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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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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
$e_{i,j_1 k_{j_1} + j_2 k_{j_2} + \ldots + j_n k_{j_n}}$	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	-
$r_{i,j_1,k_{j_1}+j_2,k_{j_2}+\ldots+j_n,k_{j_n}}$	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).

$$e_{i,j,k} = E_i \times r_{i,j,k} \quad (1)$$

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).

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

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).

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

where

$e_{i,j_1k_{j_1}+j_2k_{j_2}+\cdots+j_nk_{j_n}}$ 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.

6.5 Grounds for energy consumption ratio

The following methods, or their combinations, shall be used as the basis for predicting energy consumption.

6.5.1 Numerical simulations

If the relationship among parameters by which energy consumption is determined has been found in theory and validated by any facts, it can be used to predict the energy consumption in computer simulations or in simpler calculation methods. In some numerical simulations, there may be input data which is difficult to obtain with proofs and is usually given a value as an assumption. Especially as an input data for energy efficiency of equipment, a value measured under a rating condition is usually substituted, but the correspondence and discrepancy between the rating condition and the actual condition when the equipment is used shall be carefully checked by the suppliers of the design guidelines.

6.5.2 Experiments

Experiments are important for the estimation of the energy efficiency of equipment, because the efficiency data obtained under rating conditions is insufficient when the actual conditions differ significantly with regard to key factors having a large influence on energy efficiency.

For experiments where the actual energy efficiency of equipment is to be determined, the actual usage pattern of the equipment by occupants shall be modelled and applied.

NOTE Some notes are given in Annex B.

6.5.3 Field surveys

Field surveys provide direct information for actual conditions in buildings. The direct information includes occupants' behaviour (occupancy, usage of equipment and appliances, window opening), indoor environment (temperature, humidity, illuminance) and actual behaviour of equipment and appliances (input/output and related conditions).

6.6 Cogenerations and photovoltaic cells

The output from the cogenerations and photovoltaic cells is used for multiple energy uses, and the energy consumption ratio is not an appropriate index.

For cogenerations, the total energy consumption in buildings, including energy consumed by the cogeneration itself is predicted by the function of annual heat and electricity load. The function is obtained from the experiment of the cogenerations with patterns of heat and electricity load. The energy consumption when using the cogenerations can be predicted using Equation (5).

$$e_{\mathrm{T}} = C_1 \times e_{\mathrm{e}} + C_2 \times (L_{\mathrm{dhw}} + L_{\mathrm{h}}) + C_3 \tag{5}$$

where

e_{T} is the predicted total energy consumption (GJ/a);

e_{e} is the predicted electrical load (kWh/a);

L_{dhw} is the predicted heat load for domestic hot water (GJ/a);

L_{h} is the predicted heat load for hot-water space heating (GJ/a);

C_1, C_2, C_3 are constants.

For photovoltaic cells, an annual amount of power generation is predicted by installed peak power (kW_p), estimated system losses (%) and annual solar radiation on installed PV panels (kWh/m^2). The annual amount is to be deducted from the total energy consumption of the building, as shown in Equation (6).

$$E_T = e_T - e_{PV} \tag{6}$$

where

E_T is the predicted total energy consumption taking power generation by photovoltaic cells into consideration (GJ/a);

e_T is the predicted total energy consumption without taking power generation by photovoltaic cells into consideration (GJ/a);

e_{PV} is the predicted power generation by photovoltaic cells (GJ/a).

6.7 Further information derived from energy consumption ratio

The CO_2 emission due to consumed energy is calculated from energy consumption by using a conversion factor given in terms of CO_2 emission per unit of consumed energy.

Running cost for consumed energy is also calculated from energy consumption and the rating system for the energy.

If there are different conversion factors or rating systems according to time, energy consumption within each time zone shall be predicted.

6.8 Overall structure for predicting total energy consumption by using reference energy consumptions and energy consumption ratios of specifications for elemental technologies

Table 2 shows the relationship among the parameters described above. In this case, six energy uses, EU_1, EU_2, ···, EU_6, are dealt with in the design process, three elemental technologies are effective in reducing each energy use, 18 elemental technologies are dealt with as a whole in the design process, and four levels plus one reference level of specification are available for each elemental technology. In reality, the number of elemental technologies for each energy use can be different, and the number of levels of specification can also be different for each elemental technology. At the bottom of Table 2, four levels of power generation by photovoltaic cells are given with the amount of generated energy in addition to the reference level, namely, “LEVEL 0”. The number of the levels depends on cases.

The energy consumption ratios given in Table 2 are determined using Equation (2) and are based on the assumption that the interaction between plural elemental technologies effective in reducing a common energy use can be negligible.

EXAMPLE An example of Table 2 is contained in Table A.1.

Table 3 shows how the parameters shown in Table 2 are used in the calculation for predicting energy consumption for each energy use and total energy consumption. After selecting specifications for all technological elements listed in Table 2, energy consumption ratios are inserted in the calculation formulas shown in the second column. The reduction rate shown in the row of the subtotal means the ratio of energy reduced owing to the selected specifications except for photovoltaic cells. The reduction rate shown in the row of the total means the overall effectiveness of selected elemental technologies including the photovoltaic cells.

NOTE An example of Table 3 is contained in Table A.2.

Table 2 — Energy use parameters

Energy use EU$_i$	**Reference energy consumption** E_i (GJ/a)	**Elemental technology** ET$_j$	**Energy consumption ratio of each "LEVEL" of specification**				
			LEVEL 0 ($r_{i,j,0}$ = 1,0)	**LEVEL 1**	**LEVEL 2**	**LEVEL 3**	**LEVEL 4**
EU$_1$	E_1	ET$_1$	$r_{1,1,0}$	$r_{1,1,1}$	$r_{1,1,2}$	$r_{1,1,3}$	$r_{1,1,4}$
		ET$_2$	$r_{1,2,0}$	$r_{1,2,1}$	$r_{1,2,2}$	$r_{1,2,3}$	$r_{1,2,4}$
		ET$_3$	$r_{1,3,0}$	$r_{1,3,1}$	$r_{1,3,2}$	$r_{1,3,3}$	$r_{1,3,4}$
EU$_2$	E_2	ET$_4$	$r_{2,4,0}$	$r_{2,4,1}$	$r_{2,4,2}$	$r_{2,4,3}$	$r_{2,4,4}$
		ET$_5$	$r_{2,5,0}$	$r_{2,5,1}$	$r_{2,5,2}$	$r_{2,5,3}$	$r_{2,5,4}$
		ET$_6$	$r_{2,6,0}$	$r_{2,6,1}$	$r_{2,6,2}$	$r_{2,6,3}$	$r_{2,6,4}$
EU$_3$	E_3	ET$_7$	$r_{3,7,0}$	$r_{3,7,1}$	$r_{3,7,2}$	$r_{3,7,3}$	$r_{3,7,4}$
		ET$_8$	$r_{3,8,0}$	$r_{3,8,1}$	$r_{3,8,2}$	$r_{3,8,3}$	$r_{3,8,4}$
		ET$_9$	$r_{3,9,0}$	$r_{3,9,1}$	$r_{3,9,2}$	$r_{3,9,3}$	$r_{3,9,4}$
EU$_4$	E_4	ET$_{10}$	$r_{4,10,0}$	$r_{4,10,1}$	$r_{4,10,2}$	$r_{4,10,3}$	$r_{4,10,4}$
		ET$_{11}$	$r_{4,11,0}$	$r_{4,11,1}$	$r_{4,11,2}$	$r_{4,11,3}$	$r_{4,11,4}$
		ET$_{12}$	$r_{4,12,0}$	$r_{4,12,1}$	$r_{4,12,2}$	$r_{4,12,3}$	$r_{4,12,4}$
EU$_5$	E_5	ET$_{13}$	$r_{5,13,0}$	$r_{5,13,1}$	$r_{5,13,2}$	$r_{5,13,3}$	$r_{5,13,4}$
		ET$_{14}$	$r_{5,14,0}$	$r_{5,14,1}$	$r_{5,14,2}$	$r_{5,14,3}$	$r_{5,14,4}$
		ET$_{15}$	$r_{5,15,0}$	$r_{5,15,1}$	$r_{5,15,2}$	$r_{5,15,3}$	$r_{5,15,4}$
EU$_6$	E_6	ET$_{16}$	$r_{6,16,0}$	$r_{6,16,1}$	$r_{6,16,2}$	$r_{6,16,3}$	$r_{6,16,4}$
		ET$_{17}$	$r_{6,17,0}$	$r_{6,17,1}$	$r_{6,17,2}$	$r_{6,17,3}$	$r_{6,17,4}$
		ET$_{18}$	$r_{6,18,0}$	$r_{6,18,1}$	$r_{6,18,2}$	$r_{6,18,3}$	$r_{6,18,4}$
Total	ΣE_i						
		Photovoltaic power generation (GJ/a)	e_{PV0} (0 GJ/a)	e_{PV1}	e_{PV2}	e_{PV3}	e_{PV4}

Table 3 — Calculation for predicting energy consumption for each energy use and total energy consumption, E_T, on the basis of reference energy consumptions and energy consumption ratios in Table 1

Energy use EU_i	Calculation formula for predicting energy consumption	Predicted energy consumption or power generation (GJ/a)	Reference energy consumption (GJ/a)	Reduction rate
EU_1	$E_1 \times r_{1,1,k11} \times r_{1,2,k12} \times r_{1,3,k13}$	$e_{1,1k11+2k12+3k13}$	E_1	$1- e_{1,1k11+2k12+3k13}/E_1$
EU_2	$E_2 \times r_{2,1,k21} \times r_{2,2,k22} \times r_{2,3,k23}$	$e_{2,1k21+2k22+3k23}$	E_2	$1- e_{2,1k21+2k22+3k23}/E_1$
EU_3	$E_3 \times r_{3,1,k31} \times r_{3,2,k32} \times r_{3,3,k33}$	$e_{3,1k31+2k32+3k33}$	E_3	$1- e_{3,1k31+2k32+3k33}/E_1$
EU_4	$E_4 \times r_{4,1,k41} \times r_{4,2,k42} \times r_{4,3,k43}$	$e_{4,1k41+2k42+3k43}$	E_4	$1- e_{4,1k41+2k42+3k43}/E_1$
EU_5	$E_5 \times r_{5,1,k51} \times r_{5,2,k52} \times r_{5,3,k53}$	$e_{5,1k51+2k52+3k53}$	E_5	$1- e_{5,1k51+2k52+3k53}/E_1$
EU_6	$E_6 \times r_{6,1,k61} \times r_{6,2,k62} \times r_{6,3,k63}$	$e_{6,1k61+2k62+3k63}$	E_6	$1- e_{6,1k61+2k62+3k63}/E_1$
Subtotal	-	e_T	ΣE_i	$1- e_T/\Sigma E_i$
Photovoltaic power generation	-	e_{PVj}		
Total	$e_T - e_{PVj}$	E_T	ΣE_i	$1- E_T / \Sigma E_i$

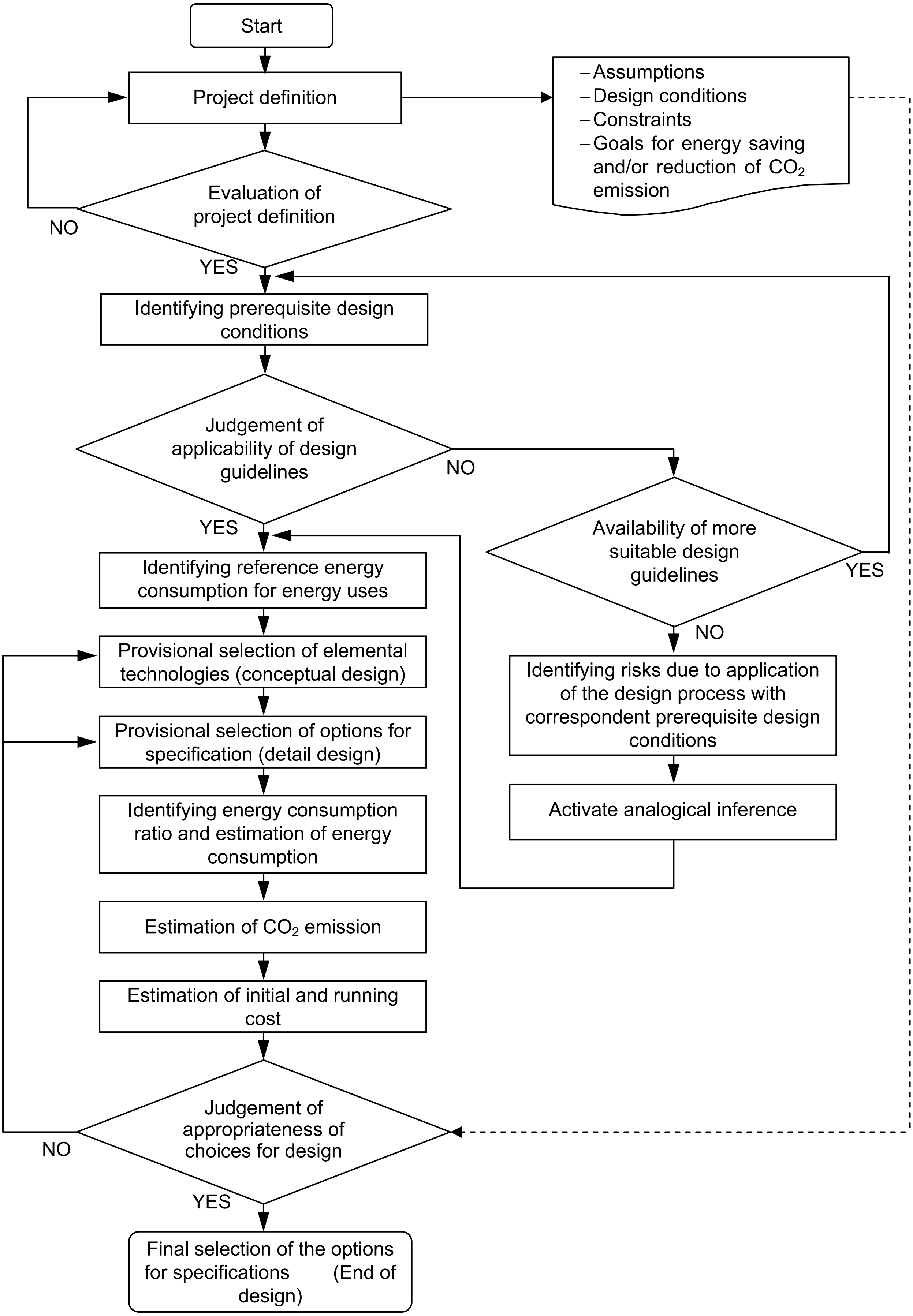

Figure 1 — Flow of design process with the energy consumption ratio as a criterion

7 Design process

7.1 General

The structure of the design process is prescribed in the following subclauses. The flow of the design process is shown in Figure 1.

7.2 Flow of the design process

7.2.1 Project definition

Project definition is the process in which designers obtain the information to define the scope of their work. The project definition lists the given constraints, the project requirements and assumptions, according to ISO 16813. In the project definition, goals for energy conservation and/or reduction of CO_2 emission are defined. The goals are to be referred to in the later stage when judging the appropriateness of design choices.

7.2.2 Evaluation of project definition

The consistency of the content of the constraints, the requirements and the assumptions shall be verified at this stage. The feasibility of the given requirements under the constraints and the assumptions shall also be verified. The major concern is whether or not the project definition is adequate and optimal under the given constraints.

7.2.3 Identifying prerequisite design conditions

In this process, the correspondence between prerequisite design conditions of the design process and design conditions for a particular building project shall be checked. The design conditions are a part of the project definition, which is focused only on the energy-related project definition.

7.2.4 Judgement of applicability of design guidelines and analogical inference, if necessary

If the prerequisite design conditions of the design guidelines correspond well to the design conditions of the project, the design process described in the design guidelines is judged to be applicable to the project. If not, the designer is to search for any other appropriate design guidelines. If the designer cannot find an appropriate design guideline, it is acceptable to utilize available design guidelines by making the analogical inference from the information in the design guidelines. In the analogical inference, there is a risk of misuse of the information on the effectiveness of a certain specification of a certain elemental technology, whose effectiveness changes considerably between the prerequisite design conditions and design conditions of the project. Therefore, such risk shall be explained as a caution to designers, and information on influential design conditions, which determine the effectiveness of elemental technologies, shall be given in design guidelines, even if it is not quantitative.

7.2.5 Identifying reference energy consumption for energy uses

The profile of energy consumptions for different uses is fundamental when a designer selects elemental technologies to be adopted. The resources of clients should be used for the reduction of energy use across larger applications, because the adoption of the same elemental technologies across larger applications will result in increased energy reductions.

7.2.6 Provisional selection of elemental technologies

To start evaluating and predicting energy consumption, a provisional decision to select some of the elemental technologies shall be made by designers at this stage. The selection and the evaluation are done iteratively, before reaching the final selection, by which satisfactory results for predicted energy consumption and for other constraints are obtained. In the selection of elemental technologies, explanations of the characteristics of those elements, and energy consumption ratios of options for the elements, help designers' judgement.

7.2.7 Provisional selection of options for specification

Once certain elemental technologies are selected, one of the options for specifications of each elemental technology shall be provisionally selected at this stage. In the selection, the energy consumption ratio, the CO_2 emission, the initial cost increase, the requirements and warnings of each option are briefly referred to by designers.

7.2.8 Identifying energy consumption ratio and estimation of energy consumption

The energy consumption ratio of each option for specification shall be identified by designers at this stage. As already stated, the energy consumption ratios shall be prepared by suppliers of the design guidelines and given in the design guidelines in a plain and understandable way.

Once the energy consumption ratio is identified, the energy consumption can be predicted using Equation (1), (2) or (3).

7.2.9 Estimation of CO_2 emission

In parallel with the prediction of energy consumption, the method to estimate the CO_2 emission shall be given in the design process and the estimation shall be done at this stage. For that purpose, the predicted energy consumption shall be divided into consumptions of different energy carriers, such as electricity, gases and oil. In addition, conversion factors for each energy carrier shall be given for the design process.

7.2.10 Estimation of initial and running cost

In parallel with the prediction of energy consumption and the estimation of CO_2 emission, the method to estimate costs shall be given in the design process and done at this stage. The cost estimation is a matter of global concern for the propagation of energy-saving technologies, but needs a detailed survey for local prices of products and labour as well as prices of energy carriers, which are sometimes sold on unique rating systems of local companies. In order to avoid complexity, simplified methods for the estimation are acceptable (e.g., national average price of a certain energy carrier), but assumptions for any simplified method shall be explained.

7.2.11 Judgement of appropriateness of choices for design

After the selections of elemental technologies and their options for specifications, their energy consumption, CO_2 emission and cost shall be estimated. If any of the estimated results are unsatisfactory, the selections and estimations are repeated by designers. Once some satisfactory combination of elemental technologies and their options for specifications are found, final judgement of the combination as a design solution for this design process shall be made at this stage.

All stages, from the project definition to the cost estimation, shall be reviewed to confirm correctness. If any mistake is found, it shall be corrected and the estimation shall be redone in stages.

Annex A
(informative)

Examples of energy-saving elemental technologies and options for specification

A.1 General

In this annex, a set of energy-saving elemental technologies and their options for specification are outlined as an example. The exemplified set is for wooden detached houses built in a mild climate region (its heating degree day in Celsius, $HDD_{18\text{-}18}$, is in the range between 1 500 and 2 500), and is quoted from an existing design guideline for practitioners in Japan. The objective of this annex is to show an example of the design process for energy-saving single-family residential buildings, in which energy consumptions depending on applied elemental technologies are predicted by the reference energy consumption and energy consumption ratios. At the end of this annex, an example of a set of prerequisite design conditions is described. Care should be taken when applying this example to other design conditions.

A.2 Energy-saving elemental technologies dealt with in this exemplified design process

In this example, the following elemental technologies are utilized as effective and practical for energy saving:

a) natural energy application:
   1) natural ventilation for heat removal,
   2) daylight utilization,
   3) photovoltaic power generation,
   4) solar radiation heat utilization for space heating,
   5) solar water heating;

b) heat control by building envelope:
   1) insulated building envelope,
   2) solar shading;

c) energy-efficient equipment:
   1) space heating and cooling system,
   2) ventilation system,
   3) domestic hot water system,
   4) lighting system,
   5) consumer electronics.

A.3 Summary of options for specification of each elemental technology and their energy consumption ratio

All options of specification and their energy consumption ratios are summarized in Table A.1. As energy uses, space heating, space cooling, ventilation, domestic hot water, lighting, consumer electronics and cooking are dealt with in this design process, although no energy-saving elemental technology is approved to be effective for “cooking” in this example. The reference energy consumptions for those energy uses are 12,8 GJ, 2,4 GJ, 4,7 GJ, 24,5 GJ, 10,7 GJ, 23,7 GJ and 4,4 GJ, respectively. For space heating and cooling, the intermittent and partial heating/cooling by room air-conditioners is assumed as a design condition, for simplicity as an example.

Three elemental technologies, namely, “Insulated building envelope planning”, “Solar radiation heat utilization for space heating” and “Heating and cooling system planning (heating)” are approved as the elemental technologies, which are effective in saving space heating energy. For the insulated building envelope planning, there are five levels of specifications, which are designated as “LEVEL 0” to “LEVEL 4”. For each level of specification, the energy consumption ratio is shown in Table A.1. More detailed information for each specification of the elemental technologies in Table A.1 is given in the next clause.

Table A.2 shows how to use the energy consumption ratios in Table A.1 to predict energy consumptions for energy usages. In this example, the interaction of different elemental technologies on the effectiveness in energy saving is not taken into consideration, and Equation (2) in 5.3.3 is applied.

Table A.1 — Relationship among energy usage, reference energy consumption, elemental technology and energy consumption ratio of each level of specification

Energy use	Reference energy consump-tion	Elemental technology		Energy consumption ratio (reference value considered to be 1,0)				
			Design conditions	LEVEL 0	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4
Space heating	12,8 GJ	Insulated building envelope planning		1,0	0,8	0,65	0,55	0,45
		Use of solar radiation heat [a]		1,0	0,95	0,9	0,8	0,6
		Heating and cooling system planning (heating)	Partial intermittent heating by room air-conditioner	1,0	0,8	0,7	0,6	
Space cooling	2,4 GJ	Natural ventilation for heat removal		1,0	0,9	0,8	0,7	
		Solar shading method	South-facing	1,0	0,85	0,7	0,55	
			Southeast/ southwest-facing	1,0	0,8	0,75	0,65	
			East/west-facing	1,0	0,8	0,75	0,65	
		Heating and cooling system planning (cooling)	Partial intermittent cooling by room air-conditioner	1,0	0,8	0,7	0,6	
Ventilation	4,7 GJ	Ventilation system planning		1,0	0,7	0,6	0,4	
Domestic hot water	24,5 GJ	Solar water heating and hot water system planning		1,0	0,9	0,8	0,7	0,5
Lighting	10,7 GJ	Daylight utilization		1,0	0,98	0,95	0,9	
		Lighting system planning		1,0	0,7	0,6	0,5	
Consumer electronics	23,7 GJ	Introducing high-efficiency consumer electronics		1,0	0,8	0,6		
Other (cooking)	4,4 GJ	-						
Total	83,2 GJ	-						
Power	-	Photovoltaic power generation		-0,0 GJ	-29,3 GJ	-39,1 GJ		

[a] Requires insulated building envelope planning of at least LEVEL 3.

Table A.2 — Prediction of energy consumption by using energy consumption ratios (for the intermittent and partial heating/cooling case)

Energy use	Equations to predict the design values by inserting energy consumption ratios into the blankets, referring to Table A.1	Predicted energy consumption or power generation	Reference energy consumption	Reduction rate (%)
Space heating	12,8 × ([ ] × [ ] ×[ ])		12,8 GJ	
Space cooling	2,4 × ([ ] × [ ] ×[ ])		2,4 GJ	
Ventilation	4,7 × [ ]		4,7 GJ	
Domestic hot water	24,5 × [ ]		24,5 GJ	
Lighting	10,7 × ([ ] × [ ])		10,7 GJ	
Consumer electronics	23,7 × [ ]		23,7 GJ	
Other (cooking)	4,4 × 1,0		4,4 GJ	
Subtotal			83,2 GJ	
Power	Power generation by photovoltaic cells depending on the capacity (3 kW or 4 kW) (□ -29,3 GJ □ -39,1 GJ)		-	
Total			83,2 GJ	

A.4 Description and specifications of energy-saving elemental technologies

A.4.1 General

In this clause, examples of the description of the elemental technologies and specifications are shown. As described in 5.3.3 and in Equations (1), (2) and (3), the energy consumption ratio of each option for specification is predetermined by the supplier of the design guidelines. The methods for the determination of energy consumption ratios are provided in this clause.

A.4.2 Natural ventilation for heat removal

Each level of specification of this elemental technology is defined by application of the following methods.

Method 1: Install plural openings facing different directions in each habitable room. In case there are habitable rooms, where only one opening can be installed, install another opening in the adjacent space and opening(s) on the partition wall between those two spaces, which can be left open without any inconvenience for the occupant.

Method 2: Install wind catchers beside major openings, which cannot enjoy higher wind pressure due to surrounding obstacles. It contributes to inducing higher wind pressure on the major openings.

Method 3: Install roof window(s) or high side window(s), which can induce larger wind pressure difference or stack effect.

Each level of specification is defined in Table A.3. The energy consumption ratio is affected by the surrounding building density, which is categorized into Locations 1-3, as shown in Table A.4.

Table A.3 — Levels for the elemental technology "Use of natural wind"

Level	Requirement to comply with each level, depending on the building density of surroundings (methods to be applied)			Energy consumption ratio
	Location 1	Location 2	Location 3	
LEVEL 0	No method applied	No method applied	No method applied	1,0
LEVEL 1	Methods 4 & 5	Methods 2, 3 & 5	Methods 1 & 5	0,9
LEVEL 2	-	Methods 2, 3, 4 & 5	Methods 1, 2 & 5	0,8
LEVEL 3	-	-	Methods 1, 2, 3, 4 & 5	0,7

Table A.4 — Description of conditions for surrounding building density for natural wind utilization

Location	Description
Location 1	Very densely built location with higher buildings, where natural wind utilization is difficult
Location 2	Densely built location, where natural wind utilization is possible with thoughtful design
Location 3	Suburban location with low density, where natural wind utilization is easy

A.4.3 Daylight utilization

Each level of specification of this elemental technology is defined by the daylight conditions and surrounding building conditions, which is evaluated by the number of window(s) effective for day-lighting in each type of room. The daylight condition is described in Table A.5, and the effective methods are described in Table A.6.

Table A.5 — Daylight conditions and their requirements

Daylight condition	Room type			
	Living and dining room	Private room for elderly persons or for children [private room with occupant(s) who tends to stay longer during daytime]	Other habitable rooms including master bedroom [private room with occupant(s) who tends to stay mainly during night time]	Non-habitable rooms including kitchen, hall, entrance hall, washroom, bathroom, toilet, etc.
Daylight condition 0	One method and side	One method and side	One method and side	-
Daylight condition 1	Two methods or sides	One method and side	One method and side	-
Daylight condition 2	Two methods or sides	Two methods or sides	One method and side	-
Daylight condition 3	Two methods or sides	Two methods or sides	One method and side	One method and side applied for each space

Table A.6 — Daylight utilization methods

Method	Utilization method		
Method 1	Direct daylight utilization methods (day-lighting methods)	Side window	Direction
			Shape
			Height
		Top side window	
		Skylight	
Method 2	Indirect daylight utilization methods (daylight guiding methods)	Transom window, etc.	
		Light well	

The conditions surrounding the house are categorized into three locations, as shown in Table A.7; the relationship between levels, locations and daylight conditions are shown in Table A.8.

Table A.7 — Description of conditions for surrounding building density for daylight utilization

Location	Description
Location 1	Very densely built location with higher buildings, where daylight utilization is difficult
Location 2	Densely built location, where daylight utilization is possible with thoughtful design
Location 3	Suburban location with low density, where daylight utilization is easy

Table A.8 — Levels for the elemental technology "Daylight utilization"

Level	Daylight conditions (application of methods)			Energy consumption ratio
	Location 1	Location 2	Location 3	
LEVEL 0	Daylight condition 0 (mono-directional day-lighting, floor area x 1/7)	-	-	1,0
LEVEL 1	Daylight condition 3	Daylight condition 2	Daylight condition 1	0,98
LEVEL 2	-	Daylight condition 3	Daylight condition 2	0,95
LEVEL 3	-	-	Daylight condition 3	0,9

A.4.4 Photovoltaic power generation

Each level of specification of this elemental technology is defined by the solar cell capacity, as shown in Table A.9.

Table A.9 — Levels for photovoltaic power generation

Level	Energy saving effect
LEVEL 0	No photovoltaic power generation
LEVEL 1	Reduction in annual primary energy consumption; 33,7 GJ (approx. 3 kW of solar cell capacity)
LEVEL 2	Reduction in annual primary energy consumption; 45 GJ (approx. 4 kW of solar cell capacity)

A.4.5 Solar radiation heat utilization for space heating

Each level of specification of this elemental technology is defined by the application of three methods (Table A.10) contributing to the use of solar radiation heat for space heating. The requirement depends on the climatic zones defined by the ratio of the mean solar radiation in January to the heating degree day, as well as the building site condition (Table A.14) and the direction of openings serving as heat collection area.

Table A.10 — Solar radiation heat methods

Method	Description	Minimum requirement
Method 1	Further improvement of window thermal performance	U-value lower than 2,91 W/(m^2K)
Method 2	Increase of window area collecting solar radiation	No less than 20 % of total floor area
Method 3	Installation of heat storage per unit floor area for direct heat gain	No less than 170 kJ/(m^2K) incl. furniture, etc.

Table A.11 — Levels for use of solar radiation heat for space heating (Zones A and B)

<table>
<tr><th rowspan="3">Level</th><th colspan="4">Methods to be applied</th><th rowspan="3">Energy consumption ratio</th></tr>
<tr><th colspan="2">Location 3: reduction rate of available solar radiation = 0 %</th><th colspan="2">Location 2: reduction rate of available solar radiation = 25 %</th></tr>
<tr><th>Direction 1
Due south ±15°</th><th>Direction 2
Due south ±30° except for Direction 1</th><th>Direction 1
Due south ±15°</th><th>Direction 2
Due south ±30° except for Direction 1</th></tr>
<tr><td>LEVEL 1</td><td>-</td><td>-</td><td>Method 1
Methods 1 & 2
Methods 1 & 3
Methods 1, 2 & 3</td><td>Method 1
Methods 1 & 2
Methods 1 & 3
Methods 1, 2 & 3</td><td>0,95</td></tr>
<tr><td>LEVEL 2</td><td>Method 1
Methods 1 & 2
Methods 1 & 3</td><td>Method 1
Methods 1 & 2
Methods 1 & 3
Methods 1, 2 & 3</td><td>-</td><td>-</td><td>0,9</td></tr>
<tr><td>LEVEL 3</td><td>Methods 1, 2 & 3</td><td>-</td><td>-</td><td>-</td><td>0,8</td></tr>
</table>

Table A.12 — Levels for use of solar radiation heat for space heating (Zone C)

Level	Methods to be applied				Energy consumption ratio
	Location 3: reduction rate of available solar radiation = 0 %		Location 2: reduction rate of available solar radiation = 25 %		
	Direction 1 Due south ±15°	Direction 2 Due south ±30° except for Direction 1	Direction 1 Due south ±15°	Direction 2 Due south ±30° except for Direction 1	
LEVEL 1	-	-	Methods 1 & 2 Methods 1 & 3	-	0,95
LEVEL 2	Method 1	Method 1	Methods 1, 2 & 3	Methods 1, 2 & 3	0,9
LEVEL 3	Methods 1 & 2 Methods 1 & 3	Methods 1 & 2 Methods 1 & 3 Methods 1, 2 & 3	-	-	0,8
LEVEL 4	Methods 1, 2 & 3	-	-	-	0,6

Table A.13 — Levels for use of solar radiation heat for space heating (Zones D and E)

Level	Methods to be applied				Energy consumption ratio
	Location 3: reduction rate of available solar radiation = 0 %		Location 2: reduction rate of available solar radiation = 25 %		
	Direction 1 Due south ±15°	Direction 2 Due south ±30° except for Direction 1	Direction 1 Due south ±15°	Direction 2 Due south ±30° except for Direction 1	
LEVEL 1	-	-	Methods 1 & 3	Methods 1 & 2	0,95
LEVEL 2	Method 1	Method 1	Methods 1 & 2	Methods 1, 2 & 3	0,9
LEVEL 3	Methods 1 & 2 Methods 1 & 3	Methods 1 & 2 Methods 1 & 3	Methods 1, 2 & 3	-	0,8
LEVEL 4	Methods 1, 2 & 3	Methods 1, 2 & 3	-	-	0,6

Table A.14 — Description of conditions for building site for solar radiation heat utilization

Location	Degree of obstruction of sunlight	Guideline for sunshine hours (winter solstice)
Location 1	Site with large influence of obstruction of sunlight (approx. 50 %) where solar radiation heat utilization is difficult	At least 3 hours (e.g. only 3 hours of sunlight between 10:30 and 13:30)
Location 2	Site with small influence of obstruction of sunlight (approx. 25 %) where solar radiation heat utilization is possible	At least 5 hours (e.g. 5 hours of sunlight between 9:30 and 14:30)
Location 3	Site with no influence of obstruction of sunlight (0 %) where solar radiation heat utilization is easy	Sunlight can be received all day

A.4.6 Solar water heating

Each level of specification of this elemental technology is defined by the application of two methods (Table A.15) contributing to the solar water heating. If the solar water heating is combined with water heaters of high efficiency, energy consumption ratios in Table A.27 should be used instead of Table A.15.

Table A.15 — Levels of solar water heating

Level	Method to be applied	Energy consumption ratio
LEVEL 0	Use of conventional domestic hot water systems without solar water heating nor other energy saving methods	1,0
LEVEL 1	Method 1	0,9
LEVEL 3	Method 2	0,7

Table A.16 — Methods for solar water heating

Method	Type of heating	Subtype
Method 1	Solar water heater	Natural circulation, no connection with other water heater
Method 2	Solar hot water system	Natural circulation, connection with back-up water heater
		Forced circulation, connection with back-up water heater

A.4.7 Insulated building envelope

Each level of specification of this elemental technology is defined by the thermal performance of each part of the building envelope, as shown in Table A.17. In the design guidelines, an additional instruction on the control of undesirable airflow inside the building envelope, which can deteriorate thermal performance of the installed insulation materials, is necessary. The techniques to prevent moisture problems inside the building envelope should also be instructed.

The energy consumption for space heating and the energy consumption ratio depend on the method of space heating for occupants. Therefore, there are two columns for the energy consumption ratio in Table A.17. The reference energy consumption for different methods of space heating is shown in Table A.1.

Table A.17 — Levels of insulated building envelope

Levels	Conditions of thermal performance for each part of the building envelope[a]				Energy consumption ratio (Partial intermittent heating)
	Window[b]	Wall[c]	Ceiling[c]	Floor[c] (with crawl space below)	
LEVEL 0	6,51	≥0,7	≥0,8	≥0,5	1,0
LEVEL 1	6,51	≥1,2	≥1,8	≥0,9	0,8
LEVEL 2	4,65	≥2,2	≥4,0	≥2,2	0,65
LEVEL 3	4,65	≥2,2	≥4,0	≥2,2	0,55
LEVEL 4	4,07	≥2,2	≥4,0	≥2,2	0,45

[a] Values for each part of the building envelope are examples drawn from the existing design guidelines for wooden detached houses built in rather mild climate regions (heating degree day, $HDD_{18\text{-}18}$, is in the range between 1 500 and 2 500); higher target levels may be given if it is a colder climate. Furthermore, there are different expressions of the requirement for insulated building envelope than those in this example. Some expressions allow a sort of trade-off of insulation performance between parts of the building envelope, which contributes to a more flexible determination of the specification.

[b] Thermal performance is expressed by heat transmission coefficient [W/(m^2K)].

[c] Thermal performance is expressed by thermal resistance of insulation material (m^2K/W).

A.4.8 Solar shading

Each level of specification of this elemental technology is defined by the solar heat gain coefficient (SHGC) at openings. The SHGC indicates the ratio of the solar heat that flows into a building through the fenestration area to the incident solar radiation heat. The SHGC at openings is influenced by overhang, glazing specification and solar shading component attached to the openings. Information on the SHGC is provided in Tables A.19, A.20, and A.21.

Table A.18 — Levels of solar shading

Level	Standard values of solar heat gain coefficient at openings		Energy consumption ratio		
	True north ±30°	Range other than the direction listed in the left column	Direction of main opening surface		
			South	South-east or south-west	East or west
LEVEL 0	Approx. 0,79	Approx. 0,79	1,0	1,3	1,1
LEVEL 1	0,79 or below	0,60 or below	0,85	0,8	0,8
LEVEL 2	0,55 or below	0,45 or below	0,7	0,75	0,75
LEVEL 3	0,55 or below	0,30 or below	0,55	0,65	0,65

Table A.19 — Solar heat gain coefficient for openings without overhangs

Specification of glazing	Solar shading component type				
	None	Sheer curtain	Internal blinds	Paper sliding door	External blinds
Regular single glazing	0,88	0,56	0,46	0,38	0,19
Regular double glazing	0,79	0,52	0,44	0,37	0,17
Regular triple glazing	0,71	0,50	0,44	0,38	0,16
Insulating low-E double glazing (12 mm air space)	0,63	0,48	0,43	0,37	0,15
Insulating low-E double glazing (6 mm air space)	0,62	0,47	0,43	0,37	0,15
Heat shielding low-E double glazing (12 mm air space)	0,42	0,32	0,29	0,26	0,11
Heat shielding low-E double glazing (6 mm air space)	0,43	0,33	0,30	0,26	0,11
Heat shielding double glazing (class 2 of heat reflecting glazing, 6 mm air space)	0,39	0,31	0,28	0,25	0,10
Heat shielding double glazing (class 3 of heat reflecting glazing, 6 mm air space)	0,28	0,23	0,21	0,19	0,08
Heat shielding double glazing (heat absorbing glazing, 6 mm air space)	0,57	0,41	0,36	0,31	0,13
Class 2 of heat reflecting single glazing	0,48	0,38	0,34	0,31	0,12
Class 3 of heat reflecting single glazing	0,35	0,31	0,28	0,25	0,10
Heat absorbing single glazing	0,68	0,47	0,41	0,35	0,15

Table A.20 — Solar heat gain coefficient for openings with overhangs (directions other than true south ±30°)

Specification of glazing	Solar shading component type				
	None	Sheer curtain	Internal blinds	Paper sliding door	External blinds
Regular single glazing	0,62	0,39	0,32	0,27	0,13
Regular double glazing	0,55	0,36	0,31	0,26	0,12
Regular triple glazing	0,50	0,35	0,31	0,27	0,11
Insulating low-E double glazing (12 mm air space)	0,44	0,34	0,30	0,26	0,11
Insulating low-E double glazing (6 mm air space)	0,43	0,33	0,30	0,26	0,11
Heat shielding low-E double glazing (12 mm air space)	0,29	0,23	0,20	0,18	0,07
Heat shielding low-E double glazing (6 mm air space)	0,30	0,23	0,21	0,18	0,08
Heat shielding double glazing (class 2 of heat reflecting glazing, 6 mm air space)	0,27	0,21	0,19	0,18	0,07
Heat shielding double glazing (class 3 of heat reflecting glazing, 6 mm air space)	0,19	0,16	0,15	0,13	0,06
Heat shielding double glazing (heat absorbing glazing, 6 mm air space)	0,40	0,29	0,25	0,22	0,09
Class 2 of heat reflecting single glazing	0,34	0,27	0,24	0,22	0,08
Class 3 of heat reflecting single glazing	0,24	0,21	0,20	0,18	0,07
Heat absorbing single glazing	0,47	0,33	0,28	0,25	0,11

Table A.21 — Solar heat gain coefficient for openings without overhangs (directions of true south ±30°)

Specification of glazing	Solar shading component type				
	None	Sheer curtain	Internal blinds	Paper sliding door	External blinds
Regular single glazing	0,44	0,28	0,23	0,19	0,09
Regular double glazing	0,39	0,26	0,22	0,19	0,09
Regular triple glazing	0,36	0,25	0,22	0,19	0,08
Insulating low-E double glazing (12 mm air space)	0,32	0,24	0,22	0,19	0,08
Insulating low-E double glazing (6 mm air space)	0,31	0,24	0,22	0,19	0,08
Heat shielding low-E double glazing (12 mm air space)	0,21	0,16	0,14	0,13	0,05
Heat shielding low-E double glazing (6 mm air space)	0,21	0,17	0,15	0,13	0,06
Heat shielding double glazing (class 2 of heat reflecting glazing, 6 mm air space)	0,20	0,15	0,14	0,13	0,05
Heat shielding double glazing (class 3 of heat reflecting glazing, 6 mm air space)	0,14	0,11	0,10	0,10	0,04
Heat shielding double glazing (heat absorbing glazing, 6 mm air space)	0,29	0,20	0,18	0,16	0,07
Class 2 of heat reflecting single glazing	0,24	0,19	0,17	0,15	0,06
Class 3 of heat reflecting single glazing	0,17	0,15	0,14	0,13	0,05
Heat absorbing single glazing	0,34	0,24	0,20	0,18	0,08

When there are no overhangs, etc., or when conditions in Figure A.1 are not met even if there are overhangs, the shading coefficient is 1, which means that a decrease in solar heat gain coefficient through overhangs cannot be expected. It is necessary to adjust the projection of overhangs and eaves according to the height of openings.

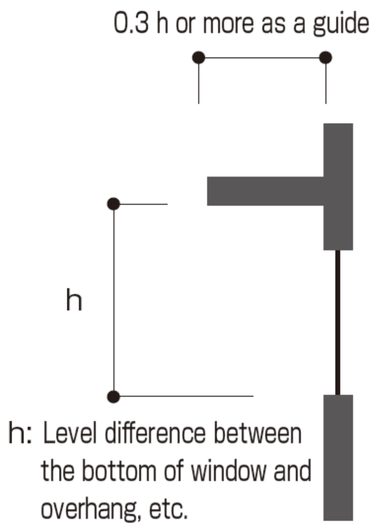

Figure A.1 — Overhang

A.4.9 Space heating and cooling system

In this design process, room air conditioners and floor heating systems with gas water heaters are evaluated for partial and intermittent heating. For partial and intermittent cooling, room air conditioners are evaluated. For whole-building continuous heating and cooling, forced air heating and cooling systems with heat pump are evaluated.

Each level of specification of this elemental technology is defined by the rated COP of room air-conditioners and the specification of the insulation below the floor heating panels and around the hot water pipe, as for partial and intermittent heating. For whole-building continuous heating and cooling, the rated COP of the system and the availability of room-by-room temperature control function define the level of specification.

Table A.22 — Levels of space heating and cooling system (room air-conditioners both for heating and cooling)

Level	Mean rated COP for heating and cooling	Energy consumption ratio
LEVEL 0	Lower than 4,0	1,0
LEVEL 1	4,0 or higher	0,8
LEVEL 2	5,0 or higher	0,7
LEVEL 3	6,0 or higher	0,6

A.4.10 Ventilation system

Each level of specification of this elemental technology is defined by the application of four methods contributing to an energy efficient ventilation system as shown in Table A.23. As the reference system, a balanced ventilation system using ducts for fresh air supply to each room (without heat recovery) is assumed.

Table A.23 — Methods for ventilation system

Method	Methods to be applied
Method 1	Minimizing pressure loss at ducts and other components (diameter of at least 75 mm or thicker)
Method 2	Using high-efficiency devices (motor and fan)
Method 3	Adoption of hybrid ventilation system
Method 4	Simplification of ventilation system (change into exhaust only ventilation system with ducts for exhaust from each room)

Table A.24 — Levels of ventilation system

Level	Methods to be applied	Energy consumption ratio
LEVEL 0	Usual specification of balanced ventilation system with duct (diameter 50 mm for branch ducts)	1,0
LEVEL 1	Method 1 or Method 4	0,7
LEVEL 2	Methods 1 & 2	0,6
LEVEL 3	Methods 1, 2, 3 & 4	0,4

A.4.11 Domestic hot water system

Each level of specification of this elemental technology is defined by the application of four methods contributing to the energy efficient domestic hot water system, as shown in Table A.25. In Table A.26, energy consumption ratio is determined using the methods in Table A.25 and methods for solar water heater heating.

Table A.25 — Methods for domestic hot water system

Method	Description of method		Energy consumption ratio
Method 1	Using a solar water heater		0,9
Method 2	Using a solar hot water system		0,7
Method 3	Using high-efficiency water heater	Latent heat recovery gas/oil water heater	0,9
		Electric water heater with a natural refrigerant heat pump (CO_2 HP)	0,8
Method 4	Considering energy-efficient design/construction for each component of domestic hot water system (header-conduit piping, thermal insulation of bathtub, hot water saving faucets, etc.)		0,9

Table A.26 — Levels for domestic hot water system and how to achieve them

Level	Method to be applied	Energy consumption ratio
LEVEL 0	Using a conventional domestic hot water system device only and does not apply any energy saving methods	1,0
LEVEL 1	Method 1 Method 3 (latent heat recovery gas/oil water heater) Method 4	0,9
LEVEL 2	Methods 1 & 3 Methods 3 & 4 Method 3 (CO_2 HP)	0,8
LEVEL 3	Method 2 Methods 1, 3 & 4	0,7
LEVEL 4	Methods 2 & 3 Methods 2, 3 & 4	0,5

A.4.12 Lighting system

Each level of specification of this elemental technology is defined by the application of three methods contributing to the energy efficient lighting system, as shown in Table A.27. Energy consumption ratio can be determined according to the application of the methods, as shown in Table A.28.

Table A.27 — Methods for lighting system

Method	Method to be applied
Method 1	Using a light source with high overall efficiency, such as compact fluorescent lamp, high-frequency fluorescent lamp and LED
Method 2	Using control system activating manual control for dimming and on-off, as well as automatic control by timer, motion sensor and illuminance sensor
Method 3	Using distributed multiple lighting system in living and dining room, instead of one-light-per-room lighting system

Table A.28 — Levels for lighting system and how to achieve them

Level	Method to be applied	Energy consumption ratio
LEVEL 0	Conventional methods, no application of the methods listed in this table	1,0
LEVEL 1	Method 1	0,7
LEVEL 2	Methods 1 & 2	0,6
LEVEL 3	Methods 1, 2 & 3	0,5

A.4.13 Consumer electronics

Each level of specification of this elemental technology is defined by the selection of refrigerator, television, hot water heated toilet seat, electric hot water pot, washing machine for clothes and electric appliances with low standby electricity consumption.

Table A.29 — Levels of high-efficiency consumer electronics

Level	Requirement for electric appliances	Energy consumption ratio
LEVEL -1	400 L refrigerator manufactured up to 1994 28” CRT-based television manufactured up to 2000 Hot water heated toilet seat of hot water storage type Electric hot water pot without vacuum bottle Washing machine without inverter	1,25
LEVEL 0	400 L refrigerator manufactured in 2000 28” CRT-based television manufactured up to 2000 Hot water heated toilet seat of hot water storage type Electric hot water pot without vacuum bottle Washing machine without inverter	1,0
LEVEL 1	400 L refrigerator manufactured in 2003 28” LCD television manufactured up to 2000 Hot water heated toilet seat of hot water storage type Electric hot water pot without vacuum bottle Washing machine without inverter	0,8
LEVEL 2	400 L refrigerator manufactured in 2003 28” LCD television manufactured in 2001 Hot water heated toilet seat of instant boiling type with timer Electric hot water pot with vacuum bottle Washing machine with inverter Choose all electric appliances from low standby electricity consumption types	0,6

A.5 Prerequisite design conditions

Reference energy consumptions and energy consumption ratios were prepared by developers of the design process and guidelines, by the estimation utilizing simulations and experimental data. The estimation was done under the conditions including outdoor climate, building configuration, family size, occupants' behaviour and usage of equipment, as shown in Table A.30, Table A.31, Table A.32, Figure A.2, Figure A.3 and Figure A.4.

Table A.30 — An example of prerequisite design conditions (climatic, building and living conditions)

Items			Conditions
Construction site region			Suburb of City of "Tokyo" (See Figure A.2)
Building site size			210 m^2 (2 260 ft^2)
Building	Structure		Post-and-beam construction
Conditions	Number of stories		Two-story house
	Exterior finish	Roof	Metal sheet roofing
		Exterior wall	Cement siding
		Opening	Aluminium sash
	Interior finish	Roof/wall	Plaster board/vinyl clothing
		Floor	Engineering wood flooring. Partial *tatami* mat
Living conditions	Family structure		Four people (husband, wife with two children) Householder: 45-year old (company employee) Wife: 42-year old (full-time homemaker) Daughter: 17-year old (high school student) Son: 14-year old (junior high school student)
	Lifestyle		Assume ordinary lifestyle
	Indoor set temperature		28 °C during summer and 18 °C during winter (while cooling and heating is used)
	Heating and cooling usage time slot		See Figure A.3
	Hot water usage amount		See Figure A.4
	Use of lighting device		See Table A.31
	Use of consumer electronics		See Table A.32

Table A.31 — Conditions for use of lighting devices (energy saving method not applied)

Usage location	Types of devices/lamps		Quantity (unit)	Wattage (W/unit)	Weekday		Holiday (staying home)		Holiday (away from home)	
					Switch-on time (time/day)	Power consumption (kWh/day)	Switch-on time (time/day)	Power consumption (kWh/day)	Switch-on time (time/day)	Power consumption (kWh/day)
Entrance porch	Ceiling	Mini krypton bulb	1	54	2.250	0.122	0.5	0.027	1	0.054
Hallway, corridor	Ceiling	Ring FL	1	27	0.333	0.009	1.25	0.034	0.5	0.014
	Down light	Mini krypton bulb	2	54	7.500	0.810	2	0.216	2.75	0.297
First floor toilet	Down light	Mini krypton bulb	1	54	1.417	0.077	3	0.162	1.5	0.081
Washing room	Ceiling	Ring FL	1	27	2.000	0.054	2.5	0.068	2.75	0.074
	Bracket	Straight FL	1	19	2.500	0.048	1.5	0.029	2.75	0.052
Bathroom	Bracket	Standard light bulb	2	54	0.750	0.081	1.25	0.135	1.25	0.135
Kitchen	Ceiling	Straight FL	1	46	3.000	0.138	2.75	0.127	0.75	0.035
	Under-cabinet light	Straight FL	1	21	2.500	0.053	2.75	0.058	0.75	0.016
Living/ dining room	Ceiling	Ring FL	2	70	10.250	1.435	10.75	1.505	5	0.700
	Pendant	Standard light bulb	1	90	3.500	0.315	2	0.180	0.25	0.023
Japanese-style room	Ceiling	Ring FL	1	74	2.917	0.216	1.25	0.093	3	0.222
	Bracket	Straight FL	1	22	2.917	0.064	1.25	0.028	3	0.066
Master bedroom	Ceiling	Ring FL	1	74	0.667	0.049	1.25	0.093	1	0.074
	Bracket	Mini krypton bulb	1	54	0.500	0.027	1.25	0.068	1	0.054
Children's room 1	Ceiling	Ring FL	1	59	3.250	0.192	7.75	0.457	1.75	0.103
	Desk lamp	Compact FL	1	21	2.750	0.058	5	0.105	1	0.021
Children's room 2	Ceiling	Ring FL	1	59	2.750	0.162	7.25	0.428	2.5	0.148
	Desk lamp	Compact FL	1	21	1.500	0.032	3.25	0.068	0	0.000
Total (kWh/day)						3.94		3.88		2.17

Table A.32 — Conditions for use of consumer electronics

Type	Annual operation time (h)	Annual standby time (h)
Refrigerator	8760.0	0.0
29-inch TV	3048.0	5712.0
14-inch TV	505.3	8254.8
Hot water heated toilet seat	8760.0	0.0
MD player	800.3	7959.8
CD radio-cassette recorder	157.8	8602.3
Washing machine	200.5	8559.5
Desk light	896.5	0.0
PC	373.5	0.0
Vacuum	60.8	0.0
Kitchen hood fan	456.5	8303.5
Hair dryer	135.3	0.0
Iron	42.7	0.0
Computer game	505.3	8254.8

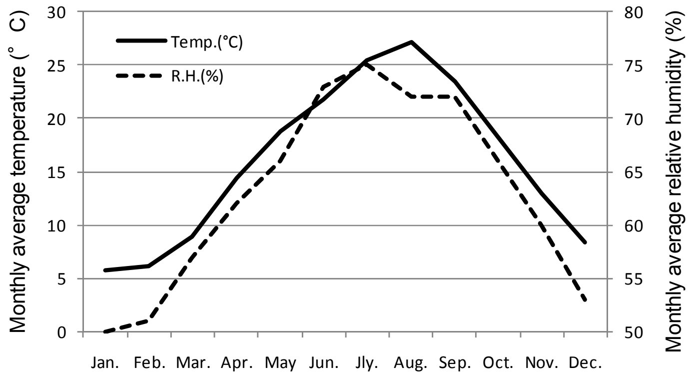

Figure A.2 — Monthly average temperature and relative humidity of "Tokyo"

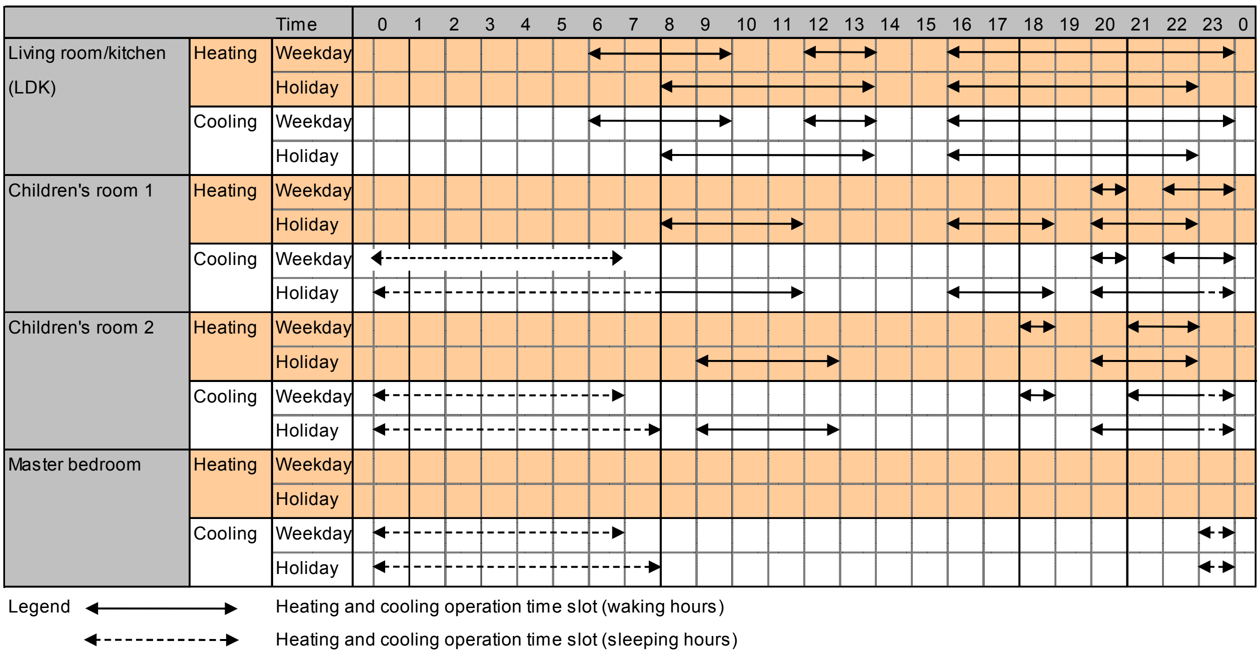

Figure A.3 — Conditions for heating and cooling usage time slot (partial intermittent heating and cooling)

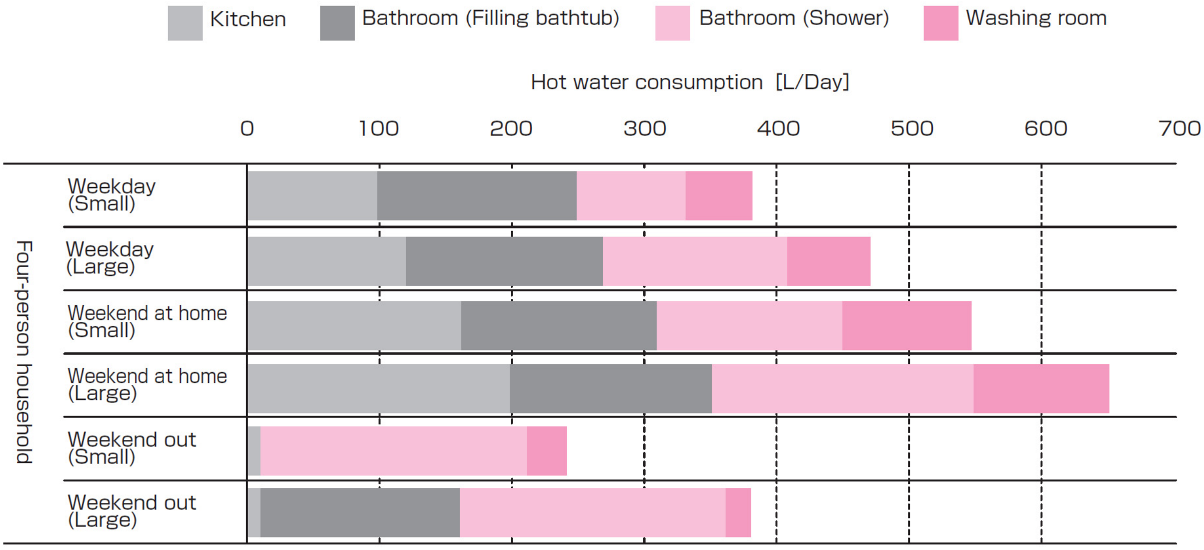

Figure A.4 — Hot water consumption during typical six days of "Corrected M1 Mode"

Annex B
(informative)

Notes on the experimental estimation of systems, taking actual conditions of usage into consideration

B.1 General

In order to determine energy consumption ratios of equipment, it is necessary to acquire data on behaviour of the equipment under actual or near-actual conditions when it is used in buildings. On the contrary, some rating conditions, which are prescribed in the standards of the equipment, are too simplified to use the rating result to predict the energy consumption ratio. It is still reasonable to set simplified rating conditions for standards from the viewpoint of cost effectiveness for manufacturers, as long as the results are used for relative evaluations of energy efficiency among products of the same kind. However, in the design practice for better energy-saving buildings, different kinds of technologies, including equipment of higher efficiency, should be compared. For example, an improvement of COP of room air conditioners and the replacement of a normal gas boiler for domestic hot water with condensing gas boiler should be compared for their effectiveness in the reduction of energy consumption.

In this annex, three examples of the trials to acquire data on behaviour of the equipment under the modelled conditions simulating the actual conditions are overviewed.

B.2 Room air-conditioner

The energy efficiency of the room air-conditioners is usually evaluated by rated COP, which is measured for fixed heating or cooling capacities under the fixed conditions for outdoor temperature. However, it is recognized that energy efficiency under actual conditions depends on outdoor temperature, ratio of the capacity to the rated or maximum capacity of the room air conditioners and other parameters. Therefore, the actual energy efficiency is predicted by using the relationship at least among energy efficiency, outdoor temperature and partial load condition.

B.3 Hot water floor heating system

The efficiency of boilers for hot water floor heating systems cannot be evaluated independently from other parts of the heating systems including the floor heating panel and the hot water pipe. Heat loss from those parts of the systems should be taken into consideration when evaluating the system energy efficiency. The efficiency of the boilers depends on their control and operation as well as on the temperature of return hot water, which is affected by heating load, size of the heating panels and the temperature of supply hot water.

B.4 Domestic hot water heater

The estimation of the efficiency of a heat source without a hot water tank is relatively simple, although the consumption of electricity for ignition and anti-freezing should be taken into consideration. On the contrary, if there is a hot water tank connected to the boiler, the energy efficiency of the domestic hot water system is affected by the heat loss from the tank, the temperature of water supplied from the tank to the heat source and that of hot water sent back to the tank from the boiler.

For instant water heaters for domestic hot water systems without hot water storage, the efficiency of heat sources, which is measured under the rating condition, usually at the maximum output, tends to correspond to its actual efficiency if electricity consumption for anti-freezing and ignition is considered. On the contrary, for domestic hot water systems with a hot water tank, the matching between the volume of heat storage and hot water consumption should be reflected upon their system efficiency by also taking into consideration the heat loss from the tank and the heat sources' efficiency when water of higher temperature is supplied from the tank.

For the evaluation of domestic hot water systems, it is necessary to prepare patterns (quantity and timing) of occupants' hot water usage as an experimental condition. As a basis of the patterns, data from field surveys is useful. Such patterns of hot water usage, which depend upon the number of occupants in residential buildings, are one of the prerequisite design conditions of the design process.

Annex C
(informative)

Contents of design guidelines including expression of energy consumption ratio for elemental technologies and options for specification

C.1 General

The framework of the design process using the energy consumption ratio as a key criterion is described in the main body of this International Standard. However, in actual design guidelines describing the design process, other information is necessary to guide designers toward practical and concrete solutions for the buildings in question. Such information is listed and described in this annex.

C.2 Framework of design guidelines

At first, the framework of the design guidelines is explained and should contain at least the following items:

1) main users of the design guidelines (general designers);

2) prerequisite design conditions, which define the applicability and the limitations in which the design guidelines can be utilized;

3) structure of the information contained in the design guidelines, especially the relationship among predicted energy consumptions, reference energy consumptions and energy consumption ratios;

4) flow of the design process and each of its stages, as shown in Figure 1;

5) list of energy saving elemental technologies dealt with in the design guidelines, and the relationship between those elemental technologies and energy uses;

6) description of energy saving elemental technologies, including an explanation of general characteristics, possible options for specification with different reduction rate of energy consumption, and points to pay attention to when detailed design and construction works are carried out;

7) if there are a variety of more detailed selections for each option for specification, examples should be given using drawings;

8) information on the initial cost, the reduction of the running cost and the payback period.

C.3 Prerequisite design conditions

To clarify the concrete requirement for the design of energy-saving buildings, the design conditions should be limited so that a very detailed analysis can be done beforehand by the suppliers of the design guidelines and at the same time necessary experimental data on the near-actual energy performance of equipment can be prepared. Without prerequisite design conditions and the limitation for applying the design guidelines, knowledge for practitioners cannot be simplified enough as expressed in the energy consumption ratio. Moreover, without such prerequisite design conditions, even reference energy consumption cannot be determined. An example of the prerequisite design conditions is shown in A.5.

C.4 Description of energy-saving elemental technologies

When the energy-saving elemental technologies are described, the following information should be given:

1) mechanism by which each energy-saving elemental technology can contribute to energy saving in the related energy use;

2) merits other than energy saving, which can be obtained when each energy-saving elemental technology is applied.

C.5 Presentation of options for specification of each elemental technology and their effectiveness on energy conservation

When each level of specification is described in the design guidelines, the following information should be given:

1) levels of specification and their energy consumption ratio;

2) requirements for each level of specification;

3) steps of the design for each elemental technology (design flow);

4) cost information on each level of specification;

5) examples of each level of specification (drawings);

6) basic database, such as for materials to be used for each level of specification.

C.6 Description of grounds for energy consumption ratio

Scientific grounds on the effectiveness of elemental technologies should be touched upon in the design guidelines, even though practitioners do not necessarily need very detailed information. If there is not enough scientific ground on the effectiveness, and judgement based on the expert experience is necessary, assumption on the effectiveness should be clearly described, so that the energy consumption ratio can be replaced when a more reliable value becomes available.

C.7 Summary of reference energy consumption and energy consumption ratio

To summarize elemental technologies dealt with in the design guidelines, a summary of reference energy consumption and energy consumption ratio should be given as shown in Table A.1. The summary table represents the design guidelines by clarifying kinds of elemental technologies and their options for specification, as well as by clarifying how much energy can be saved when applying the design guidelines.

Annex D
(informative)

Media for the design process

D.1 General

Appropriate media for the design process prescribed in this International Standard should be considered so that general designers can approach and fully utilize the design process. There are two kinds of media; one is the paper-based design guidelines, and another is computer-based software.

D.2 Paper-based design guidelines

The use of paper-based media limits the complexity of predictions of energy consumption. The interaction among different technological elements, which affects a particular energy use, cannot easily be reflected since the calculation described in the paper-based design guidelines is limited to the usage of pocket calculators. Nevertheless, the main calculation by using the energy consumption ratio and the reference energy consumptions for different uses can be described and guided by the paper-based design guidelines. Compared with the computer-based software, the paper-based design guidelines are much simpler and convenient for many practitioners and students.

D.3 Computer-based software

The use of computer-based software allows for more complicated calculations. For example, the effect of the energy reduction for lighting or electric appliances can be reflected on the calculation of heating and cooling energy. If the software is on-line it is possible for practitioners to perform the calculation anywhere, as long as they have access to a computer and internet connection.

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