r_{i,j_1,k_{j_1}+j_2,k_{j_2}+\dots+j_n,k_{j_n}}$	energy consumption ratio for energy use "i", when evaluating the interaction among options of multiple elemental technologies (the level of option "k_{j_1}" of the elemental technology "j_1", the level of option "k_{j_2}" of the elemental technology "j_2", ⋯ and the level of option "k_{j_n}" of the elemental technology "j_n")	-

5 Fundamentals

5.1 General

The design process, whose framework is given by this International Standard, has its own characteristics. The primary characteristic is being equipped with quantitative information on the energy-saving effectiveness of design options. It comes from the fact that there are still many designers who are engaged mainly in small-scale building projects and cannot carry out their own tailor-made evaluation of the design options by themselves. The following shows the decisions by those designers, who are assisted by the design process and the design guidelines as their media. In this International Standard, "elemental technology" and "specification" are fundamental concepts in the design process.

5.2 Core decisions by designers in design process in this International Standard

5.2.1 Provisional selection of elemental technologies

In the design process for energy conservation in buildings, the provisional selection of elemental technologies, which are to be evaluated for their effectiveness before the final selection, shall be made. The number of provisionally selected elemental technologies depends on design conditions.

EXAMPLE In cold climates, the insulation of the building envelope is selected as an elemental technology, which contributes to energy conservation in space heating energy. Other examples of the elemental technologies are given in A.2.

5.2.2 Provisional selection of specification for the elemental technology

After the selection of a certain elemental technology, the specification for the elemental technology shall be provisionally selected so that the effect of the design on energy consumption can be quantitatively evaluated.

NOTE Examples of specifications for elemental technologies are given in Annex A.

EXAMPLE The performance of the insulation of the building envelope is dependent on thermal resistance of insulation materials, thermal transmittance of windows and construction method affecting the air movement in or through the building envelope. Options for overall specification of the envelope from the viewpoint of the insulation are prescribed by those parameters.

5.2.3 Final selection of the options for specifications to be adopted in the building project

After checking predicted energy consumption or the reduction of energy consumption from the reference specifications, and after checking the balance between initial cost increase and running cost reduction, designers make the final selection on the options for specifications of elemental technologies if they give satisfactory results from the viewpoint of energy conservation and cost-effectiveness.

5.3 Key information helpful for the core decisions

5.3.1 Characteristics of elemental technologies

The elemental technologies, which are covered by the design process according to this International Standard, shall be clearly defined and explained in the design guidelines in plain terms with explanations of technical terms in engineering fields with which general designers of buildings may not be familiar. Technologies for energy conservation in buildings are not necessarily well-known to general designers of buildings. In order to propagate such technologies, even basic information shall be provided in design guidelines so that the designers can understand how each elemental technology can reduce energy consumption.

5.3.2 Characteristics of options of specifications for elemental technologies

It is necessary not only to let designers know of the existence and characteristics of elemental technologies for energy conservation in buildings, but also to give them enough knowledge about specifications for the elemental technologies. Among the options, the reference specification shall be included and explained so that the designers can evaluate each option in comparison with the reference specification.

Specification options are accompanied with requirements and warnings (e.g., higher skill level of workers, indispensability of heavier maintenance, etc.), which shall be followed by the designers or installers to assure the performance of the options. The descriptions of options for specifications shall clearly stipulate how to design and construct/install the part of the buildings. If the designers or installers cannot follow such requirements and warnings in their circumstance, they cannot adopt the options, however large an energy reduction they can make.

5.3.3 Quantitative information on the effectiveness of each option for specification

The reduction of energy consumption is the most important objective of the design process prescribed in this International Standard. Therefore, the information on the predicted reduction of energy is the key information, which shall be prepared by suppliers of the design process and its medium. The predicted reduction shall be expressed by the energy consumption ratio, which is defined by the ratio of predicted energy consumption to the reference energy consumption as for a related energy use.

All options of specifications for each elemental technology shall be named “LEVEL 0”, “LEVEL 1”, “LEVEL 2” and so on. “LEVEL 0” shall be allocated to the reference specification as a standard level. Options with smaller energy consumption ratios shall be given a level with a higher number. If there are any specifications with a predicted energy consumption higher than the standard level included in the options, they shall be named “LEVEL -1”, “LEVEL -2” and so on.

The relationship among the reference energy consumption, the energy consumption ratio and the predicted energy consumption is as expressed in Equation (1).

$$e_{i,j,k} = E_i \times r_{i,j,k} \tag{1}$$

where

$e_{i,j,k}$ is the predicted energy consumption for energy use “i” (GJ/a), when the level of option “k” of the elemental technology “j” is adopted;

E_i is the reference energy consumption for energy use “i” (GJ/a);

$r_{i,j,k}$ is the energy consumption ratio for use “i”, when the level of option “k” of the elemental technology “j” is adopted.

The reality and reliability of the method of predicting energy consumption is crucial for designers. For this reason, the grounds for the prediction shall be explained within the design guideline, as specified in 6.5.

In cases where plural elemental technologies are effective in reducing energy consumption for a common energy use, prediction by multiplying energy consumption ratios for those plural elemental technologies is acceptable as an approximation, as shown in Equation (2).

$$e_{i,j_1 k_{j_1}+j_2 k_{j_2}+\cdots+j_n k_{j_n}} = E_i \times r_{i,j_1,k_{j_1}} \times r_{i,j_2,k_{j_2}} \times \cdots \times r_{i,j_n,k_{j_n}} \tag{2}$$

where

$e_{i,j_1 k_{j_1}+j_2 k_{j_2}+\cdots+j_n k_{j_n}}$ is the predicted energy consumption for energy use “i” (GJ/a), when the level of option “k_{j_1}” of the elemental technology “j_1”, the level of option “k_{j_2}” of the elemental technology “j_2”, and the level of option “k_{j_n}” of the elemental technology “j_n” are adopted;

E_i is the reference energy consumption for energy use “i” (GJ/a);

$r_{i,j_n,k_{j_n}}$ is the energy consumption ratio for energy use “i”, when the level of option “k_{j_n}” of the elemental technology “j_n” is adopted.

If the interaction of different elemental technologies on the effectiveness in energy saving is to be taken into consideration, the energy consumption ratio evaluating combined effectiveness can also be used as expressed in Equation (3).

$$e_{i,j_1 k_{j_1}+j_2 k_{j_2}+\cdots+j_n k_{j_n}} = E_i \times r_{i,j_1 k_{j_1}+j_2 k_{j_2}+\cdots+j_n k_{j_n}} \tag{3}$$

where

$e_{i,j_1k_{j_1}+j_2k_{j2}+\cdots+j_nk_{j_n}}$ is the predicted energy consumption for energy use "i" (GJ/a), when the level of option "k_{j_1}" of the elemental technology "j_1", the level of option "k_{j_2}" of the elemental technology "j_2", ... and the level of option "k_{j_n}" of the elemental technology "j_n" are adopted;

E_i is the reference energy consumption for energy use "i" (GJ/a);

$r_{i,j_1k_{j_1}+j_2k_{j_2}+\cdots+j_nk_{j_n}}$ is the energy consumption ratio for energy use "i" evaluating combined effectiveness in energy saving, when the level of option "k_{j_1}" of the elemental technology "j_1", the level of option "k_{j_2}" of the elemental technology "j_2", ... and the level of option "k_{j_n}" of the elemental technology "j_n" are adopted.

5.3.4 Prediction of total energy consumption by using reference energy consumption and energy consumption ratios

The total energy consumption is predicted by summing up predicted energy consumptions for energy uses of concern, as shown in Equation (4).

$$e_{\mathrm{T}} = \sum_{i=1}^{N} e_i \qquad (4)$$

where

e_{T} is the predicted total energy consumption for energy use "1", "2", ..., "N" (GJ/a);

e_i is the predicted energy consumption for energy use "i" (GJ/a) and can be calculated using Equation (1), (2) or (3).

5.3.5 Initial cost of each option for specifications

The payback period of implemented elemental technologies is useful information for designers and clients. When actual prices of products and labour costs are not available, price lists of products supplied by manufacturers or any existing database for construction labour cost are used, with an additional explanation on the source of the information.

5.3.6 Merits of elemental technologies other than energy conservation

Depending on design conditions, some elemental technologies may need a longer payback period. Even in that situation, designers may choose such kinds of elemental technologies because of merits other than energy conservation and cost effectiveness, such as the improvement of the indoor environment. Due to such diverse values of the elemental technologies, merits other than energy conservation shall be included in the explanation of the elemental technologies.

6 Energy consumption ratio and its grounds

6.1 General

As defined in Clauses 3 and 4, the energy consumption ratio contains information on the change of energy consumption for a related energy use, when a certain specification of a certain elemental technology is adopted under the prerequisite design conditions. The ratio shall be determined beforehand by suppliers of the design guidelines, which describe a particular design process for energy-saving buildings.

6.2 Energy uses

The various energy uses in buildings include space heating, space cooling, domestic hot water, ventilation, lighting, consumer electronics and cooking. The effect of a certain elemental technology for energy saving appears primarily in one of those energy uses. Therefore, when designers evaluate a certain elemental technology and its options for specifications, they concentrate on a single related energy use to check the performance of the options. When designers attempt to reduce the overall energy consumption, they should try to reduce different energy uses by checking different elemental technologies and their options for specifications, one by one.

6.3 Prerequisite design conditions for design process

Energy performance of technologies is often dependent on prerequisite design conditions, even if the technologies are energy-saving in general. In order to supply practical and simple design guidelines, design conditions, under which the effects of elemental technologies are quantified, shall be limited and clearly described. The design guidelines shall be focused on similar climatic zones (ideally a single climatic zone), a limited building type, use and size. This is a disadvantage of the design process and the design guidelines outlined in this International Standard, especially when compared with simulation programs, which can be applied to a wider range of design conditions. However, it is indispensable to limit the applicable design conditions so as to be able to prepare design processes and guidelines that are easy to use for those not familiar with simulation programs. Preparing the design process and design guidelines individually for different design conditions, and so that they cover a wide range of design conditions, allows general designers to choose the design process and guidelines most suited to their own building project, with limited analogical inference.

The prerequisite design conditions include the following:

— climatic conditions, which are represented by climatic zones or factors, such as dry-bulb temperature, humidity, solar radiation, wind speed and direction;

— building shape;

— construction type (wooden, brick, reinforced-concrete, or steel construction);

— building lot (size and orientation) and surrounding conditions (adjacent buildings, environmental quality and security);

— lifestyle of occupants (occupancy, hot water usage, lighting pattern, use of electric appliances, window opening behaviour, and requirement for indoor temperature and humidity) for residential buildings;

— building use and occupancy (working hours, number of occupants, hot water usage, lighting pattern, use of electric appliances, and requirement for indoor temperature and humidity) for small commercial buildings; and,

— internal heat gain due to occupants' metabolism, artificial lighting, electric appliances.

6.4 Reference specifications for elemental technologies

Designers choose a specification by comparing options. Among those options for specifications there shall be a standard one, which is the reference specification representing a typical specification at a certain time under the prerequisite design conditions.

EXAMPLE If a certain usual specification for houses built in 2000 is chosen, the designers get the information on how much energy can be saved by using the energy consumption ratio of each option for the elemental technology, comparing to the standard houses built in 2000.