TECHNICAL REPORT

ISO/TR 52000-2

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Energy performance of buildings — Overarching EPB assessment —

Part 2: Explanation and justification of ISO 52000-1

Performance énergétique des bâtiments — Évaluation globale de la PEB —

Partie 2: Explication et justification de l'ISO 52000-1

Reference number
ISO/TR 52000-2:2017(E)

Contents

Foreword

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

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

ISO/TR 52000-2 was prepared by the European Committee for Standardization (CEN) Technical Committee CEN/TC 371, *Energy Performance of Buildings project group*, in collaboration with ISO Technical Committees TC 163, *Thermal performance and energy use in the built environment*, and TC 205, *Building environment design*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

A list of all parts in the ISO 52000 series can be found on the ISO website.

Introduction

The set of EPB standards, technical reports and supporting tools

In order to facilitate the necessary overall consistency and coherence, in terminology, approach, input/output relations and formats, for the whole set of EPB-standards, the following documents and tools are available:

a) a document with basic principles to be followed in drafting EPB-standards: CEN/TS 16628:2014, Energy Performance of Buildings - Basic Principles for the set of EPB standards[13];

b) a document with detailed technical rules to be followed in drafting EPB-standards; CEN/TS 16629:2014, Energy Performance of Buildings - Detailed Technical Rules for the set of EPB-standards[14];

The detailed technical rules are the basis for the following tools:

1) a common template for each EPB-standard, including specific drafting instructions for the relevant clauses;

2) a common template for each technical report that accompanies an EPB standard or a cluster of EPB standards, including specific drafting instructions for the relevant clauses;

3) a common template for the spreadsheet that accompanies each EPB standard, to demonstrate the correctness of the EPB calculation procedures.

Each EPB-standards follows the basic principles and the detailed technical rules and relates to the overarching EPB-standard, ISO 52000-1[1].

One of the main purposes of the revision of the EPB-standards is to enable that laws and regulations directly refer to the EPB-standards and make compliance with them compulsory. This requires that the set of EPB-standards consists of a systematic, clear, comprehensive and unambiguous set of energy performance procedures. The number of options provided is kept as low as possible, taking into account national and regional differences in climate, culture and building tradition, policy and legal frameworks (subsidiarity principle). For each option, an informative default option is provided (Annex B).

Rationale behind the EPB technical reports

There is a risk that the purpose and limitations of the EPB standards will be misunderstood, unless the background and context to their contents – and the thinking behind them – is explained in some detail to readers of the standards. Consequently, various types of informative contents are recorded and made available for users to properly understand, apply and nationally or regionally implement the EPB standards.

If this explanation would have been attempted in the standards themselves, the result is likely to be confusing and cumbersome, especially if the standards are implemented or referenced in national or regional building codes.

Therefore each EPB standard is accompanied by an informative technical report, like this one, where all informative content is collected, to ensure a clear separation between normative and informative contents (see CEN/TS 16629[14]):

— to avoid flooding and confusing the actual normative part with informative content,

— to reduce the page count of the actual standard, and

— to facilitate understanding of the set of EPB standards.

This was also one of the main recommendations from the European CENSE project[5] that laid the foundation for the preparation of the set of EPB standards.

This document

This document accompanies the overarching EPB standard (ISO 52000-1) that addresses the overarching principles for EPB-standards. The overarching EPB standard, contains the common terms, definitions and overall energy performance assessment procedures, as a basis for a systematic, clear and comprehensive set of EPB standards. It forms part of a set of standards related to the evaluation of the energy performance of buildings (EPB).

The role and the positioning of ISO 52000-1 in the set of EPB standards is defined in the Introduction to the standard.

Accompanying spreadsheets

Spreadsheets are produced through the implementation of ISO 52000-1. These spreadsheets (including possible updated versions) are available at www.epb.center. In this document, examples of each of these calculation sheets are included.

Background and history of this document, ISO 52000-1 **and the set of EPB standards**[1]:

Boosting energy efficiency of buildings

Since buildings burn 40 % of all the energy consumed, designing better buildings and retrofitting existing ones will help to reduce the energy demand and to create significant job opportunities world-wide.

The building sector has a great potential to reduce the greenhouse gas emissions, in line with the climate targets set at the Paris climate conference (COP21) in December 2015. Helping to decarbonize the building sector is the goal of the new holistic approach, the set of EPB standards (ISO 52000-series; see below under “Road ahead”) being developed for the energy performance of buildings (EPB).

Holistic approach

The set of EPB standards ...	
take into account	**and include:**
• indoor climate	• needs
• thermal properties (of walls, windows, etc.)	• use
• heating	• calculation
• cooling and air conditioning	• measurement
• domestic hot water	• inspection
• ventilation	• building design
• lighting	• new and existing buildings
• (de)humidification	• certification/labelling
• building automation and control (BAC/BMS)	• simple and complex buildings
• renewable energy sources	

Why is the holistic approach important for the energy performance of buildings (EPB) ?

In the past, energy performance requirements were set at component level – minimum thermal insulation levels and minimum efficiencies of products. This, however, leads to sub-optimal solutions and creates a barrier to the necessary technology transitions.

The holistic approach to assessing the overall energy performance of buildings and the built environment, provided by the set of EPB standards, is a key tool to overcome these barriers.

1) The references [26] to [43] (see bibliography) contain more extensive background information on the set of EPB standards.

The set of EPB standards enable to assess the overall energy performance of a building. This means that any combination of technologies can be used to reach the intended energy performance level, at the lowest cost.

Due to this 'competition' between different technologies, the holistic approach is a key driver for technological innovation and change. Countries using the approach for several years – take, for instance, the Netherlands – have experienced large scale implementation and cost savings on a variety of new technologies.

And there is the economic benefit: Energy expenditures account for a substantial part of a building's total operating costs.

Who are the potential users of the EPB set of standards, and what should they be aware of ?

The energy assessment of buildings is carried out for various purposes, such as:

— judging compliance with building regulations expressed in terms of limited energy use or a related quantity,

— increasing transparency in real-estate transactions through an energy performance certification and/or display of the level of energy,

— monitoring the energy efficiency of the building and its technical building systems,

— helping to plan retrofit measures through predicting energy savings that would result from various actions.

In general, the holistic approach means that the energy performance is assessed as the total energy used for heating, cooling, lighting, ventilation, domestic hot water, and, in some cases, appliances. It ensures that all technologies are treated equally and balanced.

With the EPB set of standards**:**

— **Policy makers** acquire an instrumentation that enables them to take measures in the built environment and to quantify how much these measures would reduce the energy consumed in buildings.

— **Building industry, engineers and designers** can improve the energy-efficiency of their designs, building products and systems. The set of standards take these current and future products, systems and designs into account. Due to the holistic approach the risk of suboptimum solutions at component level is minimized. This way industry knows in what direction to innovate.

— **Building owners and occupants** can benchmark against other buildings and predict the energy saving potential of improvements.

First editions: European standards

The set of standards and accompanying technical reports on the energy performance of buildings have been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association (Mandate M/480[4])

Directive 2010/31/EU recasting the Directive 2002/91/EC on energy performance of buildings (EPBD[2]) promotes the improvement of the energy performance of buildings within the European Union, taking into account all types of energy uses (heating, lighting, cooling, air conditioning, ventilation) and outdoor climatic and local conditions, as well as indoor climate requirements and cost effectiveness (Article 1).

The first mandate to CEN to develop a set of CEN EPBD standards (M/343[3],), to support the first edition of the EPBD[2] resulted in the successful publication of all EPBD related CEN standards in 2007-2008.

The mandate M/480 was issued to review the previous mandate M/343 as the recast of the EPBD raised the need to revisit the standards and reformulate and add standards so that they become on the one hand unambiguous and compatible, and on the other hand a clear and explicit overview of the choices, boundary conditions and input data that need to be defined at national or regional level. Such national or regional choices remain necessary, due to differences in climate, culture & building tradition, policy and legal frameworks. Consequently, the set of CEN-EPBD standards published in 2007-2008 had to be improved and expanded on the basis of the recast of the EPBD.

Road ahead: ISO 52000- series

The numbers ISO 52000 through ISO 52150 are reserved for the EPB standards. So in the near future the term ISO 52000 series of standards will become equivalent to the term EPB set of standards.

Only standards that meet specific requirements, will be awarded such number. Currently, only 15 numbers are issued, mostly general EPB standards, or for building (thermal, solar) calculations. In 2017/2018 some 30 standards might become an ISO 52xxx standard, making use of the work already done in Europe.

The ISO 52000 series is modular and flexible, making it the perfect basis for future developments like innovations, new insights and new market demands.

Energy performance of buildings — Overarching EPB assessment —

Part 2: Explanation and justification of ISO 52000-1

1 Scope

This document refers to the overarching EPB-standard, ISO 52000-1[1].

It contains information to support the correct understanding, use and national implementation of ISO 52000-1. This includes:

— explanation on the procedures and background information and justification of the choices that have been made;

— reporting on validation of calculation procedures given in the standard;

— explanation for the user and for national standards writers involved with implementation of the set of EPB standards, including detailed examples.

2 Normative references

There are no normative references in this document.

Some explanations regarding Clause 2 of the overarching EPB standard:

If a reference is made in the text of the standard to a specific part of another standard, only this specific part is referenced, not the entire other standard.

The following text in ISO 52000-1:2017, Clause 2 “The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document.” is the standard phrasing for any ISO standard. As stated in the ISO/IEC Directives, Part 2:2016, Clause 15, the normative references clause is an informative element that lists, for information, those documents which are cited normatively in the document. Information on how these references apply is found in the place where they are cited in the document, and not in the normative references clause. The list of normative references is therefore given for the convenience of the user, who can then consult the place where they are cited in the document to understand and assess how they apply.

NOTE 1 EPB is regulated in some countries or regions: regulations do not necessarily endorse the complete set of EPB standards and might modify the content of the standard(s).

To keep flexibility in referencing standards, the references to EPB standards are placed in the national choices and input data sheet, see Annex A and Annex B.

The references to EPB standards are given as module code numbers instead of a simple list ([1], [2],.[3]), because with the EPB module code numbers the same module code numbering can be used for all EPB standards.

NOTE 2 This will facilitate the making of a consistent set of national annexes for each EPB standard and contribute to overall consistency and transparency.

3 Terms and definitions

This clause provides an explanation of some of the terms and definitions given in ISO 52000-1. The numbers in brackets refer to the term-numbers in ISO 52000-1:2017, Clause 3.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1 Buildings

Building (term 3.1.2)

"Building" means the physical construction including the technical building systems.

"Building unit" has been defined separately (term 3.1.8).

The definition in EPBD: "'building' means a roofed construction having walls, for which energy is used to condition the indoor climate" is not usable in this context, e.g. because there are buildings without walls (only roof), or without roof (e.g. pyramid shaped, only inclined walls).

Building category (term 3.1.3)

The term "category" does not only relate to the type of use: also to size, to the period of use (e.g. temporary use) and to other qualifications (e.g. historic buildings).

See also the notes and examples in ISO 52000-1:2017 at this entry and at the definition of Space category (term 3.1.14).

Reference floor area (term 3.1.12)

The reference floor area should not be confused with the **useful floor area for EPB assessment** (3.1.18, see further on). The difference between useful floor area and reference area can be found in 9.3 and 9.4.

The **reference floor area** is one of the options is for the **reference size**.

Reference size (term 3.1.13)

The reference size is used for the normalization of the energy performance.

Extensive explanation on the reference size is given in 9.4.

Space category (term 3.1.14)

A building of a certain (use) category may contain spaces of different (use) categories. Therefore a separate definition at space level: "space category" is introduced.

The purposes of the building and space classifications may be different, which is expressed in the definitions. Moreover, the choice is given (see Clause 6) whether or not, in the EPB assessment, differentiation in space categories within a building of a specific building category is foreseen.

EXAMPLE Does an office building contain only office spaces or is there a distinction (in temperature set points, ventilation needs, lighting needs, domestic hot water needs, etc.) between e.g. office spaces, corridor, entrance hall, assembly spaces, toilets, kitchen, restaurant, ...

See also the notes and examples in ISO 52000-1:2017 [1] at this entry and at the definition of Building category.

Thermal envelope area (term 3.1.15)

This term is only needed for the thermal part of the assessment, but still it is an overarching term, because it determines whether spaces are assumed to be thermally conditioned or not (e.g. staircases or attics) which subsequently may also affect e.g. the reference area and the zoning.

Useful floor area (term 3.1.18)

The terms 'conditioned (floor) area' and '(un)conditioned space' are obsolete. This is because in the context of the overall energy performance assessment these are ambiguous terms, leading to many misunderstandings, because:

— Each space belongs to a space category with specific conditions of use. Some spaces are thermally conditioned, some have domestic hot water needs, some have only lighting and ventilation needs.

— Other spaces are thermally unconditioned, but have only a specific influence (e.g. adjacent building with adiabatic boundary, adjacent unheated space with thermal influence, ..) or are thermally unconditioned but still with specific services taken into account (in some countries for instance: lighting and/or ventilation of indoor car park or common staircase).

Instead, the terms 'reference floor area' and 'useful floor area' are used.

Difference between the useful floor area and the reference floor area:

— The reference floor area is used for normalization of the energy performance.

— The useful floor area is used for various purposes, such as:

  — for conditions of use, if conditions of use are given per m^2 of floor area (e.g. hot water use, ventilation needs);

  — for weighting according to floor area, for instance for redistribution in case of zoning (see Clause 10).

For assessing the thermal envelope of the assessed building or building part and for the zoning, the term 'thermally conditioned space' is used.

Extensive explanation of the useful floor area is given in 9.3.

3.2 Indoor and outdoor conditions

Conditions of use (term 3.2.1)

This term is needed for the zoning and for the calculations. It means the set of conditions that is needed for the intended use of the space, such as temperature level, lighting level, domestic hot water needs, ventilation (IAQ) needs, …

The relation with operating conditions is: in order to achieve these conditions of use, and depending on the types of provisions (building, systems, controls), specific operating conditions are needed.

3.3 Technical building systems

Cogeneration (term 3.3.5)

"Energy is generated" is not really possible in a philosophical way. 'Transformed' or 'produced' could be better terms. But definition as used in other documents[2] is clear enough.

3.4 Energy

On-site (term 3.4.27)

This definition is linked with those of “nearby” and “distant”. On-site is a larger perimeter then the building only. On-site is often linked to energy production or energy transformation that can be exported.

Nearby the building site (term 3.4.24)

The current definition for “nearby the building site” is not fitted for nearby electricity generation. It is intended to introduce also nearby electricity. A proposal could be: Connected to the same branch of the distribution grid (distribution grid meaning voltage level lower than 150 kV)”.

Distant to the building site (term 3.4.7)

“On-site” and “nearby” are defined in the EPBD related to NZEB. “Distant” is defined in this standard to cover all perimeters where energy can be produced or transformed.

3.5 Energy performance

Energy rating (term 3.5.12)

The terms EPB assessment and energy rating have been clearly distinguished. More information can be found in ISO 52003-1[8] and its accompanying report ISO/TR 52003-2[9].

EPB standard (term 3.5.14)

Special attention is drawn to the term EPB standard. This defined term is necessary to make clear which ISO standards belong to the set of EPB standards and which do not. A standard that does not fulfil the conditions is not called an EPB standard. Of course, it may still play an (possibly even essential) role. In that case it will be referenced in an EPB standard, typically to provide appropriate input data (e.g. on products or boundary conditions).

Standard energy performance or energy performance (terms 3.5.23 and 3.5.7)

The term ‘energy performance’ is used in the EPBD . However, the affix ‘standard’ emphasizes that it concerns the energy performance under standard use and climate, in contrast to ‘tailored energy performance’.

3.6 Energy calculation

No need for additional information.

3.7 General information on terms and definitions

3.7.1 General

Definitions, term, perimeters etc. are important as a common basis and for the understanding of the assessment of the energy performance. Care has been taken to draft the definitions in line with other relevant documents and to keep them as general as possible to match existing definitions. If in a country more precise definitions exist, then the advice is to give this information in a national annex.

3.7.2 Overarching terms and definitions

ISO 52000-1 provides terms and definitions that are needed at the overarching level. The terms of lower-level EPB-standards are defined there; otherwise the overarching EPB standard would be overloaded, the limit of the definitions to be considered would be difficult to define and the overview would be difficult to manage and keep up to date over time. However, ISO 52000-1 includes terms that are not used in the standard itself, but that are needed for overall consistency in the set of EPB standards.

Other terms and definitions seem overarching, but are only used in a certain area of EPB standards. For instance "expenditure factor" [ratio of the energy input (requested energy) to the useful energy output].

3.7.3 Difference between definition and specification

A clear difference should be made between a definition of a term and the procedure to specify (e.g. quantify) the term. The definition only identifies a term. Only in special cases this is enough to unambiguously specify the term. In other cases the actual assessment procedures in the standard contain appropriate procedures to unambiguously assess the value or otherwise specify the term. For instance the value for the energy need for heating or the specification of the energy performance assessment boundary.

3.7.4 Undefined and/or unspecified policy related terms

There are certain quantities, that are strongly related to national or regional policy, due to differences in culture and building tradition, building typologies (building use), policy and legal frameworks and administrative practices (including the type and level of quality control and enforcement and assessment cost expectations). It is impossible to fully harmonize these terms at the moment. Therefore they are not, or not completely, defined in the EPB standards or they are defined in a generic way, leaving room for further national or regional specification. Annex A of these EPB standards provides a template with tables for systematically specifying these specifications. Annex B gives informative default choices, that act as examples for the policy related quantities/terms.

Examples:

— useful floor area;

— the boundaries between "on-site", "nearby" and "distant";

— assignment of building and space categories (e.g. office space, shop, assembly room or hall, bed and breakfast, children day care, nursing home, ...);

— subdivisions of building and space categories (e.g. residential buildings: single family house, student flat, senior homes, mobile home, house boat, holiday home, ..);

— assignment of category: designed building; new building after construction; existing building in the use phase; majorly renovated building.

Any (further) definition or specification of these terms would already be a too strong constraint for the required national or regional detailed specifications.

This does not lead to a problem in the form of an open end in the energy performance assessment, because such national or regional detailed specifications are done in the "pre-processing phase" of the energy performance assessment, so that it can be assumed that these have been assessed when starting the routing through the overarching EPB standard. For this reason, these issues are dealt with in the overarching EPB standard as "Overarching preparation steps" (see ISO 52000-1:2017, Clause 6).

4 Symbols, units, subscripts and abbreviations

4.1 Symbols

The list of symbols and units in ISO 52000-1:2017, 4.1 includes common symbols for the EPB standards. This list is normatively referenced in each subsequent EPB standard, but some of these may also be repeated in an individual EPB standard if convenient for the understanding. In particular if there is a need to give a systematic overview of specific subsets of symbols.

The energy, time and power units are linked together. There are two set of quantities in use:

— Joule, second, Watt;

— kW·h, h, and kW.

Both can be used but care must be given to consistency with some other units involving energy such as;

— specific heat (J/kg or kW·h/kg);

— calorific value (MJ/kg or kW·h/kg).

The symbol for Celsius temperature is "ϑ".

NOTE In the past "θ" was used as well and could still appear in some standards until they are made all consistent.

For energy, the following rules apply for the use of symbols Q, E, and W:

— Q is the symbol for heat within the building;

— W is used for auxiliary energy within the building;

— E is used for any other type of energy and for energy outside the building.

E is used mostly for energy quantities related to exchanges across the assessment boundary. E is also used as an amount of any energy carrier expressed as energy contents.

4.2 Subscripts

The list of subscripts given in ISO 52000-1:2017, 4.2 includes only subscripts used in that standard itself.

Common subscripts for all EPB standards are given in Annex C. This list is normatively referenced in each subsequent EPB standard, but some of these may also be repeated in an individual EPB standard if convenient for the understanding. In particular if there is a need to give a systematic overview of specific subsets of subscripts.

See ISO 52000-1:2017, Annex C and Annex Cof this document for further information on subscripts.

4.3 Abbreviations

For the purposes of this document, the abbreviations as mentioned and given in ISO 52000-1 apply.

The list of subscripts given in ISO 52000-1:2017, 4.3 includes abbreviations not used in that standard itself. They are given to ensure overall consistency between the set of EPB standards.

Where possible, the subscripts used for a certain term are the same as the abbreviation. Where possible the abbreviations used in connection with software are also the same.

5 Description of the overarching framework and procedures

5.1 Output of the method

The main output of this standard is

— the absolute values of the weighted total energy performance;

— the RER (renewable energy ratio).

Additional output data, namely energy performance indicators per service and/or per part of the building or delivered energy per service and/or per part of the building, can be also calculated applying the additional procedures given in Annex E to ISO 52000-1:2017 [1].

The way of expression and the calculation of energy performance indexes is specified in ISO 52003-1[8].

5.2 General description of the procedures and routing

Annex K includes a calculation flow chart.

5.3 Selection criteria between the methods

The selection of method or methods may depend on the assessed object: object type, building category, application type and assessment type.

If the object type is a whole building, then a full method will usually be selected, if the object type is a building system, then a method for calculating/measuring a partial indicator is more likely, see 9.8.

If the building category is a residential building, then it is very possible that specific methods or requirements exist. For offices this is also possible, but for industrial sites or workshops a less detailed method might be enough.

If the application type is 'energy performance certificate', then this can be done by calculating from the design, but this does not include the changes that were made during construction, so calculation from the actual built situation is better. For the application type of 'energy audit' see also EN 16247-2, Energy audits - Part 2: Buildings.

If the assessment type is 'as built' then both calculation and measured methods can be applied. Measured is usually quicker, but due to some uncertainties in behaviour of the user of the building, it is less accurate.

5.4 The over-arching reference modular structure

5.4.1 Purpose

The overarching reference modular structure is used to identify:

— all required parts of the assessment procedure and provide an overview;

— the modules covered by the EPB standards and to support specifications given to standard writers of the EPB modules;

— the connection between the EPB standards (e.g.: calculation, expression of the energy performance).

This structure also enables and facilitates a step-by-step implementation in any national or regional context.

5.4.2 Systematic modular structure of the standards

The over-arching modular structure has four main areas as shown in Table 1:

Table 1 — Modules main areas

Modules	Area
M1	Overarching standards
M2	Building (as such)
M3 - M11	Technical Building Systems under EPB
M12 - M13	Other systems or appliances (non-EPB)

Each main module is divided into sub-modules, in such a way that, where possible and feasible, some symmetry is retained.

The numbering of the systematic modular structure is shown in Table 1 in ISO 52000-1:2017.

EXAMPLE 1 M3-5 is the module on heating and cooling – the emission and control aspects.

EXAMPLE 2 M10-11 is the module on Building Automation and Control– the inspection aspects.

In the Introduction of each EPB Standard a table with the modular structure is provided. The number of the standard is placed in the module it refers to.

EXAMPLE 3 See the Introduction of ISO 52000-1:2017: the standard refers to modules M1-1, M1-2, M1-3, M1-5, M1-7, M1-8, M1-9 and M1-10.

5.4.3 The connection between the modules – step by step implementation

The connection between the different modules is illustrated by an example of the energy performance assessment of a building with heating and domestic hot water services.

Figure 1 shows an example of the needed calculation modules from the main modular structure.

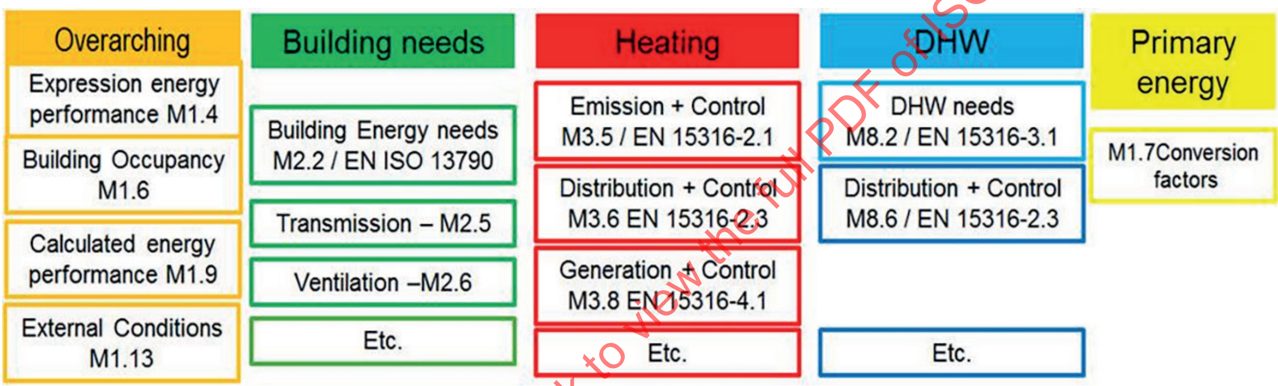


Figure 1 — Example of modules for the energy performance assessment

These different modules are connected in order to calculate the energy performance. The calculation goes from the needs to the primary energy. Figure 2 shows a simplified scheme of the connections.

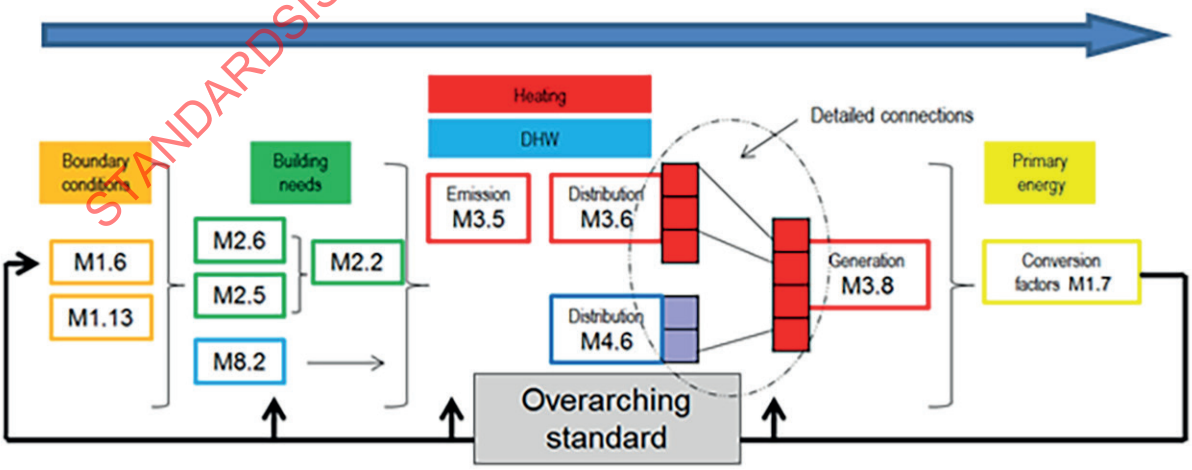


Figure 2 — Connection scheme of the modules (Example).

The overall scheme, including the detailed connections, is indicated in the overarching EPB standard and worked out in cooperation between the overarching EPB standard and the development of the modules of the EPB standards.

The connection between the modules is organized in detail by defining the input and output of the modules.

The modules are integrated in the overall modular structure by the module input and module output.

The module input contains the needed system operation conditions to calculate the energy performance of the module (see Figure 3).

The module output (see Figure 3) contains, among others things:

— the systems operation conditions influenced by the module (e.g. distribution temperature);

— data needed in the overarching EPB standard to assess the energy performance and the interactions between modules (e.g. recoverable losses);

— data for compliance check and quality control.

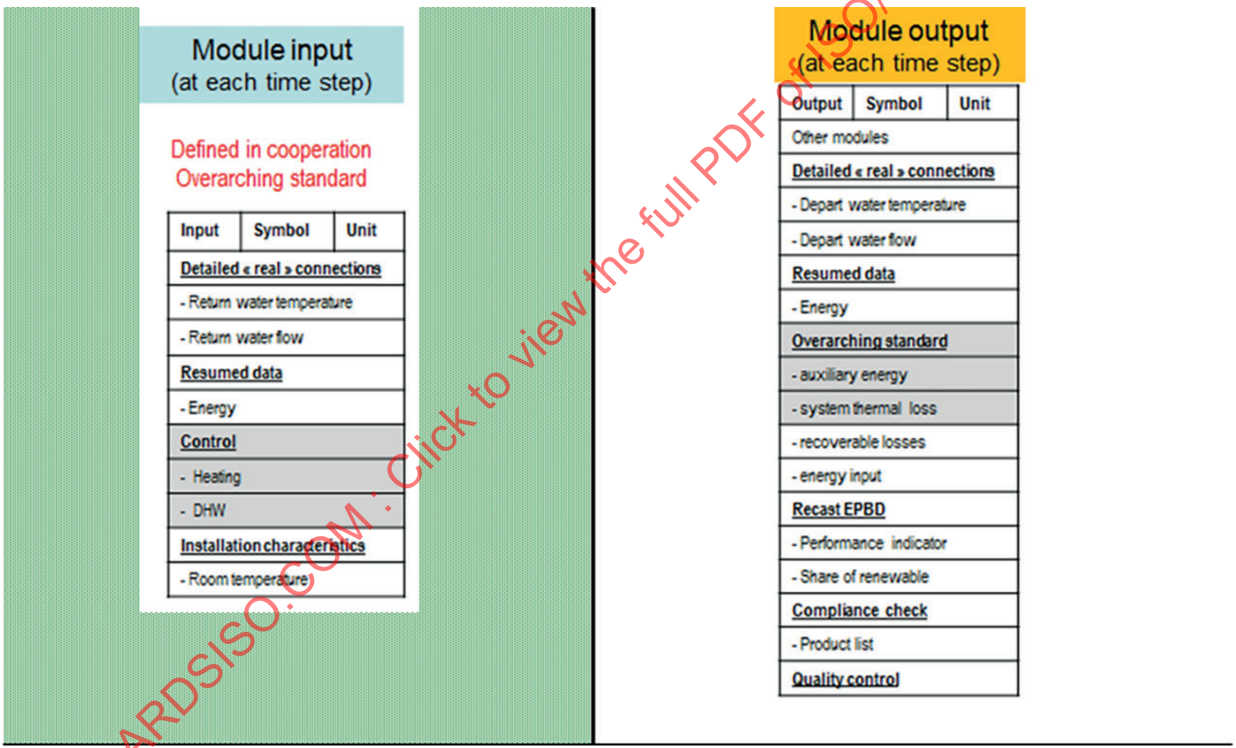


Figure 3 — Input/output data of a module

The input and output data are calculated at each calculation interval. There could be several modules dealing with the same topic (e.g. national or European boiler model) but each module fits the defined input and output data, otherwise it cannot be integrated in the overall structure.

In addition to input/output data defined in cooperation with the overarching structure, each module has also specific data, internal calculation procedures and links to databases (see Figure 4). The specific module input data is defined in a specific line of the user interface. The specific module input data are used only once at the beginning of the assessment.

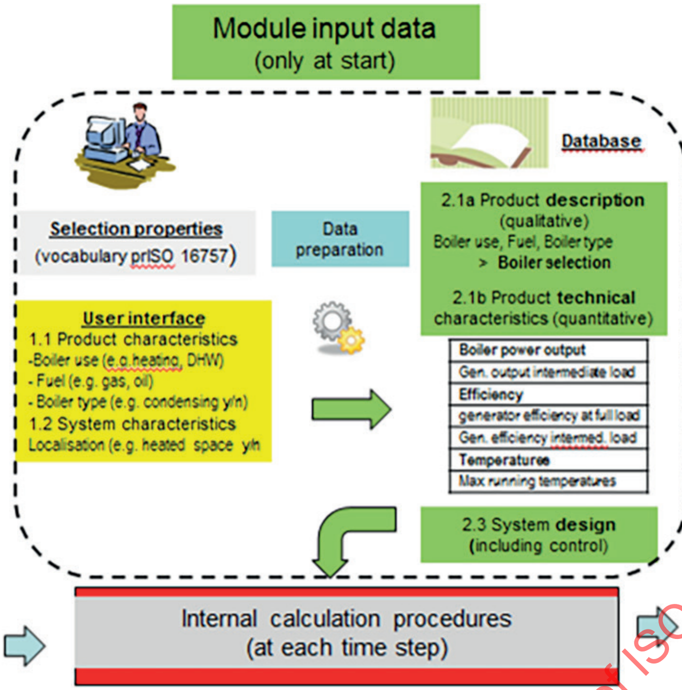


Figure 4 — Specific module data

5.4.4 Systematic consecutive numbering of the standards

The series of numbers between ISO 52000 and ISO 52150 have been reserved by the ISO Secretariat for the set of EPB standards.

Each number is intended for a specific module or part of it, with provisional titles to indicate the successive items. Per standard, different parts can be used for specific procedures. The parts with an odd number are intended for standards, while the parts with even number are intended for the accompanying technical report.

Examples are shown in Table 2:

Table 2 — Examples of module numbers and the standards they refer to

Module	Number	Title (draft)
M1-4	ISO 52003-1	*Energy performance of buildings – Indicators, requirements, ratings and certificates– Part 1: General aspects and application to the overall energy performance*
	ISO/TR 52003-2	*Energy performance of buildings – Indicators, requirements, ratings and certificates– Part 2: Explanation and justification of* ISO 52003-1
M1-13	ISO 52010-1	*Energy performance of buildings –. External environment conditions – Part 1: Conversion of climatic data for energy calculations*
	ISO/TR 52010-2	*Energy performance of buildings –. External environment conditions – Part 2: Explanation and justification of* ISO 52010-1
M2-2	ISO 52016-1	*Energy performance of buildings – Energy needs for heating and cooling, internal temperatures and sensible and latent heat loads — Part 1: Calculation procedures – Part 1: Calculation procedures*
	ISO/TR 52016-2	*Energy performance of buildings – Energy needs for heating and cooling, internal temperatures and sensible and latent heat loads — Part 1: Calculation procedures – Part 2: Explanation and justification of* ISO 52016-1 *and* ISO 52017-1

Table 2 *(continued)*

Module	Number	Title (draft)
M2-5	ISO/TR 52019-2	*Energy performance of buildings (EPB) – Building and building elements – Hygrothermal performance of building components and building elements – Part 2: Explanation and justification*
M2-8	ISO/TR 52022-2	*Energy performance of buildings – Building and building elements – thermal, solar and daylight properties of building components and elements – Part 2: Explanation and justification*
	ISO 52022-1	*Energy performance of buildings – Building and building elements – solar and visual characteristics – Simplified calculation method*
	ISO 52022-3	*Energy performance of buildings – Building and building elements – solar and visual characteristics – Detailed calculation method*

6 Overarching preparation steps

6.1 General

See the corresponding clause in ISO 52000-1 [1].

See also the discussion on policy related definitions and specifications in 3.7.3 of this document.

The reader should be aware that there are two different types of use of the overarching EPB standard (and other EPB standards) as illustrated in Figure 5:

Step 1: the use by private organizations or public institutes to make, for specific applications (e.g. for national energy performance certification and/or requirements) the input data, choices between options and choices in references to other EPB standards according to the template of Annex A: one or more (for different applications) National or Private Input and method selection data sheets.

Step 2: the use by the individual user to assess the energy performance of a specific object, using the appropriate National or Private Input and method selection data sheets from step 1.

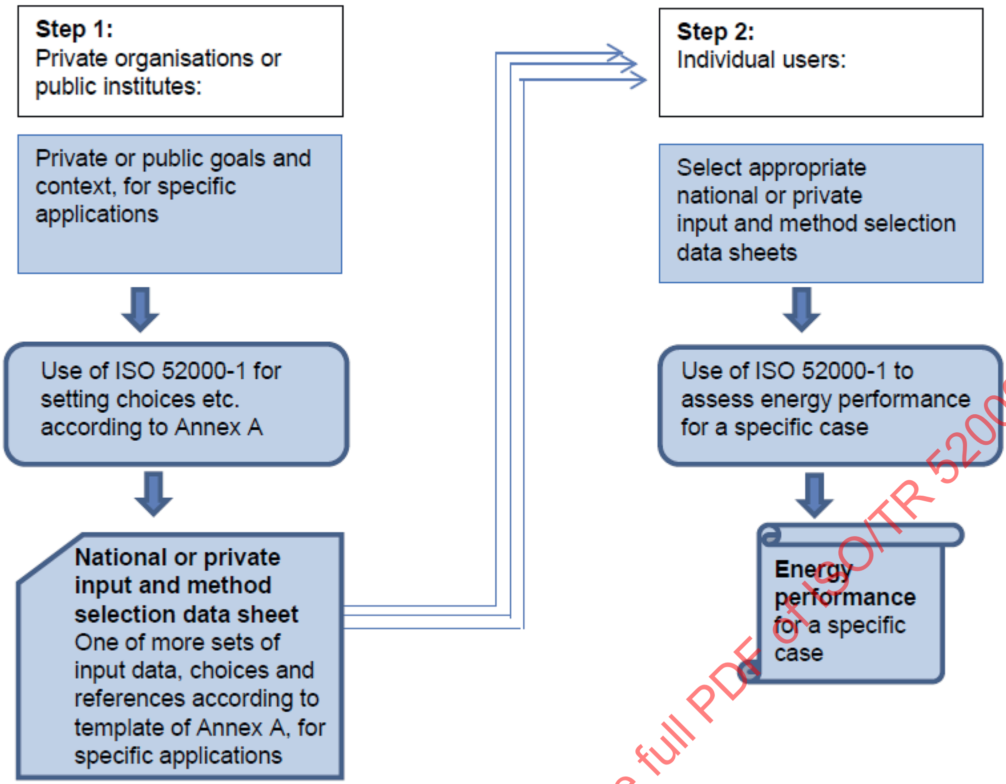


Figure 5 — Illustration of the two different types of use of the EPB standards

These two different types of use of the overarching EPB standard (or any other EPB standard) is explicitly visible in this Clause 6 that contains the preparation steps:

Clause 6.2 covers the above mentioned “Step 1”: for private organizations or public institutes (as part of the specification of the National or Private Input and method selection data sheets): to specify the list with types of object, building and space categories, types of applications, types of assessment and lists of EPB services

Clause 6.3 covers the above mentioned “Step 2”: for the individual users (after having made the appropriate selection of the National or Private Input and method selection data sheets) to select which type or types of object, building and space category or categories, type of applications, type of assessment and list of EPB services is applicable for his/her specific case.

Note that the choices in both 6.2 and 6.3 may have an effect on the choices in other EPB standards. These properties are therefore inherited by the other EPB standards, where relevant.

EXAMPLES:

— if, in a certain country, lighting is not included in the list of EPB services for residential buildings, then:

  — the fact that lighting is not included in the list of EPB services for residential buildings is taken into account in the National or Private Input and method selection data sheets of other EPB standards (e.g.: EPB standard on lighting, on indoor environment conditions, ...).

    — the fact that the specific object is a residential building or not is inherited by other EPB standards (e.g.: EPB standard on lighting, on indoor environment conditions, ...).

— if the energy certificate for apartment buildings is based on measured energy performance, then this information may obviously be very relevant for several other EPB standards.

— if the energy certificate for public buildings is based on actual energy use of the building and if the certificate needs to be displayed, then this information may obviously be very relevant for several other EPB standards.

— if the energy performance of a partially renovated building needs to meet specific partial energy performance requirements, then this information may obviously be very relevant for several other EPB standards.

— The specification of different building categories, and/or space categories and the identification which building category and/or space categories is applicable in a given case, is directly linked to (possibly) different conditions of use (temperature settings, domestic hot water needs, lighting needs, etc.), to (possibly) different EP requirements, etc. Therefore this information is very relevant for several other EPB standards.

6.2 List of types and categories

6.2.1 Type of object

ISO 52000-1 [1] asks for the identification of the type of object.

Examples of object types are: whole building or part of the building or building unit, new or existing building, large public building.

Residential or non-residential buildings may require different choice of assessment method (e.g. measured versus calculated).

A specific country or region may have special building categories that require a deviating procedure. For instance in Europe: large public building according to the EPBD[2] art. 13 (plus art. 12.1b). Another distinction of types is according to the life cycle category, for example:

— designed building,

— new building after construction,

— existing building in the use phase,

— majorly renovated building.

The energy performance procedures and requirements may differentiate between new and existing buildings or building units.

For new buildings, for which no long term actual data (necessary to assess the energy use) are known or can be measured, the energy performance procedures and requirements are limited to calculated energy performance. Compare definition of existing building (unit).

For existing buildings, for which long term actual data (necessary to assess the energy use) are known or can be measured, the energy performance procedures and requirements may include measured energy performance.

‘Major renovation’ means for instance, according to the EPBD, the renovation of a building where:

(a) the total cost of the renovation relating to the building envelope or the technical building systems is higher than 25 % of the value of the building, excluding the value of the land upon which the building is situated; or

(b) more than 25 % of the surface of the building envelope undergoes renovation.

If a so called "Representative building approach" is applicable, then the energy performance is taken from another, representative, building.

Another issue is the definition of a building: If a building category extends to two or more buildings on the same site, they can be regarded for the calculation as one building. But it is also possible to assess the energy performance of each of the buildings independent from each other, unless this conflicts with other parts of the procedures. For example if one or more residential functional units are located in another building (for example a bedroom or toilet in a separate building), the EP assessment of the building needs to be done for the buildings together.

6.2.2 Building category and space categories

6.2.2.1 Building categories

The building category may have an influence on the energy performance, because of possibly different sets of conditions of use, possibly different EP requirements, etc..

EXAMPLE Historic monuments and/or religious buildings are sometimes excluded from the energy performance regulations.

For residential buildings a categorization could be: (a) single-family houses of different types and (b) apartment blocks.

For residential buildings, there may be a need for subcategories, because of possible differences in EP requirements or in the assessment type (measured or calculated EP). For example:

— Individual residence;

— Apartment building;

— Building unit in an apartment building with individual technical system(-s);

— Building unit in an apartment building with collective technical system(-s).

Again for residential buildings, there may be a need for special subcategories, because of possible differences in EP requirements and/or in the assessment type or conditions of use. For example:

— Residence for collective use;

— Mobile home;

— Holiday home.

A 'residence for collective use' is a residential building in which one or more spaces for a residential use are used collectively, with the result that the individual apartments are not independent building units, for example student-housing with kitchens and/or bathrooms or livings for collective use (see example cases in 6.4). In such cases the energy performance assessment of the building would typically be done for the total residence. But this is a choice that is linked to the choices of space categories and such.

But even more subcategories are feasible. For instance: a student flat, senior homes, house boat, bed and breakfast (residential?).

Another issue: What specific rules are needed for mixed buildings? A mixed residential/non-residential building is for example an apartment building comprising shops, office rooms, hotel rooms and/or for instance nursing rooms or an assembly hall. Are there any specific restrictions when dealing with mixed residential/non-residential buildings?

6.2.2.2 Space categories

A differentiation in space categories in a given building may be allowed or not (see Table A.6/B.6 of ISO 52000-1:2017 [1]). If so, the most likely reason is, that different categories of spaces have different conditions of use (to be specified in the EPB standards covering module M1-6).

The conditions of use imply which services are assumed to be present.

The space categories include unconditioned or partially conditioned spaces which have an influence on other spaces (e.g. thermal, daylight, additional energy use,..).

Examples of possible space categories: living space, (residential) kitchen, entrance hall, (indoor) stair case, (in)habitable attic, bed room, nursing room, education room, corridor, toilet, server room, storage room, kitchen of "industrial" type (e.g. in restaurant), undetermined space, etc.

For existing buildings: a space that is formally allocated as inhabitable spaces should, for the purpose of the assessment of the energy performance, be assumed to be a inhabitable area, and be assigned the corresponding space category, if this space is in practice regularly occupied. For instance an inhabited attic (even if legally uninhabitable e.g. due to insufficient daylight).

Consideration should be given to buildings that are not equipped with all services for which the energy performance should be assessed (e.g. building without cooling systems when cooling is part of the energy performance calculation). See discussion in 9.2 of this document.

6.2.3 Type of application

There are different types of application possible. For instance:

— To check compliance with energy performance requirements

— Energy performance certification

— To obtain building permit

— To obtain permit to use

— Energy audit (tailored)

— Energy performance inspection

Obviously the type of application may have an influence on the assessment and the routing through the EPB standards. Therefore also the type of application is inherited by the subsequent EPB standards.

6.2.4 Types of assessment

The assessments given in Table 3 of ISO 52000-1:2017 are derived from EPBD requirements. There are other possible assessments not in relation to the EPBD, but addressing "added value to the market". See also CEN/TS 16628:2014,[13] 7.8. The type or types of EPB assessment should be specified and, if depending on the application and/or building category, for which application and building categories.

Rationale for making the choice:

The selection of the relevant energy performance assessment type should take into account the following points. The procedure for building energy certification should describe how these points have been taken into account as part of the procedures in ISO 52003-1[8].

— For new buildings, the measured energy indicator is not available.

— Measured energy offers a means of adjusting recommendations to suit the actual building use rather than standardized assumptions.

— For tracking year-on-year improvements (or otherwise) of operational performance, measurements need to be taken. (Public buildings are sometimes required to display annual measured ratings for several consecutive years).

— The utilities which collect data on energy consumption should not be authorized to disclose them for privacy reasons.

— A measured energy indicator will no longer be valid following a change of building occupier or of the pattern of use of the building. For existing buildings which are rented or sold, the way the building is managed could change and the measured energy indicator could change as a result.

— Defining a standard calculated energy indicator includes the collection of data on the building (insulation, heating system, etc.) which will be useful in giving advice on the improvement of its energy performance.

— In existing public buildings where there is no change in ownership, the measured energy indicator can be a measure of the quality of the management and can be used to motivate building operators and users.

— When the energy certificate is displayed in an existing public building, the operational indicator can be a measure of the quality of the management and can be used to motivate building operators and users.

— For managers of buildings, a measured energy indicator can be easily obtained from data often stored in their information systems (energy bills, areas, etc.).

— Measured energy indicator and standard calculated energy indicator do not necessarily include the same energy uses.

— For new buildings, a design indicator may be the only practical means of assigning an indicator.

EXAMPLE A mix of tailored and design assessment may be used for an optimization of the building and the technical systems during the design phase, if the use is better known and different from the standard use. A variant of this assessment using standard use data may then be used for the design assessment as a by-product.

6.2.5 Building services

The building category is linked to typical uses satisfied by building services. The definition of 'energy performance of a building'[2)] takes into account the following building services:

— heating;

— cooling;

— ventilation;

— domestic hot water;

— lighting;

— humidification;

— dehumidification.

Other energy services, for example "appliances", "transport" (e.g. lift, mechanical escalators) may be considered. If other appliances are considered, this should be indicated in the related table of the Input and method selection data sheet, according to Annex A of ISO 52000-1:2017.

2) Following definition 4 of the recast EPBD[2].

The energy services for appliances will become more and more important in high performance buildings. The reasons for not selecting “appliances” in the default option are the following:

— only the energy services heating, cooling, ventilation, hot water and lighting are taken into account;

— only energy services characterising the performance of the building, linked to the building envelope and to “building integrated” technical systems, are considered;

— only energy services where it is possible and practical to verify the compliance with building regulations are considered (legal aspects).

NOTE 1 Assessment based on measured consumption (commonly used for public display certificates) can include these other energy uses.

The use of energy for the considered building services is linked to the occupancy patterns (e.g. tapping patterns for domestic hot water (DHW), internal air temperatures, occupancy, and scenarios).

NOTE 2 If verifiable construction specifications influence the ”other energy services”, then a possibility could be to take into account the other energy services by linking the construction specifications to different default values.

Another important part related to the building services are the recovered losses and the internal gains of an energy service, for example the heat gains related to appliances. A distortion of the energy balance can be created if the energy used is not considered in the energy balance and if only the internal gains are taken into account. In this case only the benefit related to the internal gains would be taken into account, without counting the needed energy use.

In order to be close to a realistic evaluation, especially of the indoor temperature and the load calculation, it has been decided to take into account internal gains even without the related energy service.

The value of these internal gains should be reported in the occupancy patterns and conditions of use.

Consideration should be given to buildings that are not equipped with all services for which the energy performance should be assessed (e.g. building without cooling systems when cooling is part of the energy performance calculation). Possible options are:

— provide specification of a default technical system for each missing service;

— accept a better assessment for buildings missing some service and possibly highlight the discomfort with a complementary indicator (example: hours of summer discomfort).

See discussion on this issue in 6.2.2 (Space categories) and 9.2 of this document.

6.3 Identification of types and categories for a specific case

See explanation in 6.1.

6.4 Example cases

6.4.1 General

The typical building services of the building, e.g. heating, cooling, ventilation, hot water and lighting seem related to the building category. However, the category is essentially a property of the individual space, because a building seldom consists of one space category only.

EXAMPLE A typical office building contains also a hall, toilets, corridors: spaces servicing the use as an office; a school building often has some office spaces: spaces with other use than education.

Consequently: Schematization of a building starts with the categorization of spaces.

Each space may have its own space category that needs to be specified since this determines the (assumed standard) conditions of use: temperature, lighting, ventilation and air quality, domestic hot water needs, use of (other) appliances, etc. So the categorization of spaces determines the **internal conditions** that influence the **energy use**.

The minimum energy performance **requirements** ("energy budget") and **benchmarking** are the mirror image of the energy performance assessment procedures: they should be based on the same assumptions to avoid that "apples are compared with oranges".

Consequently, one should be aware that choices that influence the energy use (e.g. which types of spaces and which energy services are included), also have an impact on the minimum energy performance requirements and the benchmarking. Setting legal requirements on energy performance should take into account the case of buildings including several space categories.

For administrative purposes, the prevailing space category may be attributed to the building.

In contrast to the categorization of spaces, the allocation of a building category seems to have no other impact on the energy performance assessment than certain legal implications (e.g. setting of minimum energy performance requirements, energy certificates, safety and health). The building categories apply either to the whole building or to a building unit.

It is up to the user of the standard to make simplifications in the differentiation and allocation of space categories, within the appropriate legal context of course. In this way it is even possible to allocate the prevailing space category to all the spaces of the building or building unit.

The following example cases (see Figures 6a to 6f) serve as catalyser for the discussion and better understanding of the specifications of the assessed building (part) and the allocation of space categories and conditions of use. Other exercises can be added easily.

6.4.2 Example case 1

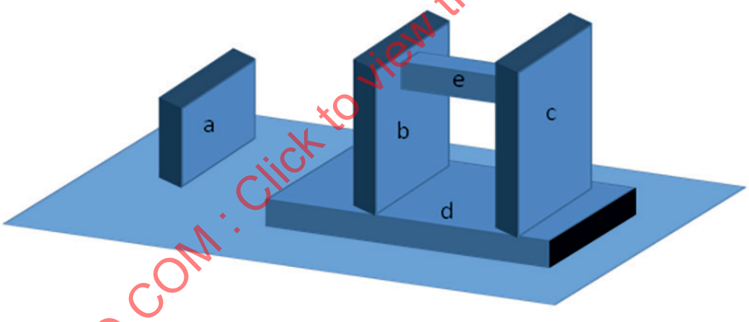


Figure 6a — Example 1

Description: More than one building on the same building site

Exercises:

— Is it possible to give a common EPB definition of a (separate) building? No, e.g. if (d) is an indoor car park and (e) is a sky bridge (as corridor): any definition is arbitrary whether (b) and (c) are separate buildings (connected via the sky bridge and indoor parking (d)) or (b) and (c) are a single building.

For the EP assessment this choice (two or one building) should not make a difference (but nevertheless probably will…).

— See 6.2: Situation may be for example:

  — Building (a) is a new building for which EP is to be assessed.

  — Building unit in building (a) needs to be assessed.

  — Building (b) is to be assessed; (including (some of?) common part (d) and sky bridge (e).

— All buildings (a - e) are to be assessed.

— Building part (d) is renovated (including entrance hall for building parts (b) and (c); to be assessed, but large part is only entrance hall.

6.4.3 Example case 2

Description: A students flat.

Floor plan each floor:

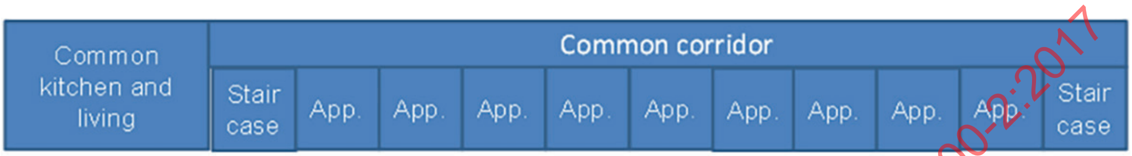


Figure 6b — Example 2

NOTE The apartments are not independent building units: each floor has a number of apartments with one common kitchen and living room (e.g. with also common showers per floor or an individual shower per apartment). This building type is also known as “Residence for collective use”.

Exercises:

— See 6.2: Can the EP per apartment be assessed, as a building unit? No: each apartment is not an independent part of the building. An independent part of a residential building requires at least a living room, bed room, kitchen area, toilet and bath room, or combined toilet and bathroom. Therefore, the smallest building unit is one floor.

— See 6.2.2: What if the same building has, in addition to the common kitchen and living per floor, also a large common indoor space for the whole building, e.g. at the ground floor? Then it might depend on national building regulations whether this space is regarded as necessary common living space or as extra space.

6.4.4 Example case 3

Description: Mixed building with different space categories, common spaces (hall, toilets, escape route), spaces not for human occupation and spaces outside the considered building or building part.

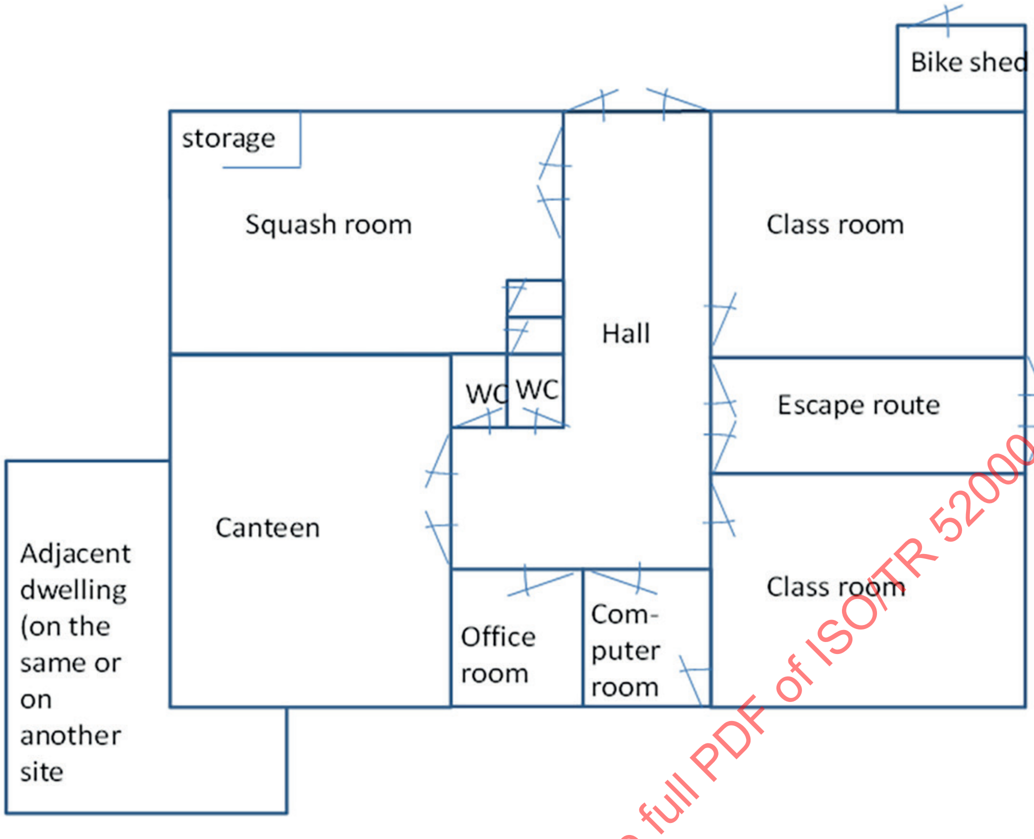


Figure 6.c — Example 3

Exercises:

— What is the space category of the common hall, escape route and the common toilets? See the three options with pro's and con's described above.

— Assume that the common hall, escape route and the common toilets have their own conditions of use. We would not like to calculate each space separately. What are the rules for allowing to combine spaces into building sections?

— Is the bike shed inside or outside the "thermal envelope"? This depends on rules, given in the standard under EPB module M2-2 (ISO 52016-1[10]). if inside: which (thermally conditioned) space category will be allocated to this space? But if there are adjacent spaces with different categories? The largest. But if they are equal size? Free choice?

— What is the link with the adjacent dwelling? Evidently: if on another site, or if not included in the object to be assessed, the adjacent dwelling is only a boundary condition. For what? A boundary condition for the calculation of the heating and cooling needs. Therefore, assumptions are needed for this boundary. But these can be specified in the specific standard dealing with energy needs for heating and cooling (ISO 52016-1[10]).

6.4.5 Example case 4

Description: Dwelling with (habitable) attic, sunspace, storage

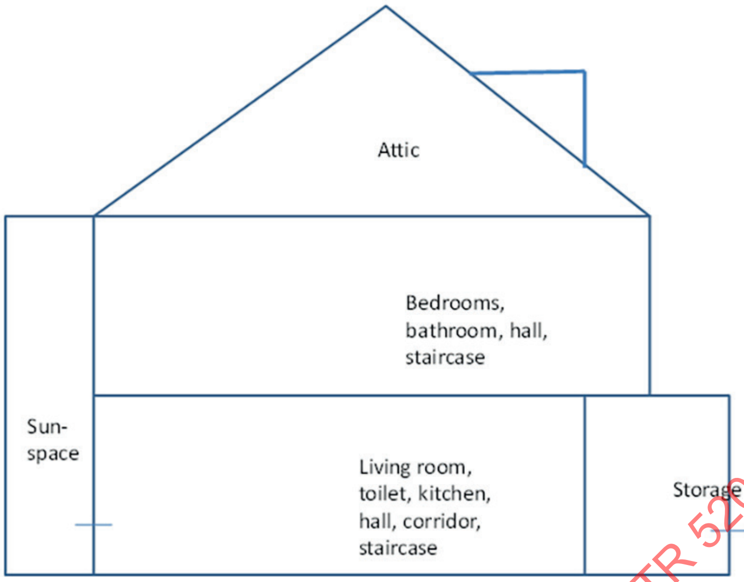


Figure 6d — Example 4

Exercises:

— What to do with attic if legally not habitable, but in practice habitable/habited?

— Storage included or excluded?

— See Clause 10: Service area for hot water needs? For a calculated EP, the amount of hot water needs (shower, kitchen) are (nationally) defined per person, with a given standard occupancy per m^2 floor area. In a residential building, the counting of persons is of course for the whole dwelling (evidently, because all the persons in the dwelling together determine the hot water needs of kitchen and bath room). Consequently: for the hot water needs of a dwelling the whole dwelling is a single “zone” (service area).

6.4.6 Example case 5

Description: Another mixed building with different space categories, common spaces (large entrance hall), spaces not for human occupation and (possibly) spaces outside the considered building or building part.

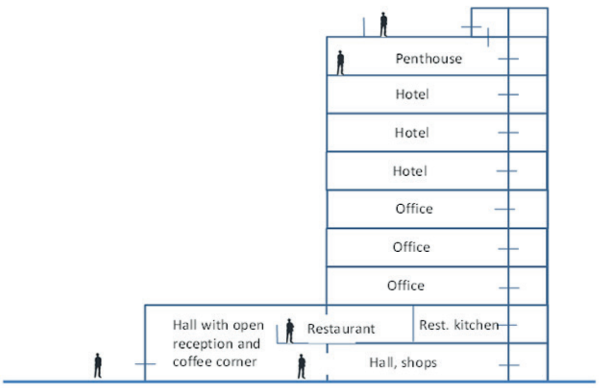


Figure 6e — Example 5

Exercises:

— EP whole building: What conditions to assume for the large common entrance hall?

— EP of penthouse: what to do with attributing (part of) the hall?

— EP of restaurant (e.g. if renovated or changed ownership): What to do with attributing (part of) the hall? How to deal with the open connection to hall? What to do with kitchen (category: "industrial")? What to do with technical building systems (TBS) in case common TBS for whole building?

6.4.7 Example case 6

Description: Building with indoor car park

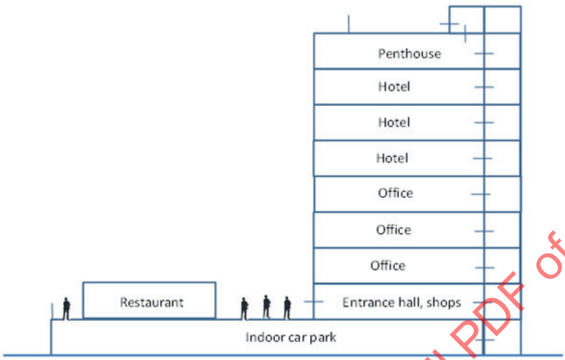


Figure 6f — Example 6

Exercises:

EP whole building: some countries include car park's energy for lighting and ventilation in EP, but not its size in the reference size (see discussion in 9.4).

7 Calculated energy performance of buildings

7.1 Output data

Obtaining data per service and per building zone can be done only at overarching levels because there can be many generation systems contributing to the same service and there are also common contributions of renewable energy produces on-site that is allocated to all the considered EPB services.

7.2 Calculation intervals and calculation period

7.2.1 Calculation interval

When defining the input and output variables between the individual modules in an unambiguous way, it is essential that it is clear which time interval is used for the variable being transferred from one module to the other. This could for instance be:

— Hourly;

— Monthly;

— Seasonal;

— Yearly;

— Bin.

“Bin” refers to a statistical method, where the frequencies of occurrence of short time interval values for one or more boundary condition variables (e.g. hourly values for the outdoor air temperature) are allocated to defined intervals (the “bins”). The calculation is then done bin by bin, by using the value of the variable in the middle of the bin as a boundary condition and multiplied by the frequency of the respective bin.

This method is especially of value when calculations with longer time intervals for some parts (e.g. monthly or seasonal for the building) need to be combined with calculations of technologies where the influence of the variation of a driving force is essential and averaging is not acceptable (e.g. the outdoor temperature for air-to-water heat pumps).

The limitation of the bin method is that there is no ‘memory’ between the bins. In case of energy storage systems or in case of heat accumulation in building elements, a bin does not know how much heat was accumulated or released during the previous time interval, because the bins are not sequential in time as e.g. an hourly time interval.

The calculation interval is one of the key issues. to obtain a transparent and coherent overall structure, with all of the interactions at different levels and with a coherent set of input data.

For use in the context of building regulations it is essential that the procedures to calculate the energy performance of a building are not only **accurate**, but also **robust** (applicable to a wide range of cases). It is also essential that they are **reproducible** (unambiguous) as well as **transparent** and **verifiable** (e.g. for municipalities, to check compliance with national or regional minimum energy performance requirements) and **applicable/affordable** (e.g. for inspectors, assessing the energy performance assessment of an existing building).

In other words, it is important to find a balance between transparency, robustness and reproducibility of the calculation method, an affordable and reliable set of input data, and sufficient appreciation of the wide variety of available energy saving technologies.

Therefore, the accuracy of the model should always be in proportion with the limits and uncertainty in input data and with the required robustness and reproducibility of the method: a balanced accuracy.

Consequently, the most accurate, complete and state of the art method is not necessarily the most appropriate method for a specific calculation.

Annex L contains a list of technologies.

Many of these technologies, in particular for low energy buildings, are strongly and dynamically interacting with the hourly and daily variations in weather and operation (solar blinds, thermostats, needs, occupation, accumulation, mechanical ventilation, night time -free cooling- ventilation, weekend operation, etc.). This has a strong effect on the heating and cooling calculation.

In the monthly calculation method of the energy needs for heating and cooling, correction or adjustment factors are required to account for these effects in a kind of statistical way. A direct hourly calculation may not need such correction factors and is from that point of view a favourable method. But the challenge for an hourly method is to avoid the need for too many input data from the user, which would introduce uncertainties that could easily lead to a loss of overall accuracy.

Moreover, an accurate hourly calculation covers only one specific situation, with one specific set of conditions of use: one daily pattern of temperature settings, one pattern of occupancy presence, ventilation needs, weather, etc. The impact of variations is not taken into account (unless it would be prescribed to repeat the calculation for a given building with a prescribed variation of patterns).

The correlation factors in a monthly method may have been developed on the basis of a large series of building simulations with e.g. variations of daily weather and conditions of use, leading to statistically average correlation factors that could –for certain effects- give a more robust result than an hourly calculation based on only one specific pattern.

EXAMPLE the comparison of manually controlled solar blinds versus automated operation of blinds would require that the variation in user behaviour in case of manually controlled blinds is taken into account. In a monthly calculation a correlation factor can implicitly take into account these variations. In an hourly calculation there is only one type of user behaviour.

For an hourly method it is important to avoid that the result is just a black box. Therefore, where possible, monthly results are given that can be used to check the validity or feasibility of the result. In ISO 52016-1[10] the monthly and hourly calculation method are even directly linked: both methods use almost the same input and the hourly method also yields monthly results which can be compared with the monthly method or be a basis for the derivation of correlation factors for a monthly method.an hourly calculation method does not require that all output from each EPB standard are hourly varying. This depends on several factors, such as:

— The importance of the quantity (quantities with minor influence may be regarded more easily as 'static').

— The amount of variation of the output as function of certain conditions (e.g. the U-value of a wall can usually be regarded as constant over the year, despite the (small) temperature dependency; but the performance of a heat pump is usually strongly dependent on the temperature of the source and the required power and output temperature).

— The uncertainty in the process or in the input data: if there is a lack of reliable information, then a simplification may be more appropriate than a detailed calculation with many uncertainties (for instance: the accumulation of moisture in the building fabric; see ISO 52016-1[10]).

A balanced choice is to be made in each EPB standard accordingly (open for choices in Annex A/Annex B accordingly, if necessary).

The use of detailed building simulation tools is not covered by the set of EPB standards because that would be too much an open end. A detailed building simulation method with a standard list of input data (input variables) would solve the open end with respect to the input data, but would still not meet the criteria that a method to be standardized should be transparent for the standard writers, sufficiently stable and the availability of validation test cases, covering all elements in the calculation, and criteria with sufficiently narrow band width to ensure reproducibility and reliability.

A more detailed method only leads to an *apparent* higher accuracy and not to a *real* higher accuracy, because many details that would be equally important for a higher accuracy cannot (or are not) taken into account anyway; at least not without excessive extra input data.

Examples of typical differences between the model and the reality that in general are more or less "unavoidable":

— *Conditions:* typically, the calculation will be performed for one set of standard conditions climate, occupants, use, ...). Even if this set represents the average situation in a country or region, the result will not be average due to non-linear effects.

— *Input:* there are practical limitations to the verification of the input data. Are the assumed products/components used? Are these products installed as assumed?

— *Modelling:* in particular, the redistribution of heat inside and between spaces in a building is ignored to some extent. For instance the thermal interaction by thermal transmission and air circulation between thermal zones in a building, the thermal stratification in a room, different heating or cooling needs in different parts of a room or thermal zone. In theory, a detailed model could be used, but this requires many assumptions on the use of the spaces, while the actual use of the spaces in practice will vary significantly.

— *Human factor:* uncertainty whether (on the average) the building is used as assumed; whether the building provisions are used and maintained as assumed.

— *Peaks:* Even with detailed hourly simulations "peaks", if shorter than one hour, are not picked up. For example: peaks in heating or cooling load, peaks in glare.

These differences will lead to inaccuracies in the calculation results. The accuracy in other characteristics of the model needs to be in proportion with the "unavoidable" inaccuracies, to avoid a "fake accuracy". This is in particular the case if this would lead to a decrease in other important quality aspects such as transparency, robustness, reproducibility etc., as mentioned above.

7.2.2 Calculation period

The calculation period is, as a rule, one year.

The actual length of heating and cooling periods depends on the climate and conditions of use (such as temperature settings, ventilation needs, assumed internal; heat gains, etc.), but –obviously- also depends on the specific case (design). This actual length can be derived from the calculations. For instance, the output of ISO 52016-1[10] includes information on the actual heating and cooling period length. This can be used as input for other EPB standards (e.g. to calculate the operation time of pumps, fans, etc.).

However, there may also be a need to specify an 'overall' or 'maximum' length of the heating and cooling periods. E.g. to prevent that also short periods of heating/cooling outside the actual heating/cooling period are taken into account; or to account for certain building regulations. Or, e.g., to avoid that simultaneous heating and cooling is overlooked due to a simplification in the zoning of the building.

7.3 Input data

7.3.1 Product data

No additional information needed.

7.3.2 System design data

No additional information needed.

7.3.3 Operating conditions

7.3.3.1 General

This standard assumes that auxiliary energy is electrical energy. Electricity may be also the main energy carrier that provides the input to a generation device, such as a heat pump or a blower. The distinction between "auxiliary energy" and "main electricity input" has no practical effect on the energy balance (e.g. it is electricity used for EPB purposes, indeed). In principle auxiliary energy may be of another type (it could be compressed air). In that case:

— either the auxiliary energy is produced by an electric device (it is often the case for compressed air) whose electricity use will be the real auxiliary energy;

— or it is treated just like another delivered energy carrier, using weighting factors based on the type of generation device that provide the auxiliary energy.

Each electric energy amount that is produced or used is associated with an identifier of the type of use or production. This feature has been introduced to allow features such as:

— priorities in using or exporting the electricity produced on site when multiple on-site generators are available;

— filtering of the type of uses that can be compensated by electricity produced on.

7.3.3.2 Electricity input to generators

Typically this is the input to electric heat pumps, chillers and blowers of ventilation systems.

If there is no such device, the value is zero.

7.3.3.3 Auxiliary energy input

A system without auxiliary energy is possible but this happens very seldom.

7.3.3.4 Electricity use type

The type of electricity use is recorded by an identifier to manage any condition on which type of source can be used to cover electricity use.

EXAMPLE In some countries it is not allowed to compensate electricity use for direct heating with electricity produced by PV panels. This can be done in a software only if the specification of type of use is attached to any used energy amount.

The identifier EL_USE_DEFAULT can be assumed if no specification is given.

The value of Table B.11 in ISO 52000-1:2017 can be EL_USE_DEFAULT only if no special condition in the default values is used.

A consequence of this approach is that electric energy uses are not summed in the low level standards unless they have the same use type.

7.3.3.5 On-site produced electricity

No additional information needed.

7.3.3.6 Electricity production type

The electricity production type is an identifier that is used to keep track of the origin of the electricity produced on-site. This is relevant for the following steps:

— calculating step A weighting factors;

— specifying and taking into account any priority in the use of electricity produced on-site.

Contributions from several on-site generation devices should be kept separate if a priority criteria for exportation or on-site use is considered. If they are not kept separate, then there is no priority applied and the on-site use is implicitly considered as proportional to the electricity generated by each generation device.

7.3.3.7 Electricity use for non EPB uses

It is possible to take into account the electricity used on site for non EPB uses. This option is not handled by “energy use type” because an independent weighting factor can be specified for this type of exported energy.

7.3.3.8 Delivered energy other than electricity

These are amounts of energy carriers that are not exported. Usually these are all other energy carriers than electricity.

7.3.3.9 Energy carrier specification

The coding of this identifier should be as far as possible uniform in the various national implementations of the EPB standards.

EXAMPLE GEN_CR_EL for electricity, GEN_CR_GAS for natural gas or GEN_CR_LPG for LPG.

On a broader level, there might be additional energy carriers such as special fuels, nuclear power, municipal waste, etc.

This list of energy carriers allows unambiguous and unique specification of weighting factors and physical properties (e.g. density, calorific values) of energy carriers in all EPB standards.

7.3.4 Constants and physical data

No additional information needed.

7.3.5 Other data

7.3.5.1 Primary energy weighting factors

Non-renewable, renewable and total primary energy and the corresponding weighting factors are not independent. For any energy carrier cr, the following relationships holds:

$$E_{\text{P;tot;cr}} = E_{\text{P;nren;cr}} + E_{\text{P;ren;cr}} \tag{29}$$

$$f_{\text{P;tot;cr}} = f_{\text{P;nren;cr}} + f_{\text{P;ren;cr}} \tag{30}$$

7.3.5.2 Time dependent weighting factors

The calculation model of ISO 52000-1 has been designed to support time-dependent weighting factors. In the past primary energy factors have been always considered constants. Time dependent primary energy factors might be used for electricity if the varying generation combination is taken into account. Cost of electricity is already very often a time dependent weighting factor.

<u>This does not mean that time dependent weighting factors are required. Weighting factors are usually time-independent. This means only that should anybody desire to use time dependent weighting factors, this is possible with ISO 52000-1.</u>

7.3.5.3 The k_{exp} factor

The weighting of the exported energy is done in a two-step approach:

— first weight exported energy according to the resources used to produce it (first step, step A),

— then possibly add the benefit for the external world of exporting that energy (second step, step B).

The exported energy evaluation factor k_{exp} controls how much of the second step in weighting the exported energy is taken into account.

The effect of the choice of k_{exp} is the following:

— setting the value of k_{exp} to 0 has the effect to take into account into the energy performance of the building only energy that is used in the building;

— setting the value of k_{exp} to 1 has the effect to take into account into the energy performance of the building also the energy that is produced on-site and used outside of the building.

7.4 Description of the calculation procedure

When ISO 52000-1 is applied, the calculation of all the energy flows within the building at all calculation intervals is already completed. All the energy exchanges with the external world are known in quality (which energy carriers are crossing the assessment boundary) and quantity (how many kW·h of each energy carrier are physically crossing the assessment boundary).

ISO 52000-1:2017, 9.6.1, Formula (2) only states that the energy performance balance is made of two components: delivered minus exported. Weighting factors and other indicators are defined in other parts of the standard.

The data and calculation procedure about electric energy is separated from other energy carriers because it is the energy carrier that can be produced on-site from renewable or non-renewable sources and it can be both delivered and exported. If other energy carriers are exported (e.g. biogas) then the same procedure as for electricity is followed.

8 Measured overall energy performance and comparison with calculations

8.1 General

ISO 52000-1 covers the final weighting of delivered and exported energy after the building and the technical systems have been taken into account in the other modules.

Table 3 shows a non-exhaustive comparison between calculated and measured data.

Table 3 — Comparison between calculated and measured data

Feature	Calculated	Measured
Time interval of data	Any desired time interval is possible. Data are naturally synchronous per calculation interval. Different calculation intervals can be combined.	Imposed by actual rate and time of measurements. Specific hardware is required to get a predefined time resolution. Even if metered data is available with a good time resolution, synchronicity of measurements is not guaranteed unless specific provisions are in place.
Availability of detailed data	Any desired detailed quantity can be evaluated (e.g. auxiliary energy for a single pump, fuel for a single generator, etc.) In existing buildings the information is not always visible and might need to be determined from the age and type of the building/system.	The only available data is the metered data, usually at the level of energy carrier. Sometimes heat or electricity to a building part or service is measured
Other uses than EPB	Other uses than EPB are naturally ignored unless intentionally included	Other uses are often included in the raw measured data. Separation procedures required

Table 3 *(continued)*

Feature	Calculated	Measured
Use and weather influence	Any use or weather, standard or custom, can be taken into account	Use and weather influence are included in the measured data. Normalization techniques and procedures are required
Reliability of data	Data are well defined but there is often uncertainty on their value for concealed materials and installations. New product data are defined in dedicated standards. Some product standards do not define the exact data to evaluate the performance of products within any system and possible operating condition.	The source of data needs to be checked, depending on the source (invoices, user readings, etc.). A validation information is needed.
Auxiliary energy data	Auxiliary energy is easily included in the calculation	Auxiliary energy is seldom measured independently

The measurement, filtering (e.g. separation non EPB uses), normalization, separation of services and validation of the delivered and exported energy amounts are covered by the specific modules MX-10.

ISO 52000-1:2017, Clause 8 gives specific definitions, consideration and instruction required when the delivered and exported energy amounts are measured. It gives also common definitions needed by the specific modules MX-10.

Sometimes a mix of measured and calculated data can be specified by the underlying modules to complete the measured data set for consistency with calculated data.

EXAMPLE Measuring the main fuel input and estimating (e.g. calculating) the auxiliary energy

8.2 Output of the method

The output of the measured energy performance is in principle the same as the output from the calculated energy performance (see 7.1).

However there are limitations when using measured data because usually only seasonal or yearly delivered and exported energy amounts are known, per energy carrier. Intermediate readings are seldom available. The break-out of an energy carrier use amongst several generators and/or services is seldom known.

To get reliable and useful results, a monitoring system and procedure should be planned from the design phase, based on the desired output and on the objective of the measured energy performance assessment.

8.3 Measurement intervals and measurement period

The calculated energy performance requires the concepts of “calculation period” and “calculation interval”:

— the calculation is repeated for each calculation interval (month, hour, ...)

— the results for the calculation intervals are combined to get the final result for the calculation period (year, season).

The measured energy performance assessment requires an extra concept: measurements are often extended on a time span which is a multiple of the “calculation period”, typically to average out climate influence and any other random influence.

A comparison of time intervals for measured and calculated data is given in Table 4.

Table 4 — Comparison between time intervals for calculated and measured energy performance

Calculated	Measured
Calculation interval It has a well-defined duration.	**Measurement interval** The duration depends on the actual date of each measurement. The duration may be random and is not guaranteed unless a measurement procedure was designed and implemented in the use phase. Synchronicity of data from several measurement points is an issue as well.
Assessment interval Not relevant.	**Assessment interval** This is the time span covered by measurement intervals taken into account. The assessment interval may be longer than the calculation period when interpolation techniques are used. The assessment interval may be shorter than the calculation period when extrapolation techniques are used.
Calculation period It is the time span for which the final result is desired. The result for a calculation period is a combination (usually sum) of results for shorter calculation intervals.	**Calculation period** This is the same as for calculated energy performance. The result for a calculation period is a combination of results (interpolation or extrapolation) for the assessment interval.

The concept of “assessment interval” is distinguished from the concept of “measurement interval” and measurement procedures can have requirements on the assessment interval duration.

EXAMPLE A possible requirement is that an yearly measurement is repeated for at least three years and then averaged to reduce the influence of climate which is mostly a random deviation.

NOTE Averaging over years will not reduce (or will reduce less) the user behaviour influence which is more of a systematic nature and that can change with building use and users.

Another example of the need for a distinction between “calculation period” and “assessment interval” for measured energy performance is the following: The assessment interval of heating should be one season (e.g. autumn to spring) and not one year (e.g. calendar year) because there can be very significant differences in degree days within a heating season (e.g. warm autumn and cold spring or vice-versa). Fluctuations in seasonal degree-days are usually less significant.

8.4 Input data

8.4.1 Product data

No additional information.

8.4.2 System design data

At measured energy performance module level (MX.10), the system design data define:

— the services provided by each generator;

— the generators supplied by each metered energy carrier.

Specific data on system design are defined in the relevant modules.

8.4.3 Operating conditions data

ISO 52000-1:2017, Table 8 (for measured energy performance) is the equivalent of Table 6 in the same standard (for calculated energy performance). In principle there is no difference between getting the delivered and exported energy by meter (measured energy performance) or by generator (calculated energy performance). It is indeed the amount of delivered energy per carrier which is allocated to a defined EPB service(s).

8.4.4 Constants and physical data

No additional information needed.

8.4.5 Other data

No additional information needed.

8.5 Measurement procedures

This clause gives general information on the measurement procedures that are specified and detailed by the specific modules MX-10.

One separate module should be available for each EPB service. However the separation of energy use for each EPB service is often difficult with measured energy.

The listed corrections and/or extrapolations as well as specific validation criteria are given in the specific modules MX-10.

8.6 Calculation of the energy performance based on measured energy

Once the delivered energy carrier amounts are known, the weighting procedure is in principle the same as for calculated energy performance.

However the (usually low) number of measurement intervals can strongly limit the validity of features like the evaluation of the interactions of produced, used and exported electricity.

8.7 Comparison between calculated energy performance and measured energy performance

Comparison between calculated and measured energy performance is not a trivial topic, because:

— corrections and extrapolations to convert the measured energy use under actual conditions to energy use under standard environment and operational conditions for the energy performance assessment;

— or calculating a tailored energy performance;

requires expert knowledge and/or a large amount of operational data (actual conditions of use of the building, climatic data, etc.).

Corrections and/or extrapolations and/or additional data are needed for:

— taking into account only the desired energy services (e.g.: filter out appliances, including lighting in case of residential buildings);

— determining the amount of fuels and energy carriers (e.g. weighting wood or coal or estimating the stock at the end of the assessment period);

— calorific value of fuels (e.g. taking into account humidity of wood);

— aligning to a common assessment period (e.g.: interpolate or extrapolate to a full year) which is different for heating, cooling, domestic hot water, solar or wind power, lighting, ventilation etc.;

— taking into account weather and outdoor environment (e.g.: correct to a standard year) which is again different for heating, cooling, domestic hot water, solar or wind power, lighting, ventilation etc.;

— taking into account occupancy and operation (e.g.: number of occupants different from standard assumptions, different occupancy behaviour (set points, ventilation, control of solar blinds, ...), system control settings different from assumed control, etc.).

These correction procedures are detailed in the specific modules MX-10.

As an example, EN 15378-3 ‘*Energy performance of buildings - Heating and DHW systems in buildings - Part 3: Measured energy performance, Module M3-10, M8-10*’ deals with heating and domestic hot water which are often combined and produced by the same technical system. Also, the fuel counter may take into account also non EPB uses (e.g. cooking when using natural gas). EN 15378-3 includes procedures to separate any non-heating use.

8.8 Measured energy performance reporting

No additional information needed.

9 Overall assessment of the energy performance of buildings

9.1 Categorization of building and/or spaces

See discussion in Clause 6.

9.2 Combination of building services included in EPB in each space

‘Combination of services’ means the list of which services are taken into account in the energy performance assessment.

Because this list may be different for different building (or space) categories (see also discussion in Clause 6), there may be different lists. For instance:

— Residential buildings: excluding lighting.

— Office buildings: excluding domestic hot water.

Obviously, there is a direct link with the assumed conditions of use per building or space category, to be specified in the standard covering EPB module M1-6.

Consideration should be given to buildings that are not equipped with all services for which the energy performance is assessed (e.g. building without cooling systems when cooling is part of the energy performance calculation).

More information can also be found in ISO/TR 52003-2[9] and ISO/TR 52018-2,[12] the technical reports accompanying the EPB standards on Energy performance of buildings – Indicators, requirements, ratings and certification (On general aspects and on building fabric respectively).

9.3 Useful floor area and air volume

Useful floor area is important in the possibility to reconcile the needs for harmonization, transparency and flexibility.

A complete separation has been made between reference floor area and useful floor area.

The **useful floor area** is used for various purposes, such as:

— for conditions of use, if **conditions of use** are given **per m² of floor area** (e.g. hot water use, ventilation needs),

— for weighting according to floor area, e.g. for subdivision and recombination in case of **zoning** (see Clause 10).

The **reference floor area** is one of the options for a reference size. It *can* be *based on* the useful floor area. The **reference size** is used for **normalization of the energy performance**, as explained in 9.4.

The **useful floor area** should not be confused with the **thermal transmission loss area**. The latter is specified in ISO 13789.

The **thermal transmission loss area** can be specified using e.g. internal dimensions or external dimensions (see ISO 13789). The use of internal or external dimensions and the value of linear thermal bridges due to connections between constructions are communicating vessels. If internal dimensions are used, the value of the areal thermal transmittance of the construction is smaller, but the value of the thermal bridge by the connection with an adjacent construction is larger than in case of external dimensions; and vice versa.

The **thermal transmission loss area** is relevant for any (heat loss giving) construction.

The **useful floor area** is something completely different: it includes for instance the area of intermediate floors without any heat loss. It may exclude for instance parts of a heat loss giving floor area if the space above it is not useful: e.g. if it is taken by a load-bearing construction, or if it has a height (below ceiling) that is smaller than for instance 1,5 m. These specifications are open for choice (see ISO 52000-1:2017, Table A.20/B.20).

ISO 52000-1:2017, Table B.20 gives an informative default specification.

The specification of the useful floor area does not intend to replace any national definition of useful floor area for economic and legal purposes:

— The useful floor area is explicitly defined as the useful floor area **for the EPB assessment** (which is further precised in the definition).

— The given specification in the standard is only an informative default option (in Table B.20).

It is important that whatever is the specification of the useful floor area, it **must** be **independent** of the choice of the elementary spaces, as stated in the standard. The useful floor area of a thermal zone or a service area must be the same as the sum of the useful floor areas of the elementary spaces. This condition is met with the informative default specification in ISO 52000-1:2017, Table B.20.

The air volume may be needed in different parts of the energy performance calculation, for instance to calculate the moisture (or contaminant) content resulting from the moisture supply and extraction due to ventilation, absorption and / or production in a space.

The air volume is in principle also an important parameter for the thermal balance in a space (heating up and cooling down). However, in a real situation the amount of furniture in a space will be more important than the shear air volume.

Also the air volume *can* be used as the basis for the **reference size** (see 9.4).

9.4 Normalization to building size

9.4.1 Reference size

The reference size is used for the normalization of the energy performance. For example: the non-renewable primary energy use, in kW·h per square metre.

NOTE 1 The European directive EPBD[2] refers in several articles to the size of a building in terms of square metres. And in the context of nearly zero energy buildings (art. 9) it asks for "... including a numerical indicator of primary energy use expressed in kW·h/m^2 per year."

The reference size can for instance be based on the useful floor area or net volume. If it is based on the useful floor area, it is called reference floor area. The choice is given in ISO 52000-1:2017, Annexes A and B.

Assessing the size of a building or part of a building implies the choice which spaces are considered to be included. This choice is related to the space category. For specific space categories a fraction (between 0 and 1) of the size may be appropriate. ISO 52000-1:2017, 9.4.1.

EXAMPLE A basement, attic, indoor parking.

It is evident that the reference size has a large effect on the value of the normalized energy performance.

NOTE 2 And subsequently on the energy performance requirements if these are also normalized.

Obviously the conditions of use in the different spaces (such as temperature set points, etc.) have a strong influence on the (e.g. calculated) energy use in those spaces.

Therefore it is very important that the choice of the boundary of the building with respect to the reference size is consistent with the assumed conditions of use for the different spaces. More information can be found in ISO/TR 52003-2[9] and ISO/TR 52018-2,[12] the technical reports accompanying the EPB standards on Energy performance of buildings – Indicators, requirements, ratings and certificates (on general aspects and on building fabric respectively).

The minimum energy performance requirement levels of space types, such as office spaces, educational spaces and restaurant spaces, differ for a large extent due to the different internal conditions that are typical for every activity. For instance, in the bedrooms of a hospital the indoor temperature is much higher than in an office. The higher energy use of the hospital space due to this higher internal temperature is reflected in a higher maximum allowed energy performance requirement (a higher “**energy budget**”) in the hospital space.

The energy budget (maximum allowed energy use) is typically, in one way or another, made proportional to the size of the spaces involved: the reference size (but see also discussion in 9.4.2 on normalization versus smart EP requirements).

Service spaces (**not** to be confused with service areas, term 3.3.4 in ISO 52000-1) will probably have no own energy performance requirement level. So, the energy use of a hall, corridor or toilet isn’t automatically balanced by an “energy budget”.

If the size of these service spaces is included in the reference size of the building, the energy budget is compensated for the extra energy use for the service spaces.

By excluding the size of the service space from the reference size of the building (no compensation), the energy performance of a building is **penalized** if it has shared energy using service spaces.

But allocation of the full size of the service space might lead to **overcompensation**; because the internal conditions of a service space often lead to less energy use per m^2 compared to the main spaces they service, while, by taking into account their full size, they receive the full energy budget.

A typical example in this context is the energy use versus the energy budget of an indoor parking. What is found in some countries is that the (assumed) internal condition of the indoor parking requires energy for ventilation and/or lighting, which is taken into account in the calculation of the energy use of the building.

If, for the energy budget, the size of the “indoor parking” isn’t added, at least partly, to the reference size of the building, the energy budget isn’t compensated for this additional energy use and the energy performance is penalized. This could be a very rational national choice, aiming at minimizing the energy use in such servicing spaces.

What is clear from the examples above is that the specification of the assumed standard indoor conditions per space category, for the *energy use* calculation, needs a matching specification of the assumed reference size, per space category, for the calculation of the *energy budget*.

So, assessing the size of the building or building part implies the choice which spaces are considered to be included. This choice is related to the space category. For specific space categories a fraction (between 0 and 1) of the size may be appropriate. E.g. for a basement, attic, indoor parking, etc., for reasons explained above.

9.4.2 Normalization

Since large buildings usually use more energy than comparable small buildings, the total amount of energy used is not very informative. If the total amount is divided by the reference size of the building, the outcome is normalized. This normalized outcome makes it possible to compare the energy performance of buildings of different sizes.

However, using the normalized energy performance as the basis for energy performance requirements may result in too crude energy performance requirements: the methods for assessing the energy performance of a building are very detailed. One of the purposes of creating such elaborate methods is to achieve a reasonably fine evaluation of the energetic quality of the building, taking into account the benefits that many different design and technological variants and improvements may offer. They thus create a stimulating context for the construction sector to invest in a comprehensive energy efficient planning and a careful execution. And the component supply industry is stimulated to ever further develop more energy efficient systems. Crudely expressed requirements may to a large extent annihilate this achievement.

This can be solved by requirements in which also other aspects of the building are taken into account. This subject is discussed in more detail in ISO/TR 52003-2.

9.4.3 Reference floor area

The reference floor area is used for the reference size of the assessed object. See also 3.3 of this document.

Since there are many different ways to calculate a floor area used all over the wold, the EPB standards cannot prescribe which is the best way. In particular because the choice may have several legal or practical implications. In the input and method selection data sheet the type of floor area used can be specified. This could be (based on) the useful floor area, but it could also be (based on) the net floor area.

On the other hand: the specification of the useful floor area itself is also left open via the input and method selection data sheet, with a default choice given in ISO 52000-1:2017,Table B.20.

9.5 Assessment boundary and perimeters

9.5.1 General principles

The assessment boundary is the boundary where the delivered and exported energies are measured or calculated.

All energy flows are counted and weighted at the same assessment boundary (energy use assessment boundary). To accommodate different accounting criteria, the overarching EPB standard allows to specify which energy performance components should be taken into account when calculating:

— the RER: it is possible to take into account all contributions to renewable energy, or to exclude the renewable energy included in energy carriers coming from distant and so on.

— the “total” primary energy: it is possible to take into account all contributions to the total primary energy, or to exclude on site renewable energy from the total.

This makes it possible to use the calculation procedure of the overarching EPB standard (one assessment boundary) for all possible choices, and also to express the system performance by using the total primary energy factor as indicated in Annex H. The assessment boundary is also the boundary where the delivered and exported energy are weighted in the energy balance (see Formula (2) in ISO 52000-1:2017, 9.6.1)

The assessment boundary is different from the geographical perimeters, like on-site or nearby.

The definition of the assessment boundary impacts the following conventions:

— inside the assessment boundary, the system losses and energy flows are taken into account explicitly in the energy balance;

— outside the assessment boundary energy losses are taken into account in the weighting factor applied to each energy carrier;

— energy can be delivered (imported) or exported through the assessment boundary;

— "energy plus buildings" are only possible if the effect of the exported energy is included in the energy performance of the building and the energy balance becomes negative, see ISO 52000-1:2017, 11.6.2.3 and the k_{exp} factor.

The definition of recast EPBD[2] related to Nearly Zero Energy Buildings (NZEB) [3)] in Europe includes energy from renewable sources produced on-site or nearby.

The localization of the technical building systems situated either on-site or nearby impacts the energy balance. Primary energy conversion factors are defined for on-site and nearby. Different buildings can be on-site (e.g. school building, office building) and located on the same parcel of land. Rules are provided in ISO 52000-1 to take into account the different situations in the energy assessment of each building.

9.5.2 Assessment boundary for multiple buildings

If a site comprises several buildings connected to a common technical system (e.g. a common boiler house for several apartment blocks), then:

— first, the energy performance is calculated for the whole site, including all buildings connected to the same systems;

— second, the energy performance for the individual buildings is obtained with the calculation procedure of the energy performance per part of a building (see ISO 52000-1:2017, Annex E).

9.6 Overall energy performance

9.6.1 Weighted overall energy balance

The different types of energy carriers delivered to the building are never summed directly with each other. They can be summed only taking into account a conversion factors into an homogeneous quantity (weighting).

The weighting criteria considered in ISO 52000-1 are the following:

— non-renewable primary energy;

— renewable primary energy;

— total primary energy;

— costs, which is an essential weighting criterion for cost-benefits evaluations;

— CO_2 or GHG emissions.

For each energy carrier and weighting property, an additional distinction can be made according to the "perimeter" (e.g. the origin of the energy carrier) that can be on-site, nearby and distant.

Weighting factors are the ratio of the amount of the weighting property (energy, cost) to the actual delivered or exported energy. Therefore the units of the weighting factors are kW·h/kW·h or MCO_2/kW·h or €/kW·h and so on.

3) See definition 2 of the EPBD recast.

The weighting factors for:

— delivered energy carrier *cr*: $f_{we;del;cr;t}$

— grid exported electricity $f_{we;exp;el;grid;t}$

— and exported electricity for non-EPB uses in the building $f_{we;exp;el;used;nEPus,t}$

are given in the format specified in ISO 52000-1:2017, Table A.16 in the common case that they are constant (e.g. not time dependent). Default informative values are given in ISO 52000-1:2017, Table **A**.16.

All energy flows are counted at the same assessment boundary (energy use assessment boundary). The overarching EPB standard allows to specify which energy flows (e.g. which perimeters) are taken into account depending on the calculation objective (renewable primary energy for RER, total primary energy for RER, total primary energy for energy performance of the building). As an example, for the calculation of the total primary energy for the energy performance indicator only the energies delivered from e.g. nearby and distant could be taken into account. This makes it possible for the total primary energy factors to use the calculation procedure of the overarching EPB standard (one assessment boundary), and also to express the system performance by using the total primary energy factor as indicated in Annex H.

It should be noted that the renewable and non-renewable primary energy weighting are independent. Total primary energy is the sum of renewable and non-renewable primary energy.

The energy balance formulae (such as ISO 52000-1:2017, Formula (2)) hold independently for renewable and non-renewable primary energy as well as for any other weighting criteria. Non-renewable and renewable primary energy balances are performed independently to get the required data to calculate the RER.

ISO 52000-1:2017, Formula (2) is the final difference between weighted annual delivered and weighted annual exported energy.

The sum of delivered and exported energy for each calculation interval is performed independently to support time dependent weighting factors.

NOTE $E_{we;del;el;an}$ and $E_{we;exp;el;an}$ are calculated according to ISO 52000-1:2017, Formulae (19) and (20), not ISO 52000-1:2017, Formulae (11) and (12).

9.6.2 Primary energy factors

The basic idea of primary energy balance performed in ISO 52000-1 is that each energy flow crossing the assessment boundary is characterized by the following set of properties:

— $E_{del/exp}$ which is the actual energy amount of energy crossing the assessment boundary;

— E_{Pnren} which is the associated non-renewable primary energy;

— E_{Pren} which is the associated renewable primary energy;

— E_{Ptot} which is the total associated primary energy and is given by $E_{Pnren} + E_{Pren}$.

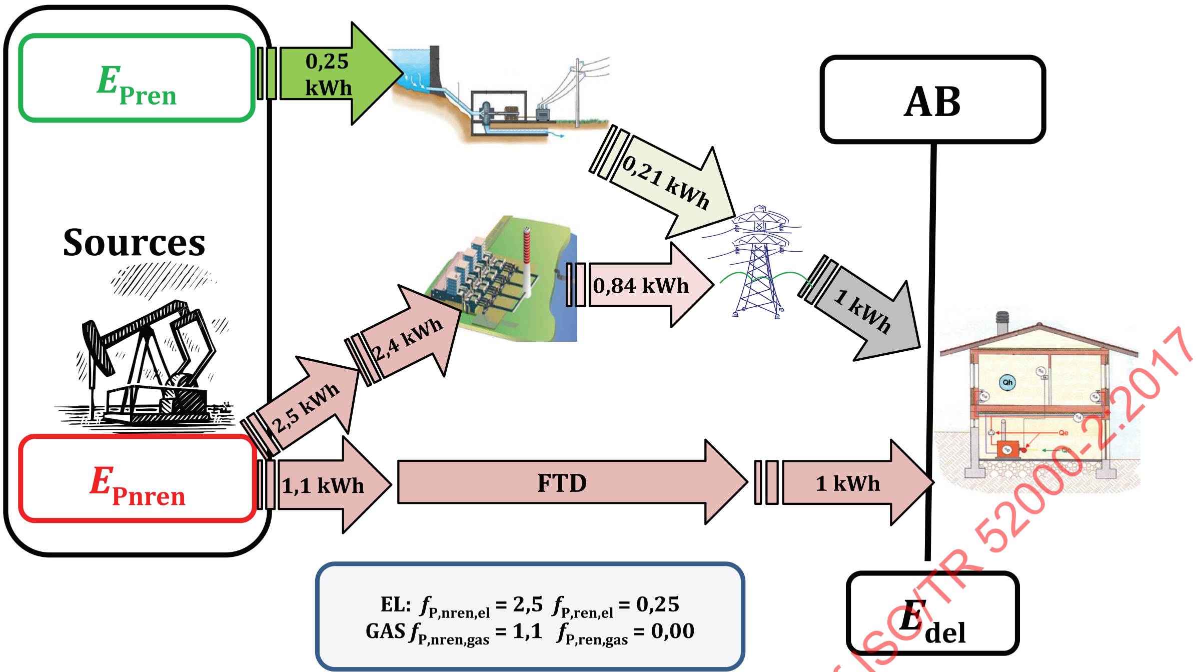
The associated amount of primary energy is the energy that has been extracted from the sources (before any transformation) to provide the actual energy amount where it is evaluated. This includes:

— as a minimum, the actual energy;

— as a common option the transport overheads (typical example is 1,1 for fossil fuels);

— as a further possible option, energy overhead for infrastructure construction (default value was 1,35 for fossil fuels in EN 15603:2008).

The primary energy factors are the ratio of a given type of primary energy (renewable, non-renewable, total) to the actual energy amount.



Key

AB	assessment boundary
EL	electricity
FTD	fuel transport and delivery
GAS	natural gas

Figure 7 — Illustration of the meaning of primary energy conversion factors

Comments to Figure 7:

— The primary energy, according to Directive 2010/31/EU definitions, is "energy from renewable and non-renewable sources which has not undergone any conversion or transformation process". According to the source, it can be either renewable (potential energy of the water) or non-renewable (fossil fuel in the well);

  — 0,25 kW·h is the energy extracted from the renewable source (water basin);

  — 2,5+1,1 kW·h is the energy extracted from the non-renewable source (oil or gas field).

  — Overhead is any loss of energy due to transport and delivery from the source to the assessment boundary:

    — renewable energy is lost in the hydropower plant (0,25 kW·h → 0,21 kW·h);

    — both renewable and non-renewable energy is lost in the grid: 0,21+0,84 kW·h = 1,05 kW·h grid input but only 1,00 kW·h to users, this means 5% grid losses in this example;

    — non-renewable energy is lost in the fuel distribution network (1,1 kW·h → 1,0 kW·h).

  — Delivered energy is what reaches and crosses the "assessment boundary" AB:

    — 1 kW·h electricity, associated with 2,5 kW·h non-renewable primary energy + 0,20 kW·h renewable primary energy (excluding overheads for renewable primary energy);

  — 1 kW·h fossil fuel, associated with 1,1 kW·h non-renewable primary energy + 0,0 kW·h renewable primary energy.

- — Primary energy factor indicates the associated primary energy to each delivered kW·h:
  - — electricity: $f_{\mathrm{Pnren;el}} = 2{,}5$ $f_{\mathrm{Pren;el}} = 0{,}20$ $f_{\mathrm{Ptot;el}} = 2{,}5 + 0{,}20 = 2{,}70$
  - — fossil fuel: $f_{\mathrm{Pnren;gas}} = 1{,}1$ $f_{\mathrm{Pren;gas}} = 0$ $f_{\mathrm{Ptot;gas}} = 1{,}1 + 0 = 1{,}1$
- — Overheads for non-renewable primary energy are usually taken into account because they contribute to the depletion of non-renewable resources.
- — All figures are purely for example purposes.

9.6.3 Greenhouse gas emission factors

No additional information needed.

9.6.4 Additional weighting factors

An example of additional weighting factors are the polluting emissions factors:

- — specific nitric oxide emission g_{NOx}/kW·h;
- — specific carbon monoxide emission g_{CO}/kW·h.

9.6.5 Costs factors

Cost weighting factors may be strongly time dependent. An example is electric energy cost.

Also cost weighting factors may be strongly different for delivered (bought) and exported (sold) energy.

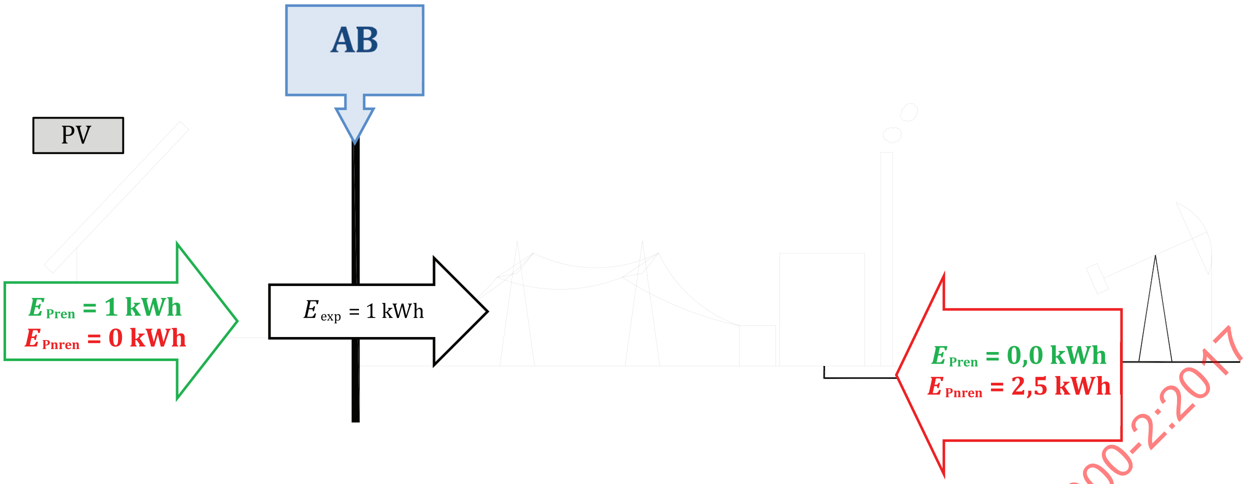
9.6.6 Weighting factors for exported energy

9.6.6.1 General

The idea of weighted energy associated to delivered energy is easy until exported energy is involved. Recent and new building often export energy and a careful additional analysis is required,

The weighted energy associated to the actual exported energy on the assessment boundary can be evaluated in two ways:

- — by taking into account the weighted energy used to produce the exported energy (only step A):
  - — for PV, it is the panel output that generated that electricity (the delivered solar radiation is conventionally accounted at the panel output). Weighted energy factors for exported PV will be therefore identical to the delivered PV conversion factors;
  - — for CHP the weighted energy factors will be a quota of the fuel input weighted energy, depending on the selected allocation method;
- — by taking into account the reduction of weighted energy used by grid generators thanks to the exported energy (step A and B):
  - — for PV and CHP, this includes the reduction in primary energy consumption of the grid generators thanks to the avoided grid electricity production. Primary energy factors for exported PV and cogenerated electricity will be something like the grid electricity values;
  - — for biogas, this includes the reduction in gas extraction and other productions thanks to the biogas injection into the grid.



Key

AB assessment boundary

PV photovoltaic panel

Figure 8 — Illustration of the alternative in the evaluation of the exported energy

Comments to Figure 8:

— the physical fact is that the PV panel in this example is producing 1 kW·h electricity (in excess of EPB uses) which is exported through the assessment boundary AB;

— the weighted energy of the exported energy is evaluated by Formula (2) in ISO 52000-1:2017 as -$E_{exp;el}$ x $f_{we;el}$

— it is obvious that $E_{exp;el}$ is 1 kW·h

— when dealing with primary energy, it is a choice that $f_{we;el}$ be:

  — either $f_{Pnren;el}$ = 0,0 and $f_{Pren;el}$ = 1,0 (PV electricity exported);

  — or $f_{Pnren;el}$ = 2,5 and $f_{Pren;el}$ = 0,0 (fossil fuel avoided by the grid generators.

This apparent alternative is presented in ISO 52000-1 as a two-step evaluation with the parameter k_{exp} that controls the alternative and is given a physical meaning. See 11.6.2 for further details.

This alternative is clearer if the economic weighting is chosen: when selling a good (e.g. exporting it) one can consider the cost or the revenue in the accounting scheme. The choice depends on the purpose.

9.6.6.2 Step A: Weighting factors based on the resources used to produce the exported energy

9.6.6.2.1 General

Step A weighting factors are not given by tables such as ISO 52000-1:2017, B.25. They are calculated based on:

— properties of the technical sub-system that produces the electricity;

— weighting factors of the energy carrier delivered and used by the technical sub-system that produces the electricity.

A dedicated calculation procedure is needed for each type of electricity generation device.

An example of time dependent weighting factor is that for cogenerated electricity. It may vary if the efficiency of the cogenerator depends on load and load is changing according to the calculation interval.

9.6.6.2.2 Photovoltaic/wind electricity

No additional information on this clause.

9.6.6.2.3 Cogenerated electricity

Cogeneration is a common example of a technical system having one or more energy inputs and at least two types of outputs: heat Q and electricity W.

The weighted amount of the delivered input fuel $E_{\mathrm{we;in}}$ should be allocated to the cogenerated electricity $W_{X;\mathrm{gen;out}}$ and heat $Q_{X;\mathrm{gen;out}}$ as shown in Figure 9. Then, the ratio of the allocated weighted energy $E_{\mathrm{we;W}}$ to the cogenerated electricity $W_{X;\mathrm{gen;out}}$ is the step A conversion factor of cogenerated electricity $f_{\mathrm{we;el;cgn}}$.

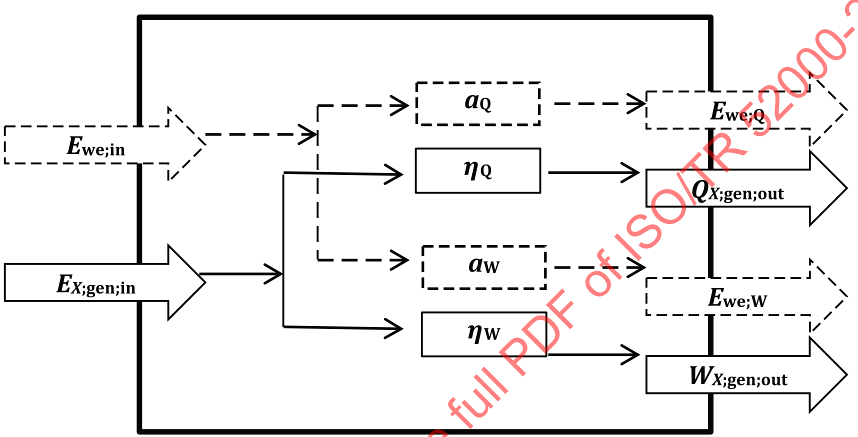


Figure 9 — Example of a simple cogeneration system

The weighted energy allocated to the outputs, $E_{\mathrm{we;W}}$ and $E_{\mathrm{we,Q}}$ is given by the following Formulae:

$$E_{\mathrm{we;W}} = E_{\mathrm{we;in}} \cdot a_{\mathrm{W}} \tag{1}$$

and

$$E_{\mathrm{we;Q}} = E_{\mathrm{we;in}} \cdot a_{\mathrm{Q}} \tag{2}$$

where

— a_{W} and a_{Q} are the allocation factors for cogenerated electricity and heat; they depend on the allocation criteria and on the electrical and thermal efficiencies η_{W} and η_{Q} ;

— $E_{\mathrm{we;in}}$ is the weighted sum of the weighted energy of all energy carrier inputs $E_{X;\mathrm{gen;in;cr},i}$ to the cogenerator, including auxiliary energy, given by the Formula:

$$E_{\mathrm{we;in}} = \sum_i E_{\mathrm{X;gen;in;cr},i} \cdot f_{\mathrm{we;cr},i} \tag{3}$$

There are several allocation methods of the input weighted energy to cogenerated heat and electricity. A complete reference is provided in EN 15316-4-5:2017 '*Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies -Part 4-5: District heating and cooling, Module M3-8-5, M4-8-5, M8-8-5, M11-8-5*'. The definition of the of some popular allocation factors is given in the following Table 5:

Table 5 — Example of allocation factors

Allocation method	allocation-factor electricity a_W	allocation-factor heat a_Q	Required reference data
Residual heat	$\frac{W}{\eta_{\text{el,ref}} \cdot E}$	$1-\frac{W}{\eta_{\text{el,ref}} \cdot E}$	η_{el}
Power loss	$1-\frac{\Delta W}{W+\Delta W}$	$\frac{\Delta W}{W+\Delta W}$	none
Carnot	$\frac{W}{W+Q \cdot \eta_{\text{carnot}}}$	$\frac{Q \cdot \eta_{\text{carnot}}}{W+Q \cdot \eta_{\text{carnot}}}$	T_0
Alternative production	$\frac{\frac{\eta_{\text{el}}}{\eta_{\text{el,ref}}}}{\frac{\eta_{\text{el}}}{\eta_{\text{el,ref}}}+\frac{\eta_Q}{\eta_{Q,\text{ref}}}}$	$\frac{\frac{\eta_Q}{\eta_{Q,\text{ref}}}}{\frac{\eta_{\text{el}}}{\eta_{\text{el,ref}}}+\frac{\eta_Q}{\eta_{Q,\text{ref}}}}$	η_{el} & η_{th}

Then the primary energy factor for the cogenerated electricity $f_{\text{we;el;cgn}}$ is given by:

$$f_{\text{we;el;cgn}} = \frac{E_{\text{we;W}}}{W_{\text{X;gen;out}}} \tag{4}$$

The same allocation factors are applied for all weighting criteria (for example, for renewable and non-renewable primary energy).

9.6.6.2.4 Multiple on-site generation systems providing exported energy

In case of multiple generation devices that produce the exported energy, a choice about which is the exported combination (and therefore which is the used combination) is required to calculate the weighting factor of exported electricity.

If the value of k_{exp} is set to 1,0, this choice is not relevant.

9.6.6.3 Step B weighting factors based on the resources avoided by the external grid due to the exported energy

No additional information needed.

9.6.7 Energy flows

According to the energy balance, the energy flows at the assessment boundary are related to:

— the delivered energies;

— the exported energies.

The energy flows are determined either by calculation or by measurements.

Recoverable losses linked to a building service are taken into account in the calculation of needs and this decreases the delivered energy.

Solar and internal gains are taken into account when calculating the energy need. They are not counted as a delivered energy.

9.7 Share of renewable energy

9.7.1 General

An energy performance certificate may include additional information such as the percentage of energy from renewable sources in the total energy consumption.

It should be noted that the objective of efficient buildings is not using renewable sources as much as possible, but using as little energy as possible from non-renewable sources. A better renewable energy ratio should not lead to a worse energy performance.

Energy from renewable sources can be:

— solar gains which contribute directly to lower the energy needs by passive solutions;

— the energy input to technical building systems, such as active solar systems or energy captured by heat pumps from the environment;

— the energy included, totally or partly, in energy carriers, like electricity, district heating or ground water cooling.

There are several possibilities to calculate the renewable part, such as:

— focussing on the appliance. The building is calculated twice, once with and once without the energy from renewable sources;

— focussing on the energy carrier (see hereafter).

In ISO 52000-1,[1] the choice has been made to focus on the energy carrier. This approach avoids calculating twice and defining a reference system. The calculation of the share of renewable energies becomes more transparent because the primary energy factors are already defined.

The renewable energy ratio RER is given by Formula (17) of ISO 52000-1:2017. It states how much of the total primary energy is marked as renewable primary energy.

ISO 52000-1 gives the option to select which energy flows are counted when determining $E_{\mathrm{Pren;RER}}$ and E_{Ptot} for the RER calculation

9.7.2 Amount of primary energy from renewable source $E_{\mathrm{P;ren}}$

The amount of primary energy from renewable source for RER calculation, $E_{\mathrm{P;ren;RER}}$, in (kW·h), is calculated taking into account only delivered energy to the assessment boundary because the renewable energy ratio (RER), in line with EPBD Article 2(2) “ The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby. Therefore the RER expresses how much renewable energy has been delivered to the building. The exported renewable energy has been accounted for in the entrance and therefore the RER can be higher than 100 %.

9.7.3 Amount of total primary energy E_{Ptot}

In addition, the renewable energy ratio RER should be calculated on the total primary energy consumptions (and not on the energy balance).

The total amount of primary energy, E_{Ptot} is linked to the required energy services of the assessed building weighted by their total primary energy factor.

9.7.4 Examples of RER calculation

In the following calculation, it is assumed:

Gas (distant): f_{Pnren} = 1,1, f_{Pren}= 0, f_{Ptot} = 1,1

Electricity (distant): f_{Pnren} = 2,3, f_{Pren} = 0,2, f_{Ptot} = 2,5

Thermal solar (on-site): f_{Pnren} = 0,0, f_{Pren} = 1,0, f_{Ptot} = 1,0

PV electricity delivered (on-site): f_{Pnren} = 0,0, f_{Pren} = 1,0, f_{Ptot} = 1,0

PV electricity exported delivered (on-site): f_{Pnren} = 2,3, f_{Pren} = 0,2, f_{Ptot} = 2,5

- **Single-family house – Base scenario**
  - Energy items (final):
    - Heating and DHW: gas 190 kW·h final
    - Other EPB uses: electricity 20 kW·h final
  - Indicators:
    - Primary energy consumptions (bases on f_{Pnren}): 255 kW·h P_{nren} (190×1,1+20×2,3)
    - Primary energy balance (assessment): 255 kW·h P_{nren} (190×1,1+20×2,3)
    - RER share (on-site, nearby and distant): 1,5 % (20×0,2/ (190×1,1 + 20×2,5)
    - RER share (on-site, nearby): 0% (0/259)
- **Single-family house – Solar thermal DHW**
  - Energy items (final):
    - Heating (+ part of DHW): gas 170 kW·h final
    - DHW from solar thermal: 20 kW·h final
    - Other EPB uses: electricity 20 kW·h final
  - Indicators:
    - Primary energy consumptions (based on f_{Pnren}): 233 kW·h P_{nren} (170×1,1+20×0,0+20×2,3)
    - Primary energy balance (assessment): 233 kW·h P_{nren} (170×1,1+20×0,0+20×2,3)
    - RER share (on-site, nearby and distant): 9,3 % ((20×0,2+20×1,0)/(170×1,1+20×1+20×2,5))
    - RER share (on-site, nearby): 7,7 % ((20×1,0)/257)
- **Single-family house – PV 40 kW·h**
  - Energy items (final):
    - Heating and DHW: gas 190 kW·h
    - Other EPB uses: electricity 20 kW·h
    - Generated electricity: 40kW·h (delivered and exported)
  - Indicators:
    - Primary energy consumptions (based on f_{Pnren}): 209 kW·h P_{nren} (190×1,1+20×0,0)
    - Primary energy balance (assessment): 163 kW·h P_{nren} (190×1,1+40×0,0-20×2,3)
    - RER share (on-site, nearby and distant): 18,1% ((40×1,0-20×0,2)/(190×1,1+40×1,0-20×2,5)
    - RER share (on-site, nearby): 20,1% ((40×1,0)/199

9.8 Energy performance indicators for technical building systems

For the purpose of optimizing the energy use of technical building systems, it is important to set systems requirement to technical building systems in existing buildings in respect of:

— the overall energy performance;

— the proper installation;

— the appropriate dimensioning, adjustment and control.

These systems requirements can also be applied in new buildings.

The rationale for this to be part of the Overarching EPB standard rather than in the subsequent standards related to the technical building systems is that it deals with not just one system but a combination of systems.

NOTE 1 ISO 52000-1 defines only the energy performance of building services. In order to get a coherent approach between the different building services, it defines the technical system performance indicator. Different building services can be provided by the same equipment (e.g. boiler providing heat for space heating and domestic hot water heating). Therefore the losses of the equipment are dispatched between the different building services. The dispatch method is also defined in ISO 52000-1.

NOTE 2 Other systems requirements (e.g. indoor air quality) are specific to the different building services and treated in the related standards. The performances of the technical building subsystems, as part of a process of providing a service, are also defined in the related system standards.

The system requirement of technical building systems could also be used for:

— checking the quality of the calculation;

— generating data for a simplified approach based on pre-calculation of the indicators (e.g. tabulated method);

— evaluating the quality of individual technical systems or even parts or specific functions of the technical systems;

— comparing different technical systems;

— estimating and localizing the improvement potential when looking for improvement recommendations.

In ISO 52000-1, the technical systems performance indicators are efficiencies and expenditure factors. Efficiency is the dimensionless term used to indicate effectiveness of a technical building system for a practical and straightforward comparison.

The objective of the technical building system performance indicator is to evaluate the technical system by itself (e.g. without taking the renewable energy contribution). The energy performance of the energy carrier is already taken into account in the energy performance indicator (primary energy) of the assessed building or building unit.

9.9 Calculation methods for energy performance indicators per part of a building and/or service

See Annex E.

10 Zoning

10.1 General

Energy performance calculation often requires that the building is divided into parts for calculation purpose. The calculation is performed independently on each part and then results are collected and assembled. This feature of dividing the building into parts for the calculation purpose is called zoning.

Complex buildings cannot be calculated directly as a whole and need to be divided in several parts. Sometimes even simple buildings may need some zoning: a “passive house” is very often designed with high solar gains in well-exposed spaces. Not all spaces may have high solar gains and it may be not realistic to assume that all the gains in the well-exposed spaces will contribute to the energy balance of other spaces (e.g. a large south oriented window in the living and a north room upstairs).

Another issue is the exchange of data between building and technical systems calculation with different zoning. If the explicit calculation of gains (holistic approach) is selected one should pay attention that the technical system zoning (service areas) may be different from thermal zones (needs balance). To make things work, each loss item should be characterized by a “location” parameter, that links it to the thermal zone (building needs balance zone) where the recoverable part of the loss will be taken into account. If a loss item cannot be localized, general rules should be established to “distribute” reasonably total values (i.e. distribute the total recoverable losses of technical systems to the relevant thermal zones according to floor area, volume, etc.). An example is given by a domestic hot water distribution network. Losses of the domestic hot water are significant not only for the domestic hot water system itself but also for the heating (where heat losses can be recovered) and cooling needs (where heat losses are an extra load) balance of the building. The importance of these interactions increases when dealing with high performance buildings.

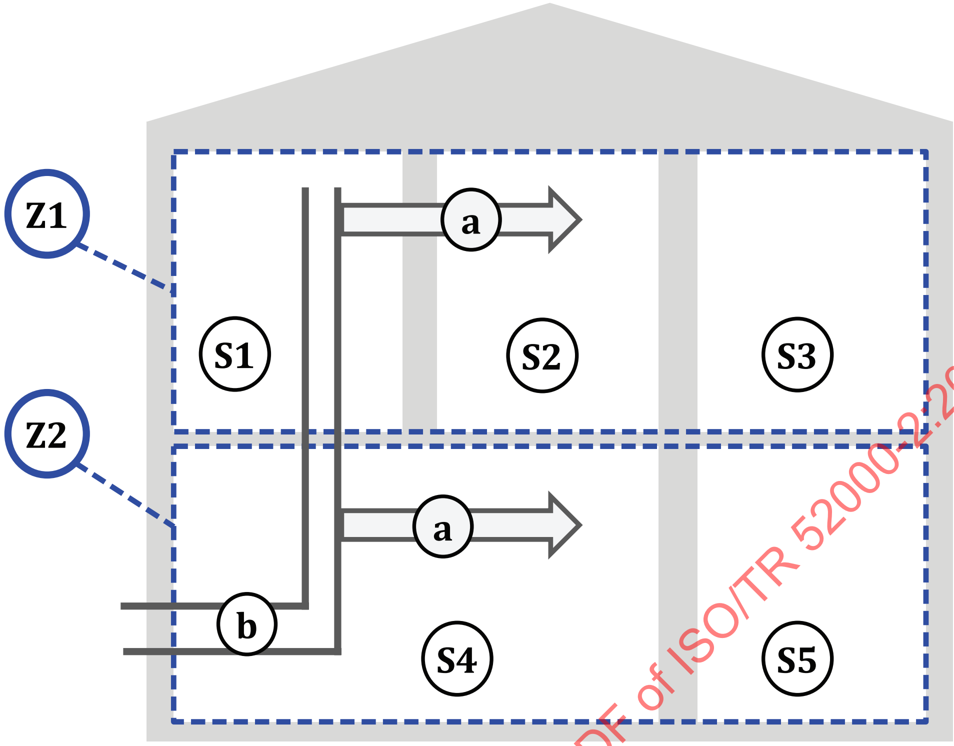
On the other hand, if there is a need to subdivide a building into several thermal zones for the thermal balance calculations (heating and cooling needs and loads and internal temperatures), this should not automatically lead to the same subdivision of –say- the zoning for the domestic hot water needs or the domestic hot water system.

In order to take care of the losses of the domestic hot water, a rule to attribute them to the correct thermal zones is needed. This is supported by clearly defining the thermal zoning and:

— either localizing all elements of the domestic hot water distribution (and therefore their losses) with respect to the thermal zones;

— or defining a rule to attribute losses to the potentially involved thermal zones, if the localization is not known in details.

Figure 10 shows this issue.



Key

S1, S2, ... elementary spaces

Z1, Z2 thermal zones

a domestic hot water distribution losses

b domestic hot water pipes

Figure 10 — Losses from the pipes should be attributed to the correct thermal zone

Zoning criteria are intrinsically different depending on the calculation objective. Thermal zones should include those parts of the building that are thermally interacting whilst technical system service areas should reflect the actual technical system structure.

If only one main zoning criteria (e.g. related to thermal zones) is used for all aspects, this will introduce hidden assumptions, constraints and difficulties in dealing with complex buildings. The overarching EPB standard gives the possibility to handle independent zoning according for each criterion.

Generally speaking, an independent zoning criteria is required according to each specific calculated aspect. Sometimes zones may be all the same but this happens in simple or in lucky cases.

Clause 10.4 provides an analysis of all the reasons that may require that the energy performance calculation be done separately on parts of the building instead of considering the building as a whole.

This does not mean that there will always be several thermal zones or service areas. Simple buildings will usually require no zoning (e.g. only one zone) and zoning rules may be decided so that the effort for zoning is minimized.

It should be noted that the starting point of the zoning procedure in 10.7 is one single space for the whole building. Then the building is divided into several spaces, thermal zones and service areas only if necessary.

Even if zoning will seldom lead to complicated distribution or subdivision rules, designing software and user interfaces requires from the very beginning a good knowledge of all possible required zoning and of the consequences in case of independent zoning. It will be easier to handle simplification in a complete scheme and data-base rather than having to introduce further subdivisions later.

Deciding to have no zoning or to align one zoning to others so that complicated calculations and/or data input are avoided is also a choice that should be made in a transparent way and after evaluation of any hidden constraint. This clause provides the basis for that.

Which rules will be needed and how zones can be combined can be decided only after that all calculation needs are identified.

10.2 Thermal zones and service areas

Building "thermal zone" is the general term for a part of a building for which a thermal needs or energy balance calculation is performed. Each thermal zone is defined as an aggregate of "spaces".

Technical system "service area" is the general term for a part of a building which is served by a uniform part of a technical system.

In principle there is no difference between dividing the building in parts for the purpose of the thermal balance or of the technical systems calculation. Therefore the first draft of the overarching EPB standard used the word "zones" for both building and technical system zones. "System zones" have been renamed "service areas" to help prevent misunderstanding since this was already customary in some countries.

A practical difference is that there are many direct interactions between any technical systems and the building (e.g. between one thermal zone and one service area) whilst there are seldom <u>direct</u> interactions (and data exchange during the calculation) between service areas.

EXAMPLE The losses from the domestic hot water system will influence the thermal zone balance and hence the heating needs are reduced. In this case, there is no direct interaction between the domestic hot water system and the heating system.

10.3 Spaces

All thermal zones and service areas should be based on a set of common elementary building spaces to guarantee the possibility to connect calculations based on different zoning criteria (this will be clearer at the end of the document). These spaces need to be identified at overarching EPB level.

The building should therefore be described as a collection of (small enough) elementary parts that can be aggregated (grouped) in different patterns to generate all desired thermal zones and service areas (zoning could be also called "grouping" of elementary spaces into thermal zones and service areas).

This "smallest elementary building part" to be used for all zoning needed in a building calculation is called an (elementary) "space".

The word "space" is chosen to avoid confusion of the logical concept of space with the physical concept of "room".

The possibility to have a dedicated zoning for each calculation scope guarantees flexibility.

NOTE Usually the smallest individually recognizable spaces in buildings are rooms. However, a different word is used here to avoid confusion and because there is not a 1 to 1 correlation between room and spaces, depending on specific applications. Very often, a space is a set of rooms or even an entire building unit or the entire building.

This does **not** mean that:

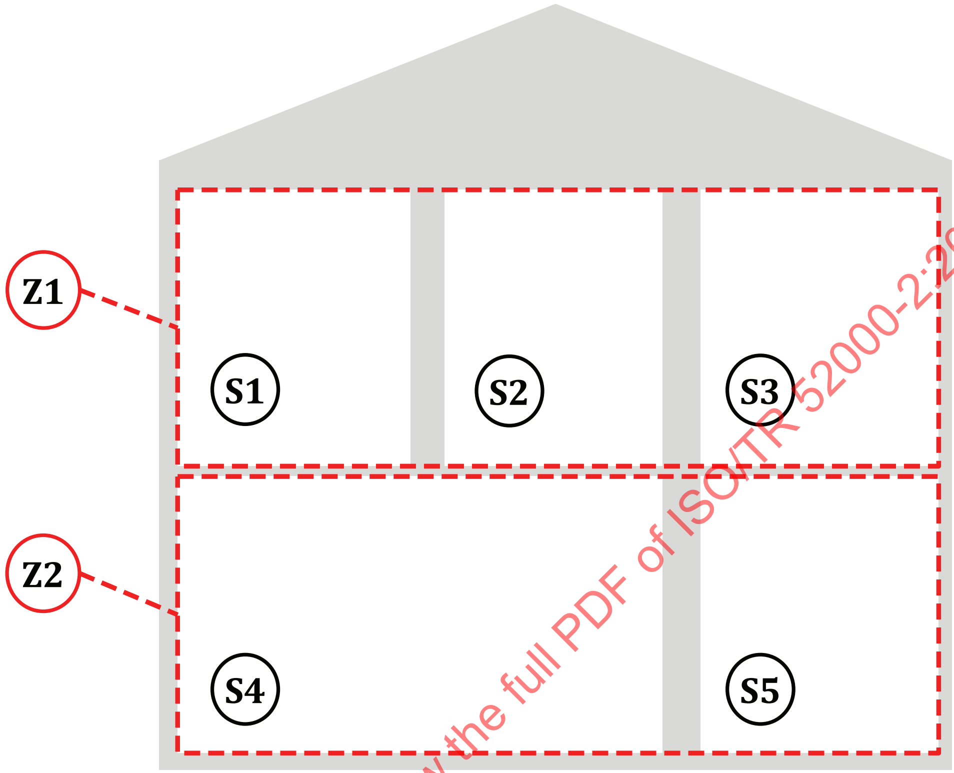
— a "room by room" calculation is always required even if rooms are used as spaces (each thermal zone or service area may include many spaces);

— nor that different zoning criteria always lead to different parts of the building;

— nor that a zoning criterion may be adapted to coincide with others (thermal zones may be assumed to be the same as building units to get individual energy performance certificate data for each building unit).

Thermal zones (of the entire building) are defined as groups of elementary spaces.

ISO 52016-1[10] requires, as an example, that under certain conditions heating and cooling need balance be performed by "thermal zones". Each thermal zone is a group of elementary spaces as explained above.



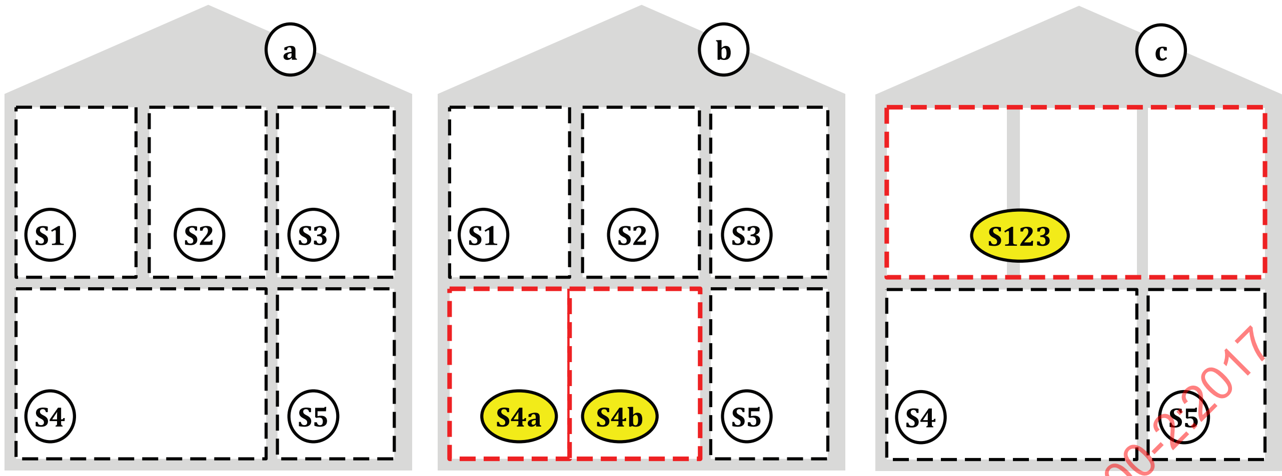
Key

S1...S5 elementary spaces

Z1...Z2 thermal zones

Figure 11 — Example of a building consisting of 5 elementary spaces grouped into two thermal zones

The logical division into elementary spaces may be not in accordance with the physical division into rooms: depending on calculation purpose an "elementary space" in a specific calculation may be an entire dwelling (even an entire building) as well as a room may be divided in several elementary spaces if a higher detail is desired. See Figure 12 for a simple comparison of physical rooms versus elementary spaces.



Key

a building; physical zoning into rooms

b dividing physical room 4 (S4) into 2 elementary spaces (S4a and S4b) considering different conditions

c combining rooms 1, 2 and 3 and considering it as one single elementary space (S123) for all calculations

Figure 12 — Physical rooms versus elementary spaces

EXAMPLE If a calculation is performed in order to prepare the energy certificates for an existing block of flats, each entire apartment (building unit) may be considered as a single elementary space, thermal zone and service area.

The calculations are not done at the level of elementary spaces. By definition, calculations are performed "per thermal zone" and (additionally, for the system parts) per "service area".

The elementary spaces are only used for the administration of the thermal zones and service areas and for the assignment of calculated data from thermal zones to service areas and vice versa. The concept of elementary spaces is flexible, simple, transparent and software proof.

10.4 Zoning rules

10.4.1 Principle

This clause identifies the principles that form the basis for the zoning criteria.

These rules are evaluated, explicitly or implicitly when performing a calculation. Ignoring some of the criteria is the same as deciding that no zoning is required for that specific calculation. This is often true (no zoning required) for simple buildings and technical systems. Ignoring this on complex buildings and technical systems may lead to inaccurate results. For transparency zoning criteria should always be considered even if the most frequent decision might be that no zoning is required according to many criteria.

ISO 52000-1 provides a common frame and ways of connecting the several zoning criteria. The rules to decide whether a zoning is required according to any specific criteria is given in the specific EPB standard. This means that:

— the rules to decide if and when thermal zones are required or not (e.g. one thermal zone for the entire building) are given in the module M2-2 about heating and cooling needs and loads and internal temperature calculation;

— the rules to decide if heating system service areas are required or not (e.g. one heating circuit for the entire building) are given in the module M3-1, general part of heating systems;

— when specifying the rules to exchange data between the building thermal balance and the technical system calculation, the rules established in the common frame for zoning (distribution rules, sub-division rule) should be followed.

For clarity, a separate name has been defined for each type of zoning (e.g. thermal zones, heating system service area, etc.).

10.4.2 Specific zoning criteria

The specific zoning criteria or links to specific zoning criteria for the service areas are provided in the relevant system standards under EPB modules M3 – M5 and M8 – M9, because the specification of the criteria needs to be done within the context of the specific expertise area, including the relevant specific terms, definitions, technologies:

thermal zoning criteria in the standard dealing with the thermal balance, criteria for system service areas in the relevant system standards.

An important element in the zoning rules is simplification: if the zoning criteria lead to zones that are small compared to adjacent zones, simplification rules may become applicable. For instance stating that a small zone or service area may be merged with the adjacent one.

Taking for example the procedures in ISO 52016-1[10] for the thermal zones:

The following steps are distinguished:

1. For each space the space category is specified, taking into account the procedures in ISO 52000-1:2017, Clause 9.
2. All adjacent spaces belonging to the same space category are grouped into one thermal zone.
3. In case of large openings between spaces, the spaces are combined into one thermal zone.
4. A thermal zone is split in such a way that a thermal zone contains only spaces that share the same combination of relevant services.
5. Adjacent thermally conditioned zones may be combined if the thermal conditions of use are the same or similar.
6. In case of system specific calculations (see 6.5.4.1 and 6.6.4.1), a thermal zone may need to be split up, due to rules (if any) in the relevant system standards, aiming at certain homogeneity in the system or subsystem within a thermal zone.
7. A thermal zone is to be split in such a way that a thermal zone is to some degree homogeneous in the thermal balance. The criteria are more stringent if cooling is involved.
8. Adjacent thermally unconditioned zones may be combined.
9. A small thermal zone may be (re-)combined with an adjacent thermal zone if it has the same set of services, but different conditions of use.
10. A very small thermal zone may be (re-)combined with an adjacent thermal zone even if it has a different set of services.

For each step there is a choice to adopt the given method or to replace it by a (e.g. national) choice; and if the method is adopted there is a choice to adopt the given parameter values or replace it. These choices are offered in Annex A (normative template) and Annex B (informative default choices and values).

10.5 Assignment rules

10.5.1 Subdivision

If two parts of the energy performance calculation are based on different zoning so that data need to be exchanged, rules should be defined to provide the correct values from one calculation part to the other one taking into account the different zoning.

Two basic cases may occur:

— a calculation result from one thermal zone or service area (output) needs to be transferred to more than one other thermal zone or service areas (input);

— a calculation result (output) from more than one thermal zone or service area (output) needs to be transferred to one other thermal zone or service areas (input).

For this purpose subdivision and recombination rules are needed.

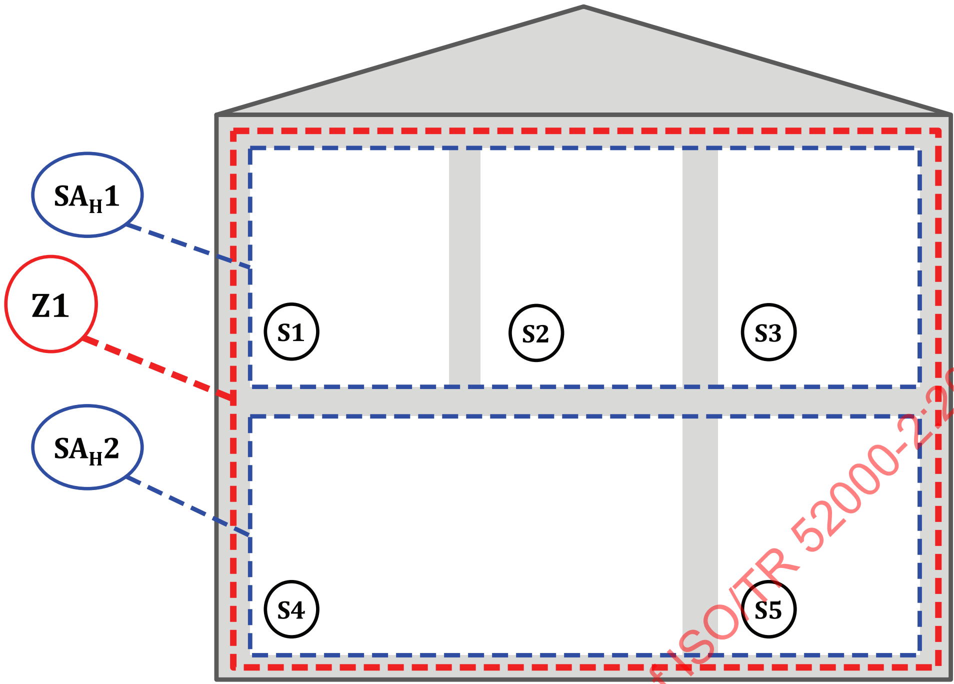
The subdivision rules are given in ISO 52000-1:2017, 10.5.1; the recombination rules are given in the next.

In this document the explanation on subdivision and recombination is combined in this subclause 10.5.1.

One zone of the first calculation (e.g. thermal zone) connects to several zones of the next calculation (e.g. a specific system). A "subdivision rule" is required to "divide" the single result/balance for the entire zone of the first calculation (e.g. thermal zone) into the share for each elementary space. Then the result subdivided per the elementary space can be grouped again according to the zoning of the next calculation (e.g. system service area).

An example is given in Figure 13. There are five spaces. If the heating needs calculation has been performed for the entire building (only one thermal zone) and there are two heating systems zones (two service areas, for each of the two types of heating subsystems) or two building units, then the heating need for the total building should be subdivided into two parts to continue the calculation individually for the two parts of the heating system or to be able to allocate the final result to the building units.

In this simple example the solution can be to adapt the thermal zoning to the heating system zones or to the building units. As a general frame, ISO 52000-1 gives the opportunity (not the obligation) to decouple the different zoning criteria. Decoupling can lead to significant simplifications in the input data. In the example used above: it avoids that the input data for the thermal calculations are gathered separately for each of the system zones (service areas).



Key

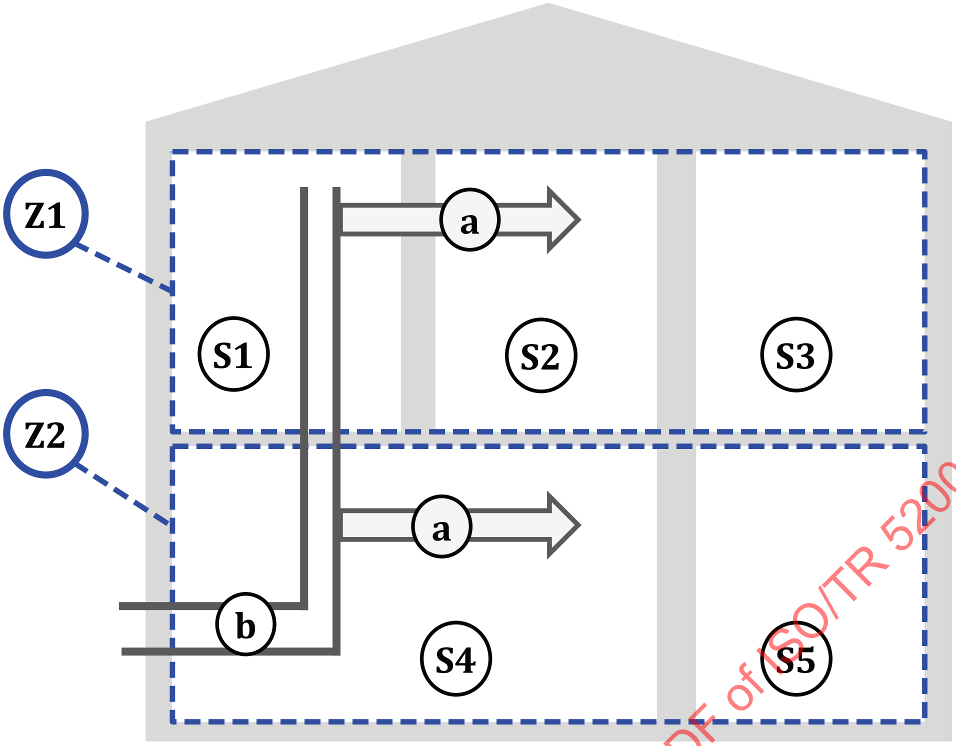
S1, S2, ...	elementary spaces
SA$_H$1	heating system service area 1 (e.g. radiators) or building unit 1
SA$_H$2	heating system service area 2 (e.g. floor heating) or building unit 2
Z1	unique thermal zone 1

Figure 13 — One thermal zone with two heating service areas

NOTE 1 A "Subdivision" rule is needed to get heating needs for space S1-2-3 and S4-5-6.

A "distribution rule" may be required to attribute to each thermal zone or elementary space its share of the result/balance incoming from a different zoning.

As an example if recoverable heat losses from the domestic hot water system have been calculated as a single value (only one domestic hot water system service area or common parts of the domestic hot water system) and there are two thermal zones, recoverable losses should be distributed to individual spaces or to thermal zones. See Figure 14.



Key

S1, S2, ...	elementary spaces
Z1, Z2	thermal zones
a	recoverable losses
b	domestic hot water distribution system piping

Figure 14 — – Two thermal zones with one distribution system piping

NOTE 2 A "distribution" rule is needed if the location of pipe segments relatively to each thermal zone is not known.

Subdivision and distribution should be performed according to a selected weighting factor. The choice of the suitable weighting factor should be explicit and indicated when the data exchange between calculation modules is defined.

A linear sub-division and/or distribution is usually performed unless there are specific reasons to proceed otherwise. As shown in Figure 14, if the locations of the pipes are known, losses will be calculated separately for the pipes in each thermal zone. This implies that the database used to describe the distribution systems must include a "location" field (location with respect to the thermal zones in this case; via the elementary spaces) for each pipe.

In simple cases many (even all) of the zonings may be identical. This will seldom happen for complex buildings so the different types of zoning should be conceptually independent as a general calculation frame. If zoning rules and priorities are not specified, a leading zoning is implicitly imposed (usually thermal zones). But as mentioned above: a differentiation between different types of zones can lead to significant simplifications in gathering input data.

10.5.2 Recombination

In this document the explanation on subdivision and recombination is combined in 10.5.1.

Each zoning criterion generates a hierarchical structure in the sense that according to one zoning criteria each property can be:

— an attribute of an individual space (space level property);

— a common attribute to all spaces included within a zone (zone level property);

— a common attribute to all zones, e.g. to the whole building (building level property).

For software development purpose, it is important to recognize which is the appropriate level for each property.

EXAMPLE 1 Area and volume are properties that are typically linked to the individual spaces.

EXAMPLE 2 Internal temperature is a common property of all spaces belonging to the same thermal zone.

10.6 Zoning procedure

This procedure simply states that to determine the minimum number of required elementary spaces, zoning criteria are applied one after the other. The starting point of the zoning procedure in 10.6 is one single space (e.g. one unique zone) for the whole building. Then it is divided into several spaces and zones only if necessary. Every time one further criterion is applied, you might have (or you might not need) to increase the number of spaces. If the minimum number of spaces is required at each step, the minimum number of spaces will be determined at the end of the process.

This procedure is the same as indicated in DIN V 18599:2011[15] but:

— there are more possible zoning criteria (types of service areas);

— the actual zoning requirements (e.g. detailed conditions that require a zoning) are given in the related modules, they are not anticipated in the general part as DIN V 18599:2011 [15] does. However, the key zoning criteria are on the thermal zones; these are covered in one single EPB standard: ISO 52016-1[10] (see 10.4.2).

The choice of leaving zoning criteria details to the specific parts allows to improve independently the calculation of the different aspects, giving more flexibility and enabling the criteria to be specified within the context of the specific expertise area, including the relevant specific terms, definitions, technologies.

Similar procedures are included *implicitly* in several national standards with wordings like “a thermal zone has the same set-point, the same type of emitters, …”. Such expression hides the use of two types of zones simultaneously (thermal and system) and subordinating the thermal zones to the type of heating system.

11 Calculation of the energy performance, routing and energy balance

11.1 General

No additional information needed.

11.2 Overall calculation procedure (steps)

ISO 52000-1:2017, 11.2 [1] gives an overview of the whole assessment procedure of the calculated energy performance for buildings.

Steps a) to c) are preparatory steps that are performed once at the beginning of the process. In practice this step includes the complete definition of the building (geometry, material, installation configuration, etc.)

Steps d) to f) are repeated for each calculation interval in the calculation period. These calculation procedures are not described in ISO 52000-1 but in the reference modules. The results of these calculations are used in the following steps.

Steps g) to j) are performed after d) to f) are complete. Steps g) to j) are the calculations described in ISO 52000-1.

Step k) calculations are performed according to the modules for building and technical systems. They may need some calculation result (such as primary energy) from ISO 52000-1.

Step l) may be integrated by specific reports defined within the building and technical systems modules.

11.3 Calculation principles of the recovered gains and losses

This sub-clause in the overarching EPB standard includes a step-by-step procedure to take into account recoverable gains and losses, either in a detailed or in a simplified way.

11.4 Effect of building automation and control (BAC) and technical building management (TBM)

This sub-clause in the overarching EPB standard provides the step-by-step description of the role, scope and the ways that BAC affects all technical building systems and the contribution of the technical building management of the overall of energy performance of a building.

The key-role of BAC and TBM is to ensure the balance between the desired human comfort - which should be maximal, and energy used to obtain this goal – which should be minimal!

The scope of BAC and TBM covers in accordance with their role from one side all technical building systems (where the effect of the BAC is used in the calculation procedures) and from another side the global optimization energy performance of a building.

There are several categories of controls:

— Technical building systems specific controls; these controllers are dedicated to the physical chain of transformation of the energy, from generation, to storage, distribution and emission. They are in the matrix starting with the Modules M3-5 to M9-5 and finishing with M3-8 till M9-8. Sometimes one controller per module exists and sometimes one controller does the control for several modules. More often, these controllers are communicating between them via a standardized open bus, such as BACnet, KNX or LON;

— BAC used for all or several technical building systems that does multidiscipline (heating, cooling, ventilation, DHW, lighting...) optimization and complex control functions. For example, INTERLOCK is a control function that avoids heating and cooling at the same time;

— If all technical building system are used in the building, this results (depending of the size of the building) in a technical building management system. Specific global functions are implemented here, necessary to reach the key-role mentioned above. Usually, in this case, an interrelation with the Building as such (Module M2) will occur, mainly to take in consideration the building needs; for example due to outside temperature, taken into account the inertia of the building when the control will reach the set point in a room.

Three main characteristics can be distinguished in a BAC and TBM:

1) **CONTROL ACCURACY (CA)** is the degree of correspondence between the ultimately controlled variable and the ideal value in a feedback control system. The controlled variable could be any physical variable such as a temperature, humidity, pressure, etc. The ideal value is in fact the SET POINT established by the user (occupant) when he determines the level of comfort. It is clear that the entire control loop is concerned with all the elements constituent, such as sensors, valves and actuators. The equipment itself is another important element and usually specific equipment asks

for a specific controller. For the energy carrier hot water, an important issue is the balancing of the hydraulic circuits. For that purposes, balancing hydraulic valves are needed.

The **Control Accuracy** for a temperature is defined by two components: the Control Variation (CV) and Control Set point Deviation (CSD). This is described in the main text of EN 15500-1. The compliance with CA is also defined in the standard. This is an important input for EN 15316-2 '*Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Part 2: Space emission systems (heating and cooling), Module M3-5, M4-5*'', where the effect of the control for heating, cooling and ventilation is taken into account. The same standard (EN 15500-1) describes also the 4 operations modes that deal with the levels of temperatures: Comfort, Precomfort, Economy and Frost Protection. These 4 predefined operation modes are parameters that could be set by the users (occupant) – the temperature allocated to each operation mode. These operations modes are important for the control strategy used for intermittence, which is described below.

2) **CONTROL FUNCTION** is the ability of a controller (or set of communicative controllers) to perform a determined task(s). Usually the functions implemented in the controllers are parametrable or free programmable. The functions could be performed by a single controller or by a set of communicative controllers. A controller could perform several functions.

The **CONTROL FUNCTIONS** present in a BAC or TBM, are present in EN 15232-1:2017, Table 4[21].

The **CONTROL FUNCTIONS** in EN 15232-1:2017, Table 4 are organized in the form of the Modular Structure of EPB standards. This Table 4 starts with **Heating** Emission, Distribution, Storage and Generation (M3-5, M3-6, M3-7, M3-8) follow by **Domestic Hot Water**, **Cooling**, **Ventilation** and **Lighting** (M9-5, M9-6, M9-7, M9-8). Each function is described in detail, in accordance with the type (level) of the function: from the lower type (NO AUTOMATIC CONTROL Type=0) to most advanced types. For each function, an IDENTIFIER in the software language for BAC and TBM is also defined, as the destination of the module where the control function gives his effect. An example of this is given in Table 6, as abstract from EN 15232-1.

Table 6 — Abstract of Table 4 in EN 15232-1:2017 [21]

Automatic control			
1	**Heating control**		
1.1	Emission control		HEAT_EMIS_CTRL_DEF M3-5
		The control function is applied to the heat emitter (radiators, underfloor heating, fan-coil unit, indoor unit) at room level; for type 1 one function can control several rooms	
	0	No automatic control of the room temperature	
	1	Central automatic control: There is only central automatic control acting either on the distribution or on the generation. This can be achieved for example by an outside temperature controller conforming to EN 12098-1[16] or EN 12098-3[17]; one system can control several rooms	
	2	Individual room control: By thermostatic valves or electronic controller	
	3	Individual room control with communication: Between controllers and BACS (e.g. scheduler, room temperature set point)	
	4	Individual room control with communication and presence control: Between controllers and BACS; Demand control/occupancy detection (this function level is usually not applied to any slow reacting heat emission systems with relevant thermal mass, e.g. floor heating, wall heating)	

For practical reasons, four different BAC efficiency classes (A, B, C, D) of functions are defined both for non-residential and residential buildings. This is the fastest way to specify a BAC or a TBM.

— Class D corresponds to non-energy efficient BAC. Building with such systems should be retrofitted. New buildings should not be built with such systems.

— Class C corresponds to standard BAC.

— Class B corresponds to advanced BAC and some specific TBM functions.

— Class A corresponds to high-energy performance BAC and TBM.

One is in class D: If the minimum functions to be in class C are not implemented.

To be in class C: Minimum functions defined in EN 15232-1:2017, Table 4 are implemented.

To be in class B: Building automation function plus some specific functions defined in EN 15232-1:2017, Table 4 are implemented in addition to class C. Room controllers are able to communicate with a building automation system.

To be in class A: Technical building management function plus some specific functions defined in EN 15232-1:2017, Table 4 are implemented in addition to class B. Room controllers are able for demand controlled HVAC (e.g. adaptive set point based on sensing of occupancy, air quality, etc.) including additional integrated functions for multi-discipline interrelationships between HVAC and various building services (e.g. electricity, lighting, solar shading, etc.)

NOTE In addition, the hydraulic system is supposed to be properly balanced.

The functions assignment to the BACS efficiency classes are listed in EN 15232-1:2017, Table 5.

BAC functions with the purpose to control or monitor a plant or part of a plant which is not installed in the building are not considered when determining the class even if they are shaded for that class. For example, to be in class B for a building with no cooling system no Individual room control with communication is required for emission control of cooling systems.

If a specific function is required to be in a specific BAC efficiency class, it is not required that it is strictly required everywhere in the building: if the designer can give good reasons that the application of a function does not bring a benefit in a specific case it can be ignored. For example, if the designer can show that the heating load of a set of rooms is only dependant on the outdoor temperature and can be compensated with one central controller, no individual room control by thermostatic valves or electronic controllers is required to be in class C.

A reference list of BACS functions to reach is defined in EN 15232-1:2017, Table 5. That table defines the minimum requirements of BACS functions according to BACS efficiency classes D, C (reference), B and A.

Unless differently specified this list can be used for the following:

— to specify the minimum functions to be implemented for a project;

— to define the BACS function to take into account for the calculation of energy consumption of a building when the BACS functions are not defined in detail;

— to calculate the energy use for the reference case in step 1 of the BACS efficiency factor method.

3) **CONTROL STRATEGY** is the methods employed to achieve a given level of control to reach a goal. Optimal control strategies deliver a desired level of control at a minimum cost. A CONTROL STRATEGY could consist by a CONTROL FUNCTION or a group of CONTROL FUNCTIONS.

An example of a CONTROL STRATEGY that consists of a CONTROL FUNCTION is OPTIMUM START, OPTIMUM STOP and Night SET BACK, as described in the standards EN 12098-1[16] and EN 12098-3.[17] The Timer function is described in EN 12098-5[18].

An example of a CONTROL STRATEGY that is realized by a group of CONTROL FUNCTIONS is the CONTROL STRATEGY used by **INTERMITTENCE**. This function uses several CONTROL FUNCTIONS, OPERATION MODES, OPTIMUM START-STOP and TIMER at the same time. All elements together are called either Building Profile or User Pattern. Usually, to implement such Building profile, a TBM is a prerequisite.

The most important CONTROL STRATEGY described and implemented in EN 15232-1 is **DEMAND ORIENTED CONTROL.** Usually these strategies implement the sense of the energy flow (from GENERATION to EMISSION) with flow of calculation (from building needs to delivered energy).

Usually for this complex CONTROL STRATEGY, a TBM is necessary with a distributed specific control for each Technical Building System who communicates in system architecture via a communication standardized bus such as BACnet, KNX or LON.

More clear, this Demand Oriented Control works as follows:

— When the comfort is reach in the Emission area, the controller from the Emission sends the message to the controller in charge of Distribution to stop to distribute energy, that sends the message to the controller in charge of Storage either to store the energy and if the Storage cannot store more energy sends the message to the controller in charge with the Generation to stop to generate more energy.

— Another important Control Strategy is the control strategy for multi generators either from same type (e.g. several boilers) or different types (e.g. a boiler and heat pomp) including also the Renewable Energy Sources. The strategy could be based as follow:

  — Priorities only based on running time;

  — Fixed sequencing based on loads only: e.g. depending on the generators characteristics, e.g. hot water boiler vs. heat pump;

  — Priorities based on generator efficiency and characteristics: The generator operational control is set individually to available generators so that they operate with an overall high degree of efficiency (e.g. solar, geothermic heat, cogeneration plant, fossil fuels);

— Load prediction based sequencing: The sequence is based on e.g. efficiency & available power of a device and the predicted required power.

The standards enabling to calculate the effect of BACS and TBM functions on energy consumption use different approaches to calculate this impact.

Five approaches are common to different standards:

— direct approach;

  — when the calculation of energy performance is performed using detailed simulation method or hourly calculation method as provided in ISO 52016-1,[10] it is possible to calculate directly the impact of a number of functions e.g. impact of intermittent heating, varying temperature between heating and cooling set points, movable solar shadings etc., by hourly varying input data.

— operating mode approach;

  — automatic control enables to operate climate systems under different operating mode e.g. for ventilation system: occupied mode/unoccupied mode, for intermittent heating normal mode, no heating mode, set back mode, peak power mode.

    — the approach to calculate the effect of the automatic control on the energy consumption is to calculate the energy consumption sequentially for each operating mode. The total energy consumption is obtained by summing the energy consumption during each operating mode.

    — Each operating mode corresponds to a given state of the control system. The calculations are performed for each operating mode by considering the relevant state of the control system: e.g. fan on / fan off.

— time approach;

  — this approach can be used when the control system has a direct impact on the operating time of a device (e.g. control of a fan, a luminary).

— temperature approach (control accuracy);

  — this approach accounts for offsets and deviations of the actual value from the set point due to control. The set-point is used to estimate energy demands assuming perfect/ideal control whereas the actual value (referred to as a virtual set-point) accounts for a real control. Control is seen is more energy efficient as closer the virtual set-point to the origin set-point thus as smaller the control deviation.

 — the principle of this approach is explained based on the room temperature control, which can be used when the control system has a direct impact on the room temperature. The approach accounts for the impact of the control system by correcting the set-point temperature when calculating the energy needs according to ISO 52016-1,[10] in case of a system specific calculation of the energy needs. Beside the control also other effects may have an impact on the virtual set-point, e.g. type of heat emitter, temperatures, building physics etc. which need to be described well.

— correction coefficient approach.

 — this approach is used when the control system has a more complex impact such as for example a combined effect on time, temperature etc.

For the TBM effect some more remarks:

The Technical Home and Building Management enables to adapt easily the operation to the user needs.

One should check at regular intervals that the operation schedules of heating, cooling, ventilation and lighting are well adapted to the actual used schedules and that the set points are also adapted to the needs.

— Attention should be paid to the tuning of all controllers this includes set points as well as control parameters such as PI controller coefficients.

— Heating and cooling set points of the room controllers should be checked at regular intervals. The users often modify these set points. A centralized system enables to detect and correct extreme values of set points due to misunderstanding of users.

— If the Interlock between heating and cooling control of the emitter and/or distributer is only a partial interlock the set point should be regularly modified to minimize the simultaneous use of heating and cooling.

— Alarming and monitoring functions will support the adaptation of the operation to user needs and the optimization of the tuning of the different controllers. This can be achieved by providing easy tools to detect abnormal operation (alarming functions) and by providing easy way to log and plot information (monitoring functions). Conformance with the EPB and minimal variation through time is the goal.

TBM also covers the calculation of the building operation data that could be influenced and optimized by a Technical Building System. Those data are mainly related to:

— set points including set back,

— run times of heating, ventilation, cooling and lighting systems including start-stop-optimization,

— sequencing of multiple generators,

— energy management with regard to the utilization of local renewable energy and local energy production,

— heat recovery and heat shifting,

— smart grid interactions and peak shaving.

Calculation is in general independent from the calculation interval chosen but is according to the time-step of the input.

11.5 Climatic and external environment data

A specific standard intended to serve as the consistent, common entry point for the climatic data for all EPB standards is ISO 52010-1[23].

11.6 Overall energy performance

11.6.1 General

The introduction in ISO 52000-1:2017, 11.6.1[1] highlights that there are two separate weighting procedures:

— one for energy carriers that are not exported;

— the other for electricity and other energy carriers that are also exported.

Weighting is straightforward for energy carriers that are not exported (see 11.6.3).

For electricity and other energy carriers that are also exported, a detailed analysis of the components of produced, used, delivered and exported energy is given in ISO 52000-1:2017, 11.6.2.

Examples of non-electricity energy carriers that could be exported are biogas and heat. In ISO 52000-1 only electricity is assumed as being exported, since this is by far the most common case.

11.6.2 Electricity and other energy carriers with exportation

11.6.2.1 General energy balance calculation

The weighting of delivered and exported electricity is performed independently for each calculation interval and then the weighted amounts for the calculation period are collected by Formula (19) for delivered energy and Formula (20) for exported energy. This is required to support time-dependent weighting factors.

Formula (20) allows to include (or not to include) the effect of exported energy into the energy performance of the building. This option is controlled by the parameter k_{exp}., as explained in 11.6.2.3.

ISO 52000-1:2017, Figure 7 shows the components of delivered and exported energy. They are listed after the figure. In short:

at each calculation interval:

— produced and used electricity are compared to determine if:

  — either delivered electricity is required;

  — or excess electricity is available for export;

— exported electricity may consist of:

  — exported for on-site non EPB uses;

  — exported to the grid.

If exported electricity is not entirely taken into account in the energy performance of the building (setting $k_{exp} < 0$), then the exported electric energy which has not been included in the energy performance of the building is reported as available exported energy $E_{exp;el;avl;an}$ given by Formula (21). Formula (22) gives the associated weighted energy $E_{we;exp;el;avl;an}$: this information is needed to guarantee the modularity of the procedure. If the building is taken into account in the context of a nearby network, this information (available energy, actual value and weighted) is the contribution of the assessed building to the network.

ISO 52000-1:2017, Formula (19) provides the weighted delivered energy for electricity from the grid.

ISO 52000-1:2017, Formula (20) includes into the energy performance of the building the effect of exported energy, which is represented by the term $E_{\text{we;exp;el},cr,i,\text{an;AB}}$. The parameter k_{exp} allows to control this inclusion.

ISO 52000-1:2017, Formulae (21) and (22) evaluate the energy, that was produced by the building technical systems and that has not been already taken into account in the energy performance of the building. It is evaluated both as energy carrier amount (21) and as weighted amount (22).

Figure 15 shows how to use Step A and Step B for exported energy.

Data for this example:

On site cogen, using 5 000 kW·h biogas, producing:

1 500 kW·h thermal

3 000 kW·h electricity

Other: natural gas: 2 222 kW·h

	f_{Pren}	f_{Prnen}
biogas	1,0	0,05
natural gas	0,0	1,05
electricity	0,2	2,3

Introduction

This case with on-site cogeneration (cogen) is more complicated than for instance and example with PV electricity production, because in the case of cogen some non-renewable energy may have been used to produce the exported electricity: in Step A this amount is excluded from the energy performance of the building and to be reported separately.

This Step A is especially relevant for countries who want to omit Step B (by setting k=0) or want to omit part of Step B (k<1).

For these cogen situations ISO 52000-1 contains rules for the allocation of the delivered energy to the produced heat and to the produced electricity which in the example leads to the numbers for (3) and (4) (the calculation of this allocation is not shown in the diagram. The allocation rule is based on the so called "power bonus method", with in this example an assumed reference efficiency for electricity = 0,46.

NOTE The reference efficiency calculates back to delivered energy, not to primary energy, so it is not the same as a primary energy factor.

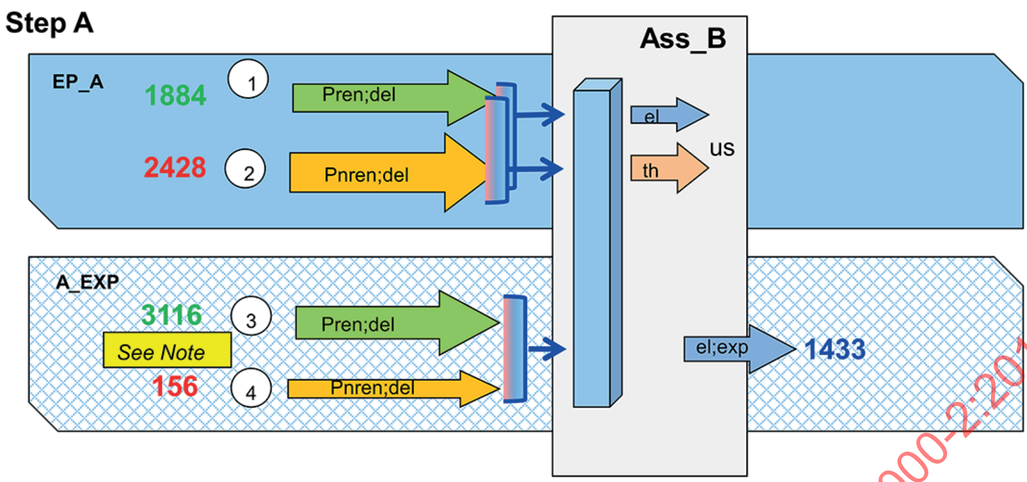


Figure 15 a)

EQUATIONS Step A: $E_{\mathrm{pren;stepA}} = 1\ 884$ kW·h $E_{\mathrm{pnren;stepA}} = 2\ 428$ kW·h

Key Step A:

]→ Conversion primary energy → energy carriers

Ass_B: Assessment boundary

us The own used energy [a)]

el Electricity

th Thermal energy

el;exp The electricity produced on site and exported [b)]

(1) The renewable primary energy delivered to the building, associated to the own used energy

(2) The non-renewable primary energy delivered to the building, associated to the own used energy

(3) The renewable primary energy delivered to the building, associated to the exported electricity

(4) The non-renewable primary energy delivered to the building, associated to the exported electricity

EP_A: The EP of the building under step A :

(1) = (1)&(3) – (3). The delivered renewable primary energy, associated to the own used energy

(2) = (2)&(4) – (4). The delivered non-renewable primary energy, associated to the own used energy

A_EXP: Under step A: kept outside the EP of the building:

the exported electricity (el;exp)

the resources used for the exported electricity ((3) and (4))

a) More precise: energy used on site for EPB services.
b) More precise: including “export” to non-EPB uses on site.

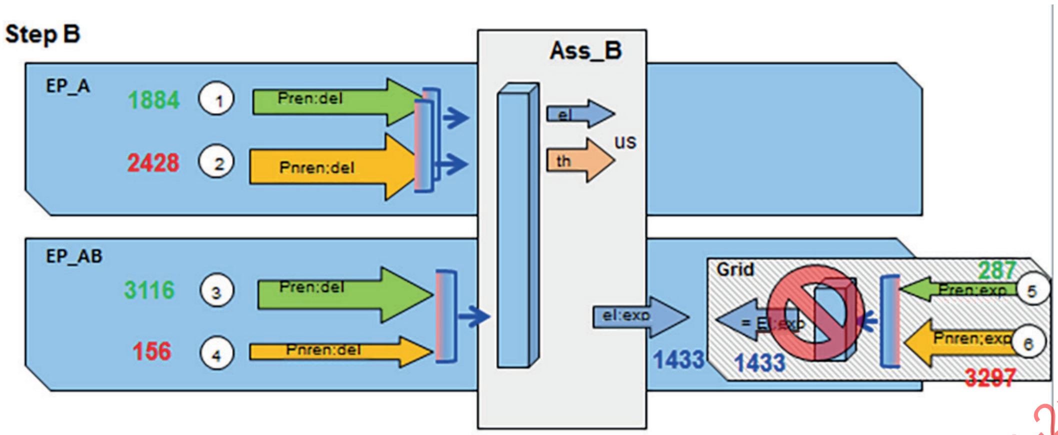


Figure 15 b)

EQUATIONS Step B:

For e.g. k = 1,0: E_{pren} = 1 884 + 1,0 x (3 116 – 287) = 4 713 kW·h
E_{pnren} = 2 428 + 1,0 x (156 – 3 297) = – 713 kW·h

For e.g. k = 0,3: E_{pren} = 1 884 + 0,3 x (3 116 – 287) = 2 733 kW·h
E_{pnren} = 2 428 + 0,3 x (156 – 3297) = 1 486 kW·h

Key Step B:

See Step A, plus:

Grid: The avoided electricity production elsewhere in the grid, due to the exported electricity

(5) Avoided renewable primary energy resources elsewhere, due to exported electricity produced on site

(6) Avoided non-renewable primary energy resources elsewhere, due to exported electricity produced on site

EP_AB: **From step A to step B: in addition to EP_A,**

the exported energy is taken into account in the EP of the building [c]**:**

+(3) – (5) In addition to (1): The renewable primary energy resources used for the exported electricity

minus the avoided renewable primary energy elsewhere [c]

+(4) – (6) In addition to (2): The non-renewable primary energy resources used for the exported electricity

minus the avoided non-renewable primary energy elsewhere [c]

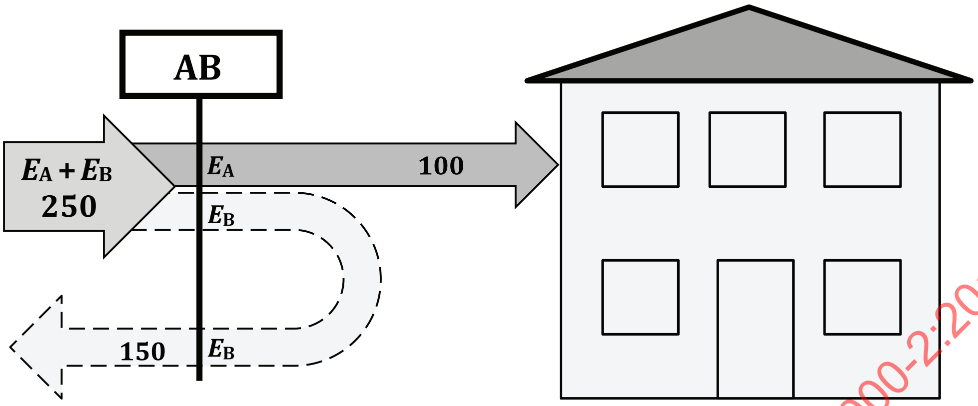
[c] Or a fraction k, between 0 and 1 (national option).

Figure 15 — Illustration of Step A and Step B for exported energy

11.6.2.2 Weighted exported energy using factors that reflect exported energy generation (step "A")

Step A evaluates the exported energy using weighting factors determined according to the weighted energy used to produce it $E_{\text{we;del;el;an;A}}$.

In this step, the weighted energy used to generate any exported energy is automatically excluded from the building energy performance, as shown in Figure 16.



Key

AB assessment boundary

Figure 16 — Example of weighted energy flow for step A

In this example:

— the actual quantity $E_A + E_B$ of electricity is generated on-site and delivered to the building (250 kW·h)

— the actual quantity E_A of electricity is used in the building (100 kW·h)

— the actual quantity E_B of electricity is exported through the assessment boundary (150 kW·h)

Since the weighting factor is the same for delivered and exported electricity ($f_{we;del;A}$) The application of ISO 52000-1:2017, Formula (2) can be written:

$$E_{we;A} = \left(E_A + E_B\right) \cdot f_{we;del;A} - E_B \cdot f_{we;del;A} \quad (31)$$

$$\left(E_A + E_B\right) \cdot f_{we;del;A} - E_B \cdot f_{we;del;A} = E_A \cdot f_{we;del;A} + E_B \cdot f_{we;del;A} - E_B \cdot f_{we;del;A} \quad (32)$$

$$E_A \cdot f_{we;del;A} + E_B \cdot f_{we;del;A} - E_B \cdot f_{we;del;A} = E_{del;A} \cdot f_{we;del;A} \quad (33)$$

Looking at the first term of Formula (31) and the last term of Formula (33) shows that:

— the exported energy E_B (150 kW·h) is automatically excluded from the energy performance;

— only E_A, the part of the produced energy that is used on-site, is included in the energy performance of the building.

This formula holds independently for all weighting criteria (e.g. separately for renewable and non-renewable primary energy).

If the exported energy is generated by several generators, it should be decided how much of the energy produced by each generator is used on-site or exported. This is done according to the procedure defined in ISO 52000-1:2017, 9.6.6.2.4.

ISO 52000-1:2017, Formulae (24) to (26) use the same weighting factor for electricity.

11.6.2.3 Effect of exported energy on weighted energy performance (“step B”),

ISO 52000-1:2017, 11.6.2.3 calculates the effect of the exported energy. The exported energy has:

— a “cost”, which is the weighted energy required to generate the exported energy

— a “benefit”, which is the weighted energy that will be saved by the grid generators thanks to the exported energy (because the exported energy reduces the energy required to the grid generators).

This is calculated in Formulae (28) to (30) for the three components of exported energy and then summed in Formula (27).

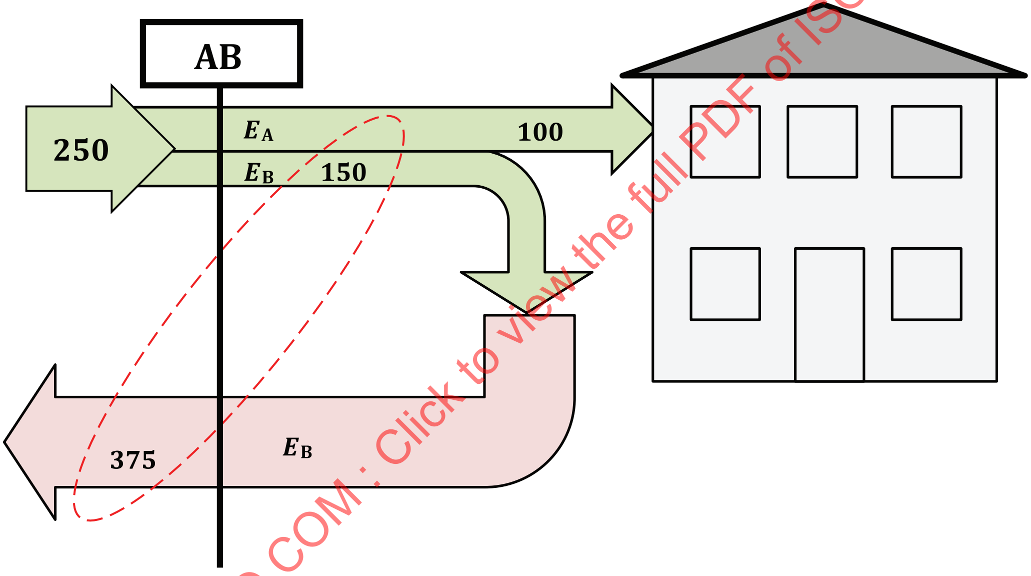
As an example, using total primary energy weighting, and assuming that conversion factor f_{Ptot} is:

— $f_{\mathrm{Ptot;PV}}$ = 1,0 for the on-site generated electricity, used at step A evaluation;

— $f_{\mathrm{Ptot;el}}$ = 2,5 for the grid delivered electricity;

then the values in Figure 16 represent both the actual energy flow and the total primary energy.

Figure 17 is the primary energy flow diagram for step B.



Key

AB assessment boundary

Figure 17 — Primary energy diagram for step B

Starting from the result of step A (100 kW·h that accounts only for the energy flow E_A (energy used within the building) two components can be added:

— the “cost” of the total primary energy used to generate the exported energy, which is 150 kW·h multiplied by the step A primary energy factor which is 1,0 giving 150 kW·h of additional total primary energy;

— the “benefit” of reducing the total primary energy requirement of the grid generators, which is 150 kW·h multiplied by the total primary energy factors of the grid which is 2,5 giving 375 kW·h.

The total energy performance, as total primary energy, is the combination of:

— + 100 kW·h total primary energy used to generate E_A

— + 150 kW·h total primary energy used to generate E_B

— – 375 kW·h total primary energy saved by the grid generators because the energy they produce is reduced by E_B.

and the total primary energy performance of the building taking into the account the effect of exported energy is -125 kW·h.

Clause 11.6.2.3 calculates the last two terms (+150 and – 375).

Detailing the application of ISO 52000-1:2017, Formula (2), it is noted that:

$$E_{\text{we;A}} + E_{\text{B}} \cdot \left(f_{\text{we;del;A}} - f_{\text{we;exp}} \right) = E_{\text{A}} \cdot f_{\text{we;del;A}} + E_{\text{B}} \cdot f_{\text{we;del;A}} - E_{\text{B}} \cdot f_{\text{we;exp}} \tag{34}$$

$$E_{\text{A}} \cdot f_{\text{we;del;A}} + E_{\text{B}} \cdot f_{\text{we;del;A}} - E_{\text{B}} \cdot f_{\text{we;exp}} = E_{\text{del;A}} \cdot f_{\text{we;del;A}} - E_{\text{exp}} \cdot f_{\text{we;exp}} \tag{35}$$

Looking at the first term of Formula (34) and at the last term of Formula (35) show that:

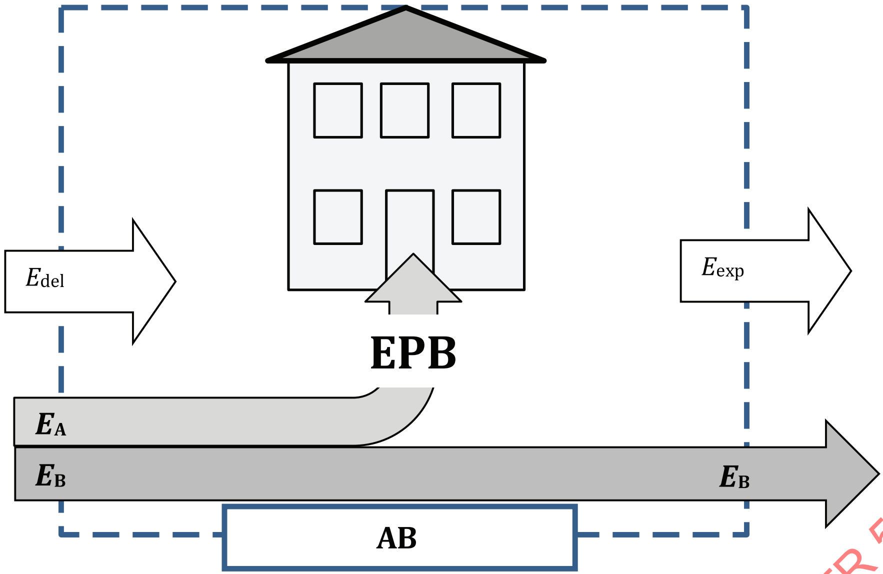
— starting from the step A evaluation (using ISO 52000-1:2017, Formula (2)) with weighting factors depending on the resource used to generate the exported electricity;

— and adding the effect of exported energy;

gives the same result as using directly ISO 52000-1:2017, Formula (2) with weighting factors depending on the avoided resources by the grid generators.

This shows the connection between the two alternatives highlighted in Figure 8 of 9.6.6.1: choosing one type or the other of weighting factors is the equivalent of including/excluding the effect of exported energy into the energy performance of the building. Clause 11.6.2.3 calculates the difference between the two evaluations and by applying the factor k_{exp} into ISO 52000-1:2017, Formulae (20), (21) and (22) it makes it possible to include or not the contribution of exported energy into the energy performance of the building.

The exported energy which is not taken into account in the energy performance of the building $E_{\text{exp;el;avl;an}}$ is calculated in ISO 52000-1:2017, Formula (21) so that it can be reported separately as energy available for use outside the assessment boundary. This available energy can also be fully detailed as actual energy, weighted energy, associated primary energy and RER. This is required for the scalability of the energy performance calculation model and to have the possibility to include the contribution of the assessed building into the assessment of a nearby set of buildings.



Key

AB assessment boundary

EPB EPB services

Figure 18 — Summary of step A step B approach

Figure 18 summarizes the approach.

Energy E_A and E_B is delivered to the building technical services.

— E_A is used to provide the calculated EPB services (heating, domestic hot water, etc.);

— E_B is used to generate the exported energy carrier.

Setting k_{exp}=1 includes in the energy performance of the building the effect of E_B. In association with particular sets of weighting factors, this can produce indicators with special values like:

— negative values of the energy performance (and negative efficiencies) if there is a high amount of exported energy and the weighting factor for the delivered energy is lower than the weighting factor of the corresponding exported energy;

EXAMPLE This might occur if the primary energy factor for PV is set to 1,0 and the grid electricity factor is 2,5.

— RER higher than 1 or negative because the energy balance for renewable and non-renewable energy are independent;

EXAMPLE This might occur especially with cogeneration fed by renewable fuel.

Also the use of an energy carrier (that would lead to a bad energy performance) can be compensated by the export of another energy carrier.

These are not wrong values or features: these are the coherent effects and results when the effect of the exported energy is included in the energy performance of the building.

Setting k_{exp}=0, is the same as ignoring E_B. in the energy performance of the building (step A evaluation). This produces the following effects:

— the energy performance is usually a positive number (an exception can occur with cogeneration depending on the allocation method;

— the RER is usually between 0 and 1 (see previous exception);

— there is no cross-compensation between different energy carriers.

Any value of k_{exp} between 0 and 1 partially includes the effect of E_B in the energy performance of the building.

The effects of the controlling parameter k_{exp} are demonstrated in detail in the examples of K.2.

11.6.2.4 Calculation procedure of delivered and exported electric energy components

This clause deals with the identification of the components of the delivered and exported energy depending on the timing of the import and export. All considered components of delivered and exported energy are defined in 9.6.6.1 and shown in ISO 52000-1:2017, Figure 7.

The following uses of the produced electricity $E_{pr;el,t}$ are distinguished (depending on the time relationship between production and use) and considered from highest to lowest priority:

— immediate use for EPB uses within the same calculation interval;

— exported for immediate non-EPB uses within the same calculation interval;

— exported to the grid.

The calculation steps are described one after another, in the order of execution.

a) Collect electricity uses

All on-site electricity uses are collected.

The option is given to specify electrical uses that will not be satisfied by electricity produced on-site. Electricity uses that are not covered by on-site production should be excluded from ISO 52000-1:2017, Formula (29) and are defined in ISO 52000-1:2017, Table A.31 and B.3.

This option has been introduced for several reasons:

— economic calculation may require that all the produced electricity is sold and then the needed electricity is bought again;

— not to give an advantage to auto consumption;

— to limit possible uses (e.g. no PV used for direct heating).

b) Collect non EPB electricity uses $E_{nEPus;el;t}$.

This is an optional item. If these uses are not defined then:

— $E_{nEPus;el;t}$. is set to 0;

— $E_{exp;el;nEPus;t}$ will be 0 as well.

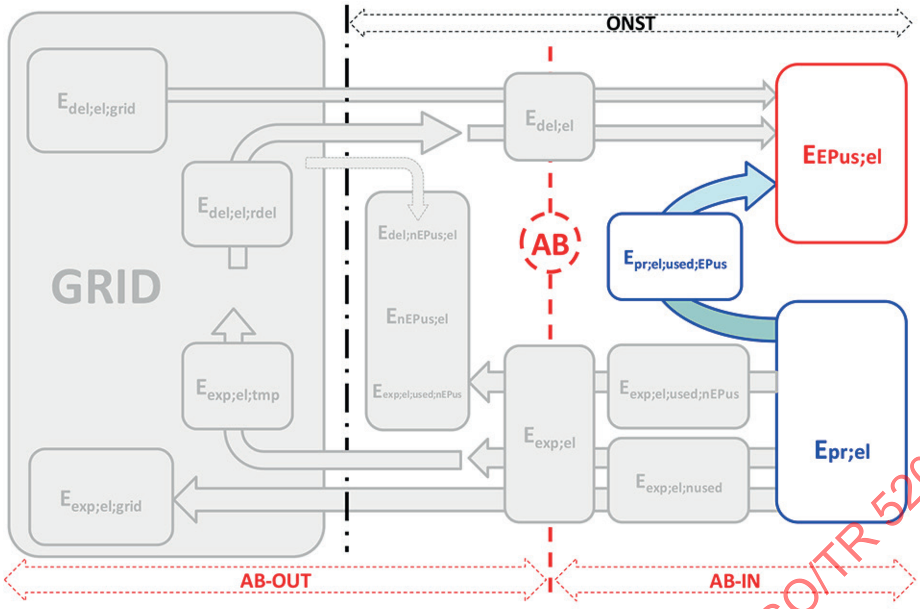
c) Collect on-site electricity production

No additional information needed.

d) Calculate immediate use for the EPB services $E_{EPus;el;t}$, in the same calculation interval, $E_{pr;el;used;EPus;t}$.

This immediate use results in less electricity $E_{del;el;t}$ to be delivered by the grid.

This path is highlighted in Figure 19.



Key

AB	assessment boundary
AB-IN	inside the assessment boundary
AB-OUT	outside the assessment boundary
GRID	grid

Figure 19 — Immediate use of on-site produced energy for on-site EPB uses

This standard assumes that on-site produced electricity will be used with priority with respect to electricity delivered from the grid.

As stated in step a) of this procedure, some uses may be excluded from the coverage by on-site production of electricity.

A matching factor function allows for consistency between monthly and hourly calculations. Hourly calculation captures much better the synchronicity between production and use of electric energy. A monthly calculation hides the compensation between night and day (Example: use of PV for lighting) and during the month.

The correlation function has been left entirely free. An example of such a function is given in the accompanying spreadsheet.

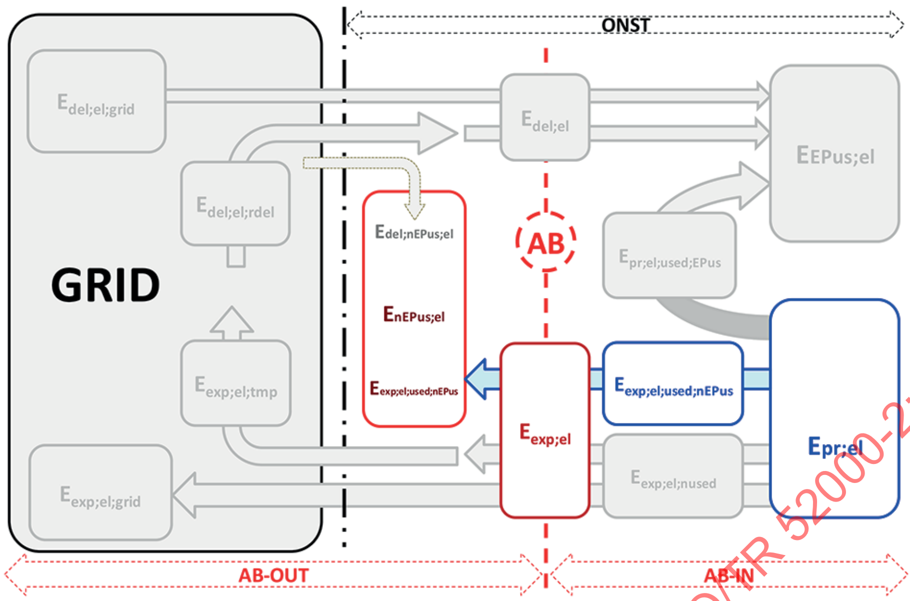
e) Calculate exported energy

No additional information needed.

f) Calculate exported electric energy used for non-EPB uses in the building

If there is a surplus $E_{\text{exp;el;}t}$, export to non-EPB services at the building site (e.g. appliances), $E_{\text{nEPus;el;}t}$ is calculated.

This path is highlighted in Figure 20.



Key

AB	assessment boundary
AB-IN	inside the assessment boundary
AB-OUT	outside the assessment boundary
GRID	grid

Figure 20 — Immediate use of on-site produced energy for on-site non-EPB uses

The reason for this step in the calculation is that electricity use at the building site itself may be preferred over exporting it to the grid. This is also closer to reality than ignoring this type of use. Note that for this use there is still no interference with the grid.

This is a type of use which is not part of the EPB energy assessment. Therefore:

— The amount of electricity use for non-EPB services $E_{\mathrm{nEPus;el}}$ is not part of the EPB calculation but a value given per calculation interval according to national application documents.

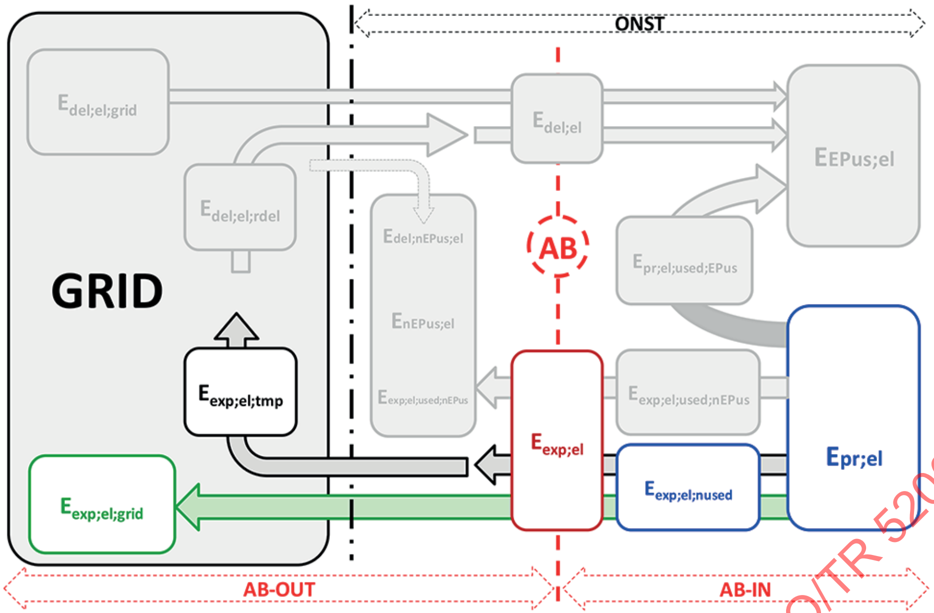
— If this type of use is not taken into account, the value for $E_{\mathrm{nEPus;el}}$ is not provided and it is set to zero.

— If $E_{\mathrm{nEPus;el}}$ is not provided or set to 0 according to the previous item, the weighting factor for exported electricity for non-EPB uses in the building $f_{\mathrm{we;exp;el;used;nEPus},t}$ is also not required.

— Typically, for hourly calculations, the values for non-EPB electric energy use in regulations could be supplied as an hourly pattern, synchronous to the occupancy of the building. Furthermore, the values typically depend on the building or space category and building size.

This type of use is considered as export to outside the EPB assessment boundary.

g) If after step f) there is still a surplus (i.e. $E_{\mathrm{pr;el};t} > (E_{\mathrm{EPus;el};t} + E_{\mathrm{nEPus;el};t})$): non-immediately used electricity is exported to the grid as $E_{\mathrm{exp;el;nused};t}$, as shown in Figure 21.



Key

AB	assessment boundary
AB-IN	inside the assessment boundary
AB-OUT	outside the assessment boundary
GRID	grid

Figure 21 — Electricity surplus (not used on-site) during calculation step t

h) At step e), if there was a shortage, $E_{\mathrm{del;el;}t}$, this is delivered to the building.

11.6.3 Energy carriers without exportation

ISO 52000-1:2017, Formula (40) simply states that the yearly total amount delivered energy for one carrier is obtained by summing all generation subsystems inputs (gen,i) for all services (X) and for all calculation intervals.

This approach is true for all energy carriers that are only delivered and not exported through the assessment boundary.

11.6.4 Exported heat on-site produced and not included in thermal use of the building

If a generator is used for EPB services but also for non-EPB services, it is calculated with the whole load to take into account the correct operating conditions.

However the entire delivered energy cannot be taken into account into the energy performance. This clause allocates to each use of the produced heat (EPB and non EPB) a quota of delivered and auxiliary energy of the generator.

This procedure has the same effect as using for exported heat a step A evaluation and $k_{\mathrm{exp}} = 0$.

12 Common overarching output – General

12.1 General

It is important for the transparency and traceability of the energy performance assessment to have procedures in ISO 52000-1 for a common “overarching” reporting:

— In general: for instance on the application (see e.g. the routing in ISO 52000-1:2017, 5.1), description of building and the assessment boundaries of the project.

— Specifically for the calculated energy performance: a clear (and comparable) breakdown into the different elements of the energy use. This will give immediate insight into the main energy uses. It may also flag specific points of attention, such as suspicious input data or parameters. Finally, some of the (e.g. aggregated) output will also serve as benchmarks (e.g. “energy signatures”) for (e.g. later) measured energy use on the same building. This will help to identify possible causes in case of a gap between predicted and real energy use.

EXAMPLE 1: Monthly value and annual total for energy flows per m^2 conditioned floor area

Brief description

A table and graph with monthly energy need for heating and for cooling and mean monthly indoor and outdoor temperatures.

Rationale

The table and graph give the main calculation results.

Procedure

Output from the hourly or monthly calculation.

Table

Monthly value and annual total for:

Energy flows per m^2 conditioned floor area

Table 7 — Monthly value and annual total for energy flows per m^2 conditioned floor area

Variable	Unit
Outdoor air temperature	ºC
Indoor mean air temperature	ºC
Indoor mean operative temperature	ºC
Heat loss by transmission and ventilation	(kW·h)/m^2
Solar and internal heat gains	(kW·h)/m^2
Heating needs	(kW·h)/m^2
Heating needs / Energy use for heating	-
Cooling needs	(kW·h)/m^2
Cooling needs / Energy use for cooling	-

EXAMPLE 2: Monthly thermal balance

Brief description

A diagram with monthly energy need for heating (H), with breakdown into transmission plus ventilation losses versus solar plus internal gains.

A bar diagram with monthly energy need for cooling (C), with breakdown into transmission plus ventilation losses versus solar plus internal gains.

Rationale

The diagram shows the significance (sensitivity) of the heating or cooling need: e.g. whether it is only a small difference between two large numbers.

Procedure

Output from the hourly calculation.

Example

See ISO 52016-1[10] and the accompanying technical report (ISO/TR 52016-2[11]).

EXAMPLE 3: Energy use for heating and cooling plotted against outdoor air temperature

Brief description

Plot of the energy use for heating (H) and energy use for cooling (C), per energy carrier (gas, oil, district heating, electric energy, etc.), as function of outdoor temperature.

Rationale

This is a simple first indication of the energy use:

The slope indicates the energy losses per degree indoor-outdoor temperature difference. The dead band indicates the influence of internal heat gains on one hand and the proper control on the other hand.

It also serves as benchmarks (e.g. "energy signature") for (e.g. later) measured energy use on the same building. This will help to identify possible causes in case of a gap between predicted and real energy use.

Procedure

For instance daily total values.

Example

See ISO 52016-1[10] and the accompanying technical report (ISO/TR 52016-2[11]).

EXAMPLE 4: Plot of hourly values for typical weeks

Brief description

A graph with hourly values for key variables for four representative weeks:

Mid-winter, spring, mid-summer, autumn.

Rationale

This reveals the hourly patterns, gives a feeling for the effects and may show unexpected values.

Procedure

Plot

Table 8 — Key variables for presenting hourly values for four representative weeks

Variable	Unit
Outdoor air temperature	ºC
Indoor mean air temperature	ºC
Indoor mean operative temperature	ºC

Table 8 *(continued)*

Variable	Unit
Heat loss by transmission and ventilation	(kW·h)/m^2
Solar and internal heat gains	(kW·h)/m^2
Heating needs	(kW·h)/m^2
Heating needs/Energy use for heating	-
Cooling needs	(kW·h)/m^2
Cooling needs/Energy use for cooling	-

Example

See ISO 52016-1[10] and the accompanying technical report (ISO/TR 52016-2[11]).

12.2 Tabulated overview of the amounts of energy per energy carrier and energy service

12.2.1 Absolute values

The tables of ISO 52000-1:2017, 12.2 are essential because they provide a common template for the reporting of the key data; without these tables it will not be possible to compare different cases.

The next tables give two worked-out examples of ISO 52000-1:2017, Tables 11 to 13, presenting the overall energy performance and the composition per energy carrier and energy service. Also included in the tables are the energy needs for heating and cooling, plus the renewable energy produced on-site and the renewable energy ratio:

— the first example is built around an office building having a net reference area of 2 000 m^2;

— the second example is built around a new residential single house, having a net reference area of 120 m^2.

12.2.1.1 Example 1: office building

Table 9 — Overview of the total energy performance and the composition per energy carrier and building service; absolute values

Service	Energy need (building level) (kW·h/an)	Generation output (building level) (kW·h/an)	Energy use per energy carrier (kW·h/an)		Weighted energy performance (kW·h/an)					
			Carrier		Step A			Final result		
			name	Amount	E_{Pren}	E_{Pnren}	E_{Ptot}	E_{Pren}	E_{Pnren}	E_{Ptot}
Heating	*90 000*	*97 830*	El grid	*4 087*	*2 044*	*8 174*	*10 218*	*1 904*	*7 616*	*9 520*
			El PV	*2 009*	*2 009*	*0*	*2 009*	*2 288*	*0*	*2 288*
			Gas	*101 603*	*0*	*111 763*	*111 763*	*0*	*111 763*	*111 763*
			Env heat	*0*	*0*	*0*	*0*	*0*	*0*	*0*
			total		***4 053***	***119 938***	***123 990***	***4 192***	***119 380***	***123 572***
Cooling	*70 000*	*77 800*	El grid	*19 309*	*9 654*	*38 617*	*48 272*	*8 995*	*35 981*	*44 976*
			El PV	*9 491*	*9 491*	*0*	*9 491*	*10 810*	*0*	*10 810*
				0	*0*	*0*	*0*	*0*	*0*	*0*
			total		***19 146***	***38 617***	***57 763***	***19 805***	***35 981***	***55 785***

Table 9 *(continued)*

Service	Energy need (building level) (kW·h/an)	Generation output (building level) (kW·h/an)	Energy use per energy carrier (kW·h/an)		Weighted energy performance (kW·h/an)					
			Carrier		Step A			Final result		
			name	Amount	E_{Pren}	E_{Pnren}	E_{Ptot}	E_{Pren}	E_{Pnren}	E_{Ptot}
Ventilation			El grid	*5 471*	*2 735*	*10 942*	*13 677*	*2 549*	*10 195*	*12 743*
			El PV	*2 689*	*2 689*	*0*	*2 689*	*3 063*	*0*	*3 063*
			total		***5 425***	***10 942***	***16 366***	***5 611***	***10 195***	***15 806***
Humidification	*4 000*	*4 350*	El grid	*119*	*60*	*238*	*298*	*56*	*222*	*278*
			El PV	*59*	*59*	*0*	*59*	*67*	*0*	*67*
			Gas	*4 444*	*0*	*4 889*	*4 889*	*0*	*4 889*	*4 889*
			Env heat	*0*	*0*	*0*	*0*	*0*	*0*	*0*
			total		***118***	***5 127***	***5 245***	***122***	***5 111***	***5 233***
Dehumidification	*14 000*	*15 500*		f)	f)	f)	f)			
Domestic Hot Water	*10 000*	*12 500*	El grid	*466*	*233*	*931*	*1 164*	*217*	*868*	*1 084*
			El PV	*229*	*229*	*0*	*229*	*261*	*0*	*261*
			Gas	*13 889*	*0*	*15 278*	*15 278*	*0*	*15 278*	*15 278*
			Solar	*0*	*0*	*0*	*0*	*0*	*0*	*0*
			Env heat	*0*	*0*	*0*	*0*	*0*	*0*	*0*
			total		***462***	***16 209***	***16 671***	***478***	***16 145***	***16 623***
Lighting			El grid	*24 136*	*12 068*	*48 272*	*60 340*	*11 244*	*44 976*	*56 220*
			El PV	*11 864*	*11 864*	*0*	*11 864*	*13 512*	*0*	*13 512*
			total		***23 932***	***48 272***	***72 204***	***24 756***	***44 976***	***69 732***
Total					*53 135*	*239 104*	*292 239*			
Exported energy			El PV	*3 659*	*3 659*	*0*	*3 659*	*0*	*0*	*0*
Total								***54 964***	***231 787***	***286 751***

Comments to Table 9:

— the carriers are identified with the following codes:

— El_PV: electricity from photovoltaic;

— El_grid: electricity delivered from grid;

— Gas: natural gas;

— Env_heat: heat captured from the environment by a heat pump;

— Solar: thermal solar energy;

— photovoltaic and grid electricity include auxiliary energy for the relevant service;

— humidification is included in heating;

— the final result of resources attributed to the exported is zero because exported energy is already accounted in the energy performance (k_{exp}=1,0, see also Table 11).

The same table is completed with each value divided by the value of E_{we} in order to obtain a quantitative overview of the relative impact of the individual elements.

Table 10 — Overview of the total energy performance and the composition per energy carrier and building service; in percentage of the EP

Service	Energy need (building level) (kW·h/an)	Generation output (building level) (kW·h/an)	Energy use per energy carrier (% of each carrier)		Weighted energy performance (% of total step A and total step B)					
			Carrier		Step A			Final result		
			name	Amount	E_{Pren}	E_{Pnren}	E_{Ptot}	E_{Pren}	E_{Pnren}	E_{Ptot}
Heating	*90 000*	*97 830*	El grid	*7,6%*	*3,8%*	*3,4%*	*3,5%*	*3,5%*	*3,3%*	*3,3%*
			El PV	*7,6%*	*3,8%*	*0,0%*	*0,7%*	*4,2%*	*0,0%*	*0,8%*
			Gas	*84,7%*	*0,0%*	*46,7%*	*38,2%*	*0,0%*	*48,2%*	*39,0%*
			Env heat	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*
			total		**7,6%**	**50,2%**	**42,4%**	**7,6%**	**51,5%**	**43,1%**
Cooling	*70 000*	*77 800*	El grid	*36,0%*	*18,2%*	*16,2%*	*16,5%*	*16,4%*	*15,5%*	*15,7%*
			El PV	*36,0%*	*17,9%*	*0,0%*	*3,2%*	*19,7%*	*0,0%*	*3,8%*
				0,0%	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*
			total		**36,0%**	**16,2%**	**19,8%**	**36,0%**	**15,5%**	**19,5%**
Ventilation			El grid	*10,2%*	*5,1%*	*4,6%*	*4,7%*	*4,6%*	*4,4%*	*4,4%*
			El PV	*10,2%*	*5,1%*	*0,0%*	*0,9%*	*5,6%*	*0,0%*	*1,1%*
			total		**10,2%**	**4,6%**	**5,6%**	**10,2%**	**4,4%**	**5,5%**
Humidification	*4 000*	*4 350*	El grid	*0,2%*	*0,1%*	*0,1%*	*0,1%*	*0,1%*	*0,1%*	*0,1%*
			El PV	*0,2%*	*0,1%*	*0,0%*	*0,0%*	*0,1%*	*0,0%*	*0,0%*
			Gas	*3,7%*	*0,0%*	*2,0%*	*1,7%*	*0,0%*	*2,1%*	*1,7%*
			Env heat	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*
			total		**0,2%**	**2,1%**	**1,8%**	**0,2%**	**2,2%**	**1,8%**
Dehumidification	*14 000*	*15 500*								

Table 10 *(continued)*

Service	Energy need (building level) (kW·h/an)	Generation output (building level) (kW·h/an)	Energy use per energy carrier (% of each carrier)		Weighted energy performance (% of total step A and total step B)					
			Carrier		Step A			Final result		
			name	Amount	E_{Pren}	E_{Pnren}	E_{ptot}	E_{Pren}	E_{Pnren}	E_{ptot}
Domestic Hot Water	*10 000*	*12 500*	El grid	*0,9%*	*0,4%*	*0,4%*	*0,4%*	*0,4%*	*0,4%*	*0,4%*
			El PV	*0,9%*	*0,4%*	*0,0%*	*0,1%*	*0,5%*	*0,0%*	*0,1%*
			Gas	*11,6%*	*0,0%*	*6,4%*	*5,2%*	*0,0%*	*6,6%*	*5,3%*
			Solar	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*
			Env heat	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*
			total		**0,9%**	**6,8%**	**5,7%**	**0,9%**	**7,0%**	**5,8%**
Lighting			El grid	*45,0%*	*22,7%*	*20,2%*	*20,6%*	*20,5%*	*19,4%*	*19,6%*
			El PV	*45,0%*	*22,3%*	*0,0%*	*4,1%*	*24,6%*	*0,0%*	*4,7%*
			total		**45,0%**	**20,2%**	**24,7%**	**45,0%**	**19,4%**	**24,3%**
Others			**Total**		**0**	**0**	**0**	**0**	**0**	**0**
Total					**100,0%**	**100,0%**	**100,0%**			
Exported energy			El PV	*13,9%*	**6,9%**	**0,0%**	**1,3%**	**0,0%**	**0,0%**	**0,0%**
Total								**100,0%**	**100,0%**	**100,0%**

Comments to Table 10

— Needs are reported as in Table 9 because there is no common reference for all services together.

— The percentage for the carriers are based on the total amount for each carrier independently (e.g. 7,6 % grid electricity for heating means that 7,6% of the total grid delivered electricity was used by heating).

— Percentages for step A and step B are referenced respectively to “Total step A” and “Total step B”.

— The exported weighted energy for step A is compared with the weighted energy used in the building. The sum of percentages use in the building is already 100%, the percentage for exported is an “extra”.

— The exported weighted energy for step B is zero because it is already evaluated into the energy performance of the building (k_{exp}=1,0).

Table 11 — Overview of the total energy performance and the overall energy balance per energy carrier

Overall energy balance	WE	Delivered weighted energy (Unit/an)			Weighted energy resources attributed to exported energy (Unit/an)		Exported energy, not valorized in the energy performance (Unit/an)	
Step A, with exported energy not valorized		**Electricity**	**Other energy carriers cr,*i* (summed)**	**Total**	**Attributed to exported electricity**	**Attributed to exported thermal energy**	**Electricity**	**Thermal energy**
	E_{Pren}	*53 135*	*0*	***53 135***	*3 659*	*0*	*3 659*	*0*
	E_{Pnren}	*107 174*	*131 930*	***239 104***	*0*	*0*		
	E_{ptot}	*160 309*	*131 930*	***292 239***	*3 659*	*0*		
k_{exp}		*1,0*	← Fraction of exported energy valorized in the energy performance					
Exported energy valorized in the energy performance (k_{exp})		**Weighted energy performance (Unit/ an)**			**Weighted energy resources attributed to exported energy (Unit/ an)**		**Exported energy (kW·h / an)**	
		Electricity	**Other energy carriers cr,*i* (summed)**	**Total**	**Attributed to exported electricity**	**Attrib. to exported thermal energy**	**Electricity**	**Thermal energy**
	E_{Pren}				*-1 829*	*0*	*3 659*	*0*
	E_{Pnren}				*7 318*	*0*		
	E_{ptot}				*5 488*	*0*		
Step A+B: with exported energy valorized	E_{Pren}	*51 305*	*0*	***51 305***				
	E_{Pnren}	*99 857*	*131 930*	***231 787***				
	E_{ptot}	*151 162*	*131 930*	***283 092***				
Exported energy available (not valorized in the energy performance), (1 - k_{exp})					**Weighted energy resources attributed to exported energy (Unit/an)**		**Exported energy (kW·h /an)**	
	E_{Pren}				*0*	*0*	*0*	*0*
	E_{Pnren}				*0*	*0*		
	E_{ptot}				*0*	*0*		

Table 12 — Renewable energy ratio

Energy balance terms	Included	Value (kW·h/an)
$E_{\mathrm{Pren,onst}}$	Yes	30 000
$E_{\mathrm{Pren,nrby}}$	*Yes*	0
$E_{\mathrm{Pren,dist}}$	*No*	24 964
$E_{\mathrm{Pren,RER}}$		30 000
E_{Ptot}		286 751
RER		**0,105**

12.2.1.2 Example 2: residential house

Table 13 — Overview of the total energy performance and the composition per energy carrier and building service; absolute values

Service	Energy need (building level) (kW·h/an)	Energy use per energy carrier (kW·h/an)		Weighted energy performance (kW·h/an)					
		Carrier		Step A			Final result		
		name	Amount	E_{Pren}	E_{Pnren}	E_{ptot}	E_{Pren}	E_{Pnren}	E_{ptot}
Heating	*3 000*	El grid	*0*	*0*	*0*	*0*	*-193*	*-771*	*-964*
		El PV	*190*	*190*	*0*	*190*	*575*	*0*	*575*
		Gas	*3 166*	*0*	*3 482*	*3 482*	*0*	*3 482*	*3 482*
		Env heat	*0*	*0*	*0*	*0*	*0*	*0*	*0*
		total		***190***	***3 482***	***3 672***	***383***	***2 712***	***3 094***
Cooling	*960*	El grid	*0*	*0*	*0*	*0*	*-459*	*-1 837*	*-2 296*
		El PV	*453*	*453*	*0*	*453*	*1 371*	*0*	*1 371*
			0	*0*	*0*	*0*	*0*	*0*	*0*
		total		***453***	***0***	***453***	***912***	***-1 837***	***-925***
Ventilation		El grid	*0*	*0*	*0*	*0*	*-497*	*-1 987*	*-2 484*
		El PV	*490*	*490*	*0*	*490*	*1 483*	*0*	*1 483*
		total		***490***	***0***	***490***	***986***	***-1 987***	***-1 001***
Humidification	*0*	El grid	*0*	*0*	*0*	*0*	*0*	*0*	*0*
		El PV	*0*	*0*	*0*	*0*	*0*	*0*	*0*
		Gas	*0*	*0*	*0*	*0*	*0*	*0*	*0*
		Env heat	*0*	*0*	*0*	*0*	*0*	*0*	*0*
		total		***0***	***0***	***0***	***0***	***0***	***0***
Dehumidification	*360*								

Table 13 *(continued)*

Service	Energy need (building level) (kW·h/an)	Energy use per energy carrier (kW·h/an)		Weighted energy performance (kW·h/an)					
		Carrier		Step A			Final result		
		name	Amount	E_{Pren}	E_{Pnren}	E_{ptot}	E_{Pren}	E_{Pnren}	E_{ptot}
Domestic Hot Water	*1 800*	El grid	*0*	*0*	*0*	*0*	*-57*	*-228*	*-285*
		El PV	*56*	*56*	*0*	*56*	*170*	*0*	*170*
		Gas	*1 125*	*0*	*1 238*	*1 238*	*0*	*1 238*	*1 238*
		Solar	*1 238*	*1 238*	*0*	*1 238*	*1 238*	*0*	*1 238*
		Env heat	*0*	*0*	*0*	*0*	*0*	*0*	*0*
		total		***1 294***	***1 238***	***2 531***	***1 351***	***1 009***	***2 360***
Lighting		El grid	*0*	*0*	*0*	*0*	*0*	*0*	*0*
		El PV	*0*	*0*	*0*	*0*	*0*	*0*	*0*
		total		***0***	***0***	***0***	***0***	***0***	***0***
Others		**Total**		*0*	*0*	*0*	*0*	*0*	*0*
Total				*2 426*	*4 720*	*7 146*			
Exported energy		El PV	*2 412*	*2 412*	*0*	*2 412*	*0*	*0*	*0*
Total							***3 632***	***-103***	***3 528***

The same table is completed with each value divided by the value of E_{we} in order to obtain a quantitative overview of the relative impact of the individual elements.

Table 14 — Overview of the total energy performance and the composition per energy carrier and building service; in percentage of the EP

Service	Energy need (building level) (kW·h/an)	Energy use per energy carrier (% of each carrier)		Weighted energy performance (% of total step A and total step B)					
		Carrier		Step A			Final result		
		name	Amount	E_{Pren}	E_{Pnren}	E_{ptot}	E_{Pren}	E_{Pnren}	E_{ptot}
Heating		El grid	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*-5,3%*	*746,6%*	*-27,3%*
		El PV	*5,3%*	*7,8%*	*0,0%*	*2,7%*	*15,8%*	*0,0%*	*16,3%*
		Gas	*73,8%*	*0,0%*	*73,8%*	*48,7%*	*0,0%*	*-3372,3%*	*98,7%*
		Env heat	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*
		total		**7,8%**	**73,8%**	**51,4%**	**10,5%**	**-2626%**	**87,7%**
Cooling		El grid	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*-12,6%*	*1778,7%*	*-65,1%*
		El PV	*12,6%*	*18,7%*	*0,0%*	*6,3%*	*37,8%*	*0,0%*	*38,9%*
			0,0%	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*
		total		**18,7%**	**0,0%**	**6,3%**	**25,1%**	**1778,7%**	**-26,2%**
Ventilation		El grid	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*-13,7%*	*1924,3%*	*-70,4%*
		El PV	*13,6%*	*20,2%*	*0,0%*	*6,9%*	*40,8%*	*0,0%*	*42,0%*
		total		**20,2%**	**0,0%**	**6,9%**	**27,2%**	**1924,3%**	**-28,4%**
Humidification		El grid	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*
		El PV	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*
		Gas	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*
		Env heat	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*
		total		**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**
Dehumidification									
Domestic Hot Water		El grid	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*-1,6%*	*221,1%*	*-8,1%*
		El PV	*1,6%*	*2,3%*	*0,0%*	*0,8%*	*4,7%*	*0,0%*	*4,8%*
		Gas	*26,2%*	*0,0%*	*26,2%*	*17,3%*	*0,0%*	*-1198,3%*	*35,1%*
		Solar	*100,0%*	*51,0%*	*0,0%*	*17,3%*	*34,1%*	*0,0%*	*35,1%*
		Env heat	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*
		total		**53,3%**	**26,2%**	**35,4%**	**37,2%**	**-977,3%**	**66,9%**

Table 14 *(continued)*

Service	Energy need (building level) (kW·h/an)	Energy use per energy carrier (% of each carrier)		Weighted energy performance (% of total step A and total step B)					
		Carrier		Step A			Final result		
		name	Amount	E_{Pren}	E_{Pnren}	E_{ptot}	E_{Pren}	E_{Pnren}	E_{ptot}
Lighting		El grid	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*
		El PV	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*
		total		**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**
Total step A				**100,0%**	**100,0%**	**100,0%**			
Exported energy		El PV	*67,0%*				**0,0%**	**0,0%**	**0,0%**
Total step B							**100,0%**	**100,0%**	**100,0%**

Table 15 — Overview of the total energy performance and the overall energy balance per energy carrier

Overall energy balance	**WE**	**Delivered weighted energy (Unit/ an)**			**Weighted energy resources attributed to exported energy (Unit/an)**		**Exported energy, not valorized in the energy performance (Unit/an)**	
Step A, with exported energy not valorized		**Electricity**	**Other energy carriers cr,*i* (summed)**	**Total**	**Attributed to exported electricity**	**Attributed to exported thermal energy**	**Electricity**	**Thermal energy**
	E_{Pren}	*1 188*	*1 238*	***2 426***	*2 412*	*0*	*2 412*	*0*
	E_{Pnren}	*0*	*4 720*	***4 720***	*0*	*0*		
	E_{ptot}	*1 188*	*5 957*	***7 146***	*2 412*	*0*		
k_{exp}		*1,0*	← Fraction of exported energy valorized in the energy performance					
Exported energy valorized in the energy performance (k_{exp})		**Weighted energy performance (Unit/an)**			**Weighted energy resources attributed to exported energy (Unit/an)**		**Exported energy (kW·h/an)**	
		Electricity	**Other energy carriers cr,*i* (summed)**	**Total**	**Attributed to exported electricity**	**Attrib. to exported thermal energy**	**Electricity**	**Thermal energy**
	E_{Pren}				*-1 206*	*0*	*2 412*	*0*
	E_{Pnren}				*4 823*	*0*		
	E_{ptot}				*3 617*	*0*		
Overall energy balance		**Delivered weighted energy (Unit/an)**			**Weighted energy resources attributed to exported energy (Unit/an)**		**Exported energy, not valorized in the energy performance (Unit/an)**	
Step A+B: with exported energy valorized	E_{Pren}	*-17*	*1 238*	***1 220***				
	E_{Pnren}	*-4 823*	*4 720*	***-103***				
	E_{ptot}	*-4 841*	*5 957*	***1 117***				
Exported energy available (not valorized in the energy performance), (1 - k_{exp})					**Weighted energy resources attributed to exported energy (Unit/an)**		**Exported energy (kW·h/an)**	
	E_{Pren}				*0*	*0*	*0*	*0*
	E_{Pnren}				*0*	*0*		
	E_{ptot}				*0*	*0*		

Comments to Table 15

— The difference between step A and final result (step B) in this example shows the high potential impact of incorporating exported energy into the energy performance of the building.

Table 16 — Renewable energy ratio

Energy balance terms	Included	Value (kW·h/an)
$E_{\text{Pren,onst}}$	Yes	4 838
$E_{\text{Pren,nrby}}$	*Yes*	0
$E_{\text{Pren,dist}}$	*No*	-1 206
$E_{\text{Pren,RER}}$		4 838
E_{Ptot}		3 528
RER		**1,371**
NOTE See Annex B for the energy sources that are or are not taken into account		

It may also be helpful to present diagrams as presented in Figure 15 of 11.6.2.

13 Additional information to the over-arching EPB standard

13.1 Worked out examples

The demonstration of the calculation method of ISO 52000-1 [1] is given with a number of simplified examples intended to highlight all features independently for clarity.

So, the following examples are supplied in Annex J:

— a series of examples focused on the primary energy weighting (Clause J.2);

— an example dealing mostly with the identification of delivered and exported energy components (Clause J.3).

— an example of the procedure to get the energy performance for part of the building or a part of the services (Clause J.4).

Each example includes an introduction, a detailed calculation procedure and comments.

A comprehensive example is available in the accompanying spreadsheet.

13.2 Application range

ISO 52000-1 applies the energy performance calculation for any purpose.

The differences between design, standard and tailored assessment are all handled in the underlying standards. The parameters used in ISO 52000-1 are not depending on the application.

13.3 Regulation use

Energy performance indicators and partial performance indicators are calculated:

— to determine a class, by comparison with a scale;

— to check compliance with legal requirements, by comparison with values defined in legal documents or in legally enforced documents.

Depending on the choice of the values of the parameters given in ISO 52000-1 (weighting factors, k_{exp} factor), the results may be deeply influenced depending on the building and technical system typology. It is essential that these values are set and taken into account when deciding any legal requirement depending on them.

The effect of the choices of the parameters are illustrated in the relevant clauses.

13.4 Validation test

The procedure in the overarching EPB standard has been tested with spreadsheets. The expected values are obtained in the examples.

The overarching EPB standard only deals with a final accounting and is independent from product characteristics, so there is no need to perform any validation test other than mathematical correctness.

13.5 Quality issues

The procedure described in this standard is a pure mathematical accounting procedure. So there is no reproducibility question.

Primary energy factors are embedded in the database of any application software. Even if they should be input manually, the time for data input would be negligible.

Annex A
(informative)

Input and method selection data sheet — Template

A.1 General

In ISO 52000-1, this Annex is normative.

This subclause is a common subclause for all EPB standards.

In this document, more information and explanation on the concept of Annex A and Annex B is given.

Annex A and Annex B give a structure to separate the harmonized procedures from the national or regional options, boundary conditions, input data and references to other EPB standards. In the set of EPB standards this is being achieved by the following set up:

Each EPB standard has the following two Annexes:

— Annex A (normative): mandatory (empty) framework template for choices and input data and references to other EPB standards

— Annex B (informative): framework template of Annex A completed with one set of voluntary **default choices** and input data and references to other EPB standards.

In general each individual user of the EPB standard is free to create his/her own data sheet according to the template of Annex A (i.e.: to replace the default choices and values of Annex B). But:

— For instance private parties can mutually agree (private contract) to use any specific set of choices and values (a completed data sheet according to the template of Annex A) for the assessment of the energy performance for their private use;

— In addition e.g. (national or regional) authorities can mandatory prescribe a specific set of choices and values (a specific data sheet according to the template of Annex A, replacing the default choices and input values of Annex B) for the assessment of the energy performance in the context of their building regulations (or different sets, depending on the application).

  — published via the National Standardization Body[4)];

  — embed as a completed data sheet according to the template of Annex A in the building regulations.

See also the introduction on the default options in B.1.

The content of ISO 52000-1:2017, Annex A covers the template for the choices related to the procedures provided in that standard.

A national/regional/sectoral application document based on this annex may contain a reference to a national/regional/sectoral assessment protocol. Such a (typically mandatory) assessment protocol is particularly relevant in case of existing buildings. It gives guidance (per component and per type and age of construction) on:

— Which types of proof are accepted (visual inspection?, design drawings?, detailed specs?, specified invoices?, certified quality declarations?).

4) In CEN terms, such a document is preferably published as a “National Annex” to the CEN standard.

— If no (acceptable) proof is available: the default input values, usually differentiated, for instance a function of type of construction or system and the year of construction or installation, including sometimes complex decision trees (conditional choices: if-then-else) and could include pre-calculations, involving supporting data (geometrical data, conditions, …).

— The decision trees and the values for the successive classes of years typically take into account the building tradition, history of building regulations and state of implementation of new technologies.

Such protocol is typically related to the national (sometimes regional, possibly specific for certain sectors) context: to the acceptable assessment time, to the impact on the overall energy performance (climate, energetic quality) and to the EP certification infrastructure, which includes the level of expertise of the assessors and the quality control.

NOTE If the reference is undated, the national datasheet according to the template of Annex A does not have to be adjusted each time the content of such national procedures (protocols) for the assessment of input data is revised.

A.2 References

This subclause in ISO 52000-1 is a common subclause for all EPB standards.

If ISO 52000-1 is adopted (e.g. in national regulations), then also all the normative references (in Clause 2) to other Standards are adopted, including the (referenced parts of the) Standards that are not or not yet published or do not have a national data sheet yet. Sometimes this causes a problem.

To solve this, the references to EPB Standards are placed in the input and method selection data sheet. In the normative Annex A, the template for the normative references to other EPB standards is given (Table A.1), and the default references (in casu: the EPB Standards) are provided in the informative Annex B (Table B.1), according to the template in Annex A.

These informative default choices can be replaced by a national datasheet according to the template in Annex A, replacing the references in Annex B. This national data sheet can replace the default choices with references to national standards, that are in line with the set of EPB standards, or to tables or with other alternatives. However: this can only be done if the input-output matches!

A.3 Overarching preparation steps

The identifiers are very important: these define the object, application, building (and/or space) category etc. which are conveyed to several other EPB standards.

See discussion in Clause 3 on the subject of building and space categories.

See examples in 6.2.2.

A.4 Method

In ISO 52000-1:2017, Annex A, the clause numbers behind the table titles refer to the clause(s) where the tables are mentioned. In the corresponding clauses of this document additional information can be found.

Additional information on the metric for the building size can be found in ISO 52003-1[8].

Annex B
(informative)

Input and method selection data sheet — Default choices

B.1 General

This subclause in ISO 52000-1 is a common subclause for all EPB standards.

In this document more information and explanation on the concept of Annex A and Annex B is given. See also the introduction to the concept of Annex A and Annex B given in A.1.

Annex B provides one complete set of voluntary (“Informative”) choices for all options, boundary conditions and input data. This is called the set of default choices.

These choices and values have the status of “experts best guess” and are not based on extensive studies involving national preferences and limitations[5)].

By using Annex B, the procedure to calculate the overall energy performance becomes fully operational. This set can be adopted by any individual country or region as their national or regional set of choices.

This set is also intended as stimulus for further harmonization. The use of Standards with a common set of choices, input data and references to other EPB standards, facilitates the comparison of best practise by establishing a common metrics.

To provide flexibility in the application of the set of EPB standards, clearly identified options and national data remain necessary due to differences in climate, culture and building tradition, building typologies, policy and legal frameworks (including the type and level of quality control and enforcement). For example, climatic data is expected to be defined on a national and/or regional level in a national input data sheet.

Complementary to the assessment procedures in the set of EPB standards, there is a need for (national) assessment protocols that give practical guidance for the assessors in case of gathering of input data from the building as constructed or in the use phase. Such a (typically mandatory) assessment protocol gives guidance (per component and per type and age of construction) on:

— Which types of proof are accepted (visual inspection?, design drawings?, detailed specs?, specified invoices?, certified quality declarations?).

— If no (acceptable) proof is available: the default input values, usually differentiated, for instance a function of type of construction or system and the year of construction or installation, including sometimes complex decision trees (if-then-else).

— The decision trees and the values for the successive classes of years need to take into account the building tradition, history of building regulations and state of implementation of new technologies.

This is again directly related to the regulatory context: the acceptable assessment time, to the impact on the overall energy performance (climate, energetic quality) and to the EP certification infrastructure, which includes the level of expertise of the assessors and the quality control.

NOTE 1 See also the explanation in 3.7, on national specification of certain defined or undefined terms.

This is illustrated in Figure B.1.

5) For instance, it prepares the ground for the voluntary common European Union certification scheme.

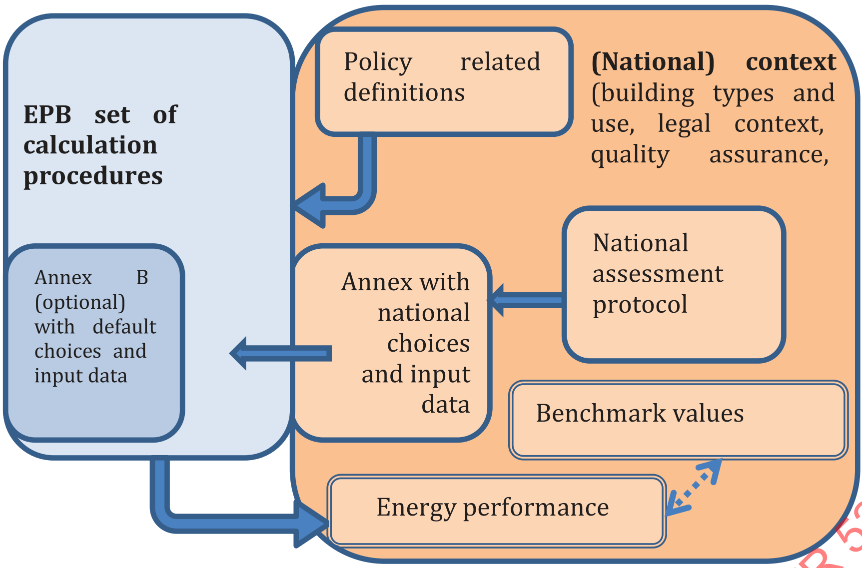


Figure B.1 — Illustration of link between set of EPB standards and national context

The content of ISO 52000-1:2017, Annex B covers the default options for the procedures provided in that document.

B.2 References

This subclause in ISO 52000-1 is a common subclause for all EPB standards.

The references, identified by the module code number, are given in ISO 52000-1:2017, Table B.1.

The references in Table B.1 represent the complete set of EPB standards. They are not all referenced in the overarching EPB standard, but are meant as a helpful overview. They represent the full set of EPB standards at the time of publication. Over time additional EBPB standards may be published or existing ones withdrawn.

It is possible for each module to replace an EPB standard with a national standard or even a table with fixed input and output values, as long as all input and output data from the replaced standard are available. The input and output data can be found in Clause 6 of each EPB standard.

For more information see A.2.

Table B.1 shows the detailed modular structure filled with the numbers of the ISO and European EPB standards.

Table B.1 — Positions of EPB standards in the EPB modular structure

Overarching			Building (as such)			Technical Building Systems											
	DESC [b]	ST [c]		DESC [b]	ST [c]		DESC [b]	H	C	V	HUM	DHUM	W	L	BACS	EL
sub1	M1		sub1	M2		sub1		M3	M4	M5	M6	M7	M8	M9	M10	M11
1	*General*	ISO 52000-1 ISO/TR 52000-2	**1**	General	--	**1**	General	EN 15316-1	EN 16798-9 CEN/ TR 16798-10	EN 16798-3 (EN 13779 rev.) CEN/ TR 16798-4	EN 16798-3 (EN 13779 rev.) CEN/ TR 16798-4	EN 16798-3 (EN 13779 rev.) CEN/ TR 16798-4	EN 15316-1	EN 15193-1	EN 15232-1 CEN/ TR 15232-2	
2	Common terms and defini-tions; symbols, units and subscripts	ISO 52000-1 ISO/TR 52000-2	**2**	Building Energy Needs	ISO 52016-1, ISO 52017-1 ISO/TR 52016-2	**2**	Needs						EN 12831-3	prEN 15193-1	[a]	
3	Applica-tions	ISO 52000-1 ISO/TR 52000-2	**3**	(Free) Indoor Conditions without Systems	ISO 52016-1, ISO 52017-1 ISO/TR 52016-2	**3**	Maximum Load and Power	EN 12831-1	ISO 52016-1, ISO/ TR 52016-2				EN 12831-3			
4	Ways to Express Energy Perfor-mance	ISO 52003-1 ISO 52003-2	**4**	Ways to Express Energy Perfor-mance	ISO 52018-1 ISO/TR 52018-2	**4**	Ways to Express Energy Perfor-mance	EN 15316-1	EN 16798-9 CEN/ TR 16798-10	EN 16798-3 (EN 13779 rev.) CEN/ TR 16798-4	EN 16798-3 (EN 13779 rev.) CEN/ TR 16798-4	EN 16798-3 (EN 13779 rev.) CEN/ TR 16798-4	EN 15316-1	EN 15193-1 CEN/ TR 15193-2	EN 15232-1 CEN/ TR 15232-2	

Table B.1 *(continued)*

Overarching			Building (as such)			Technical Building Systems											
	DESC [b]	ST [c]		DESC [b]	ST [c]		DESC [b]	H	C	V	HUM	DHUM	W	L	BACS	EL
sub1	M1		sub1	M2		sub1		M3	M4	M5	M6	M7	M8	M9	M10	M11
5	Building Functions and Building Boundaries	ISO 52000-1 ISO/TR 52000-2	**5**	Heat Transfer by Transmission	ISO 13789 ISO 13370 ISO 6946 ISO 10211 ISO 14683 ISO/TR 52019-2 ISO 10077-1 ISO 10077-2 ISO 12631	**5**	Emission & control	EN 15316-2 EN 1500 CEN/ TR 15500 EN 12098-1 CEN/ TR 12098-1 EN 12098-3 CEN/ TR 12098-3 EN 12098-5 CEN/ TR 12098-5	EN 15316-2 EN 15500 CEN/ TR 15500	EN 16798-7 CEN/ TR 16798-8 EN 15500 CEN/ TR 15500	EN 16798-5-1; EN 16798-5-2 CEN/ TR 16798-6-1 CEN/ TR 16798-6-2	EN 16798-5-1; EN 16798-5-2 CEN/ TR 16798-6-1 CEN/ TR 16798-6-2			EN 15232-1 CEN/ TR 15232-2	
6	Building Occupancy and Operating Conditions	EN 16798-1 CEN/ TR 16798-2 [ISO 17772-1, ISO/TR 17772-2 (to be published)]	**6**	Heat Transfer by Infiltration and Ventilation	ISO 13789	**6**	Distribution & control	EN 15316-3 EN 12098-1 CEN/ TR 12098-1 EN 12098-3 CEN/ TR 12098-3 EN 12098-5 CEN/ TR 12098-5	EN 15316-3	EN 16798-5-1; EN 16798-5-2 CEN/ TR 16798-6-1 CEN/ TR 16798-6-2			EN 15316-3		EN 15232-1 CEN/ TR 15232-2	

Table B.1 *(continued)*

Overarching			Building (as such)			Technical Building Systems											
	DESC [b]	ST [c]		DESC [b]	ST [c]		DESC [b]	H	C	V	HUM	DHUM	W	L	BACS	EL
sub1	M1		sub1	M2		sub1		M3	M4	M5	M6	M7	M8	M9	M10	M11
7	Aggre-gation of Energy Servic-es and Energy Carriers	ISO 52000-1 ISO/TR 52000-2	7	Internal Heat Gains	See M1-6	7	Storage & control	EN 15316-5 EN 12098-1 CEN/TR 12098-1 EN 12098-3 CEN/TR 12098-3 EN 12098-5 CEN/TR 12098-5	EN 16798-15 CEN/TR 16798-16				EN 15316-5 EN 15316-4-3		EN 15232-1 CEN/TR 15232-2	

Table B.1 *(continued)*

Overarching			Building (as such)			Technical Building Systems											
	DESC [b]	ST [c]		DESC [b]	ST [c]		DESC [b]	H	C	V	HUM	DHUM	W	L	BACS	EL
sub1	M1		sub1	M2		sub1		M3	M4	M5	M6	M7	M8	M9	M10	M11
8	Building Zoning	ISO 52000-1 ISO/TR 52000-2	8	Solar Heat Gains	ISO 52022-3 ISO 52022-1 ISO/TR 52022-2	8	Generation & control	EN 12098-1 CEN/TR 12098-1 EN 12098-3 CEN/TR 12098-3 EN 12098-5 CEN/TR 12098-5 EN 15316-4-1 EN 15316-4-2 EN 15316-4-3 EN 15316-4-4 EN 15316-4-5 EN 15316-4-6 EN 15316-4-8	EN 16798-13 CEN/TR 16798-14 EN 15316-4-2 EN 15316-4-5	EN 16798-5-1; EN 16798-5-2 CEN/TR 16798-6-1 CEN/TR 16798-6-2	EN 16798-5-1; EN 16798-5-2 CEN/TR 16798-6-1 CEN/TR 16798-6-2	EN 16798-5-1; EN 16798-5-2 CEN/TR 16798-6-1 CEN/TR 16798-6-22	EN 15316-4-1 EN 15316-4-2 EN 15316-4-3 EN 15316-4-4 EN 15316-4-5 EN 15316-4-6		EN 15232-1 CEN/TR 15232-2	EN 15316-4-3 EN 15316-4-4 EN 15316-4-5 EN 15316-4-7
9	Calculated Energy Perfor-mance	ISO 52000-1 ISO/TR 52000-2	9	Building Dynamics (thermal mass)	ISO 13786	9	Load dispatch-ing and operating conditions								EN 15232-1 CEN/TR 15232-2	

Table B.1 *(continued)*

Overarching			Building (as such)			Technical Building Systems										
	DESC [b]	ST [c]		DESC [b]	ST [c]		DESC [b]	H	C	V	HUM	DHUM	W	L	BACS	EL
sub1	M1		sub1	M2		sub1		M3	M4	M5	M6	M7	M8	M9	M10	M11
10	Measured Energy Perfor-mance	ISO 52000-1 ISO/TR 52000-2	**10**	Measured Energy Perfor-mance	- -	**10**	Measured Energy Perfor-mance	EN 15378-3					EN 15378-3	EN 15193-1 CEN/ TR 15193-2	EN 15232-1 CEN/ TR 15232-2	
11	Inspection	- -	**11**	Inspection	(existing standards on IR inspection, airtightness, ...)	**11**	Inspection	EN 15378-1	EN 16798-17 CEN/ TR 16798-18	EN 16798-17 CEN/ TR 16798-18	EN 16798-17 CEN/ TR 16798-18	EN 16798-17 CEN/ TR 16798-18	EN 15378-1	EN 15193-1 CEN/ TR 15193-2	WI 00247092	
12	Ways to Express Indoor Comfort	EN 16798-1 CEN/ TR 16798-2 (ISO 17772-1, ISO/TR 17772-2)	**12**	--		**12**	BMS								WI 00247093	
13	External Environ-ment Con-ditions	ISO 52010-1 ISO/TR 52010-2														
14	Economic Calcula-tion	EN 15459-1														

[a] The shaded modules are not applicable.

[b] DESC = Description.

[c] ST = Standard reference.

B.3 Overarching preparation steps

See discussion in Clause 3 of this document on the subject of building and space categories.

See examples in 6.2.2 of this document.

B.4 Method

In ISO 52000-1:2017, Annex B, the clause numbers behind the table titles refer to the clause(s) where the tables are mentioned. In the corresponding clauses of this document additional information can be found.

Additional information report on the subject of floor area and metric for building size can be found in ISO 52003-1[8].

The values in ISO 52000-1:2017, Table B.25 are taken from DIN V 18599-1[15].

The values in ISO 52000-1:2017, Table B.16 are aligned, where possible, with (European) regulations. The values for electricity can be found in the latest version of the EED, at the time of printing this was Annex IV of Directive 2012/27/EU.

See J.3.4 for a rationale of the proposed matching factor function in ISO 52000-1:2017, Table B.32 and its controlling parameters.

Annex C
(informative)

Common subscripts

C.1 General

ISO 52000-1:2017, Annex C is mainly addressed to the writers of each EPB standard. It states rules to be followed when naming values.

The EPB standards involve a very large number of quantities and their associated symbols. ISO 52000-1 incorporates a set of common symbols and subscripts.

ISO 52000-1:2017, Annex C contains the rules to generate all the subscripts needed to identify the energy items within a building and its technical systems. This includes:

— a definition of levels of subscripts and rules to combine them;

— a table of basic subscripts;

— further levels of subscripts; and

— other common subscripts.

It is important to consider systematically renewable/non-renewable primary energy and delivered/exported energy when calculating the energy performance and other complementary indicators of buildings. A distinction is made between energy quantities inside and outside the assessment boundary.

General drafting rules for standards state that "*as far as possible, symbols having more than one level of subscript or superscript (see Example 1) shall be avoided*". This circumstance cannot be avoided in the set of EPB standards. There are hundreds of energy and temperature quantities that need all be named with a unique symbol. Therefore a logical and consistent structure for subscripts is defined in the following.

The following characters are used in EPB standards to separate subscripts and to identify running indexes, e.g. subscripts that are identifying one element in the array:

— the regular separator between levels of subscripts is the semicolon ";"

— the separator before an index for an array is the comma ","

EXAMPLE to indicate the input to the heating generator: $Q_{\mathrm{H;gen;in}}$

EXAMPLE to indicate the input to the heating generator i: $Q_{\mathrm{H;gen},i;\mathrm{in}}$

The letters "i", "j" and "k" are used to represent indexes in the arrays.

C.2 Common subscripts

C.2.1 Order of subscripts

The general requirement is to have subscripts in the order (level) from the most general to the most detailed.

The order of subscripts is indicated in the headings of columns of ISO 52000-1:2017, Tables C.1 to C.5.

C.2.2 Rule for omitting a level if not applicable

Higher level subscripts may be omitted in symbols that are used only locally, e.g. they are not used or referenced in other standards of the set of EPB standards.

EXAMPLE The linear heat loss coefficient of a pipe of the heating distribution system can have the symbol Ψ (all levels omitted) instead of $\Psi_{\mathrm{H;dis;ls}}$.

The typical reference is for calculation purpose. Quantities may be referenced for reporting purpose as well. Therefore subscripts levels should not be omitted for quantities that are likely to be displayed in reports to avoid duplicate symbols.

EXAMPLE A load factor may be referenced for reporting purpose or to get an approximate value in another subsystem.

See also C.2.4.

C.2.3 Rule for omitting a level if obvious from context

Levels may be omitted only if the quantity is not used or referenced in other standards of the set of EPB standards.

See also C.2.4.

C.2.4 Local quantities

This rule asked for a common prefix for all local quantities. This rule has not been always respected.

The advantage of respecting this rule is avoiding any possible duplication of symbols.

The disadvantage of respecting this rule is longer symbols.

The risk in overriding this rule is duplicate symbols if any of the local quantities is referenced in another standard of the set of EPB standards.

C.2.5 Common quantities

Common quantities follow the general rule to generate subscripts, without exception.

C.2.6 Terms for subscripts

C.2.6.1 General

The overarching EPB standard identifies common subscripts for four main calculation and symbol domains:

— building needs balance, where the first subscript is the service (H, C, W, ...) and then the balance item is specified. See ISO 52000-1:2017, Table C.1;

— technical systems, where the first subscript is the service (H, C, W, ...) again and the following levels are the subsystem, the balance item within the subsystem and further specifications. See ISO 52000-1:2017, Table C.2;

— interactions across the assessment boundary, un-weighted energy. See ISO 52000-1:2017, Table C.3;

— interactions across the assessment boundary, weighted energy. See ISO 52000-1:2017, Table C.4.

C.2.6.2 Subscripts for the building domain

The first subscript (H, C or W) is normally only relevant if the second subscript is "need''. Nevertheless, it could be relevant to make an explicit distinction between e.g. ventilation heat transfer in the heating mode and in the cooling mode.

EXAMPLE Normally Q_{ve} but exceptionally $Q_{C;ve}$.

Subscript B (for building) can be used to distinguish between quantities for the whole building and quantities for a conditioned zone. In the general case a subscript B is not necessary.

Needs are only defined for thermal energies (heating, cooling, DHW), but not for ventilation and lighting.

EXAMPLES

Energy need for heating:	$Q_{H;nd}$
Transmission and ventilation heat transfer:	Q_{ht}
Transmission heat transfer:	Q_{tr}
Ventilation heat transfer:	Q_{ve}

Total gains can be utilized or non-utilized. This can be specified at the third level.

EXAMPLES

Utilized gains:	$Q_{gn;ut}$
Non-utilized gains in zone 1:	$Q_{gn;nut;z1}$

C.2.6.3 Subscripts for the technical building systems domain

For each subsystem subscripts are needed for input, output, losses, and auxiliary energy.

Subscripts "hum" and "dhum" in level 2 (lower case) represent the humidification and dehumidification subsystems, not the humidification and dehumidification services (uppercase HU and DHU in level 1).

When there are several subsystems of the same type, this is indicated by an index added to the subscript.

Subscripts at the first level are combined when there are generation systems or distribution systems or emission systems, which are common to different uses.

EXAMPLE

The output of a generator for heating (H) and domestic hot water (W)	$Q_{HW;hen;out}$

The main input to a generator is not heat (Q) but an energy carrier such as:

— oil, gas, etc. for a boiler;

— electricity for a heat pump.

Therefore the symbol for the input to a generator is E not Q. See also 4.1.

For thermal system losses the subscript "sys" refers to the whole system for the use indicated. "gen", "dis", etc. refer to the generation system, the distribution system, etc., for the use indicated.

EXAMPLES

Energy input to a heat generator:	$E_{H;gen;in}$
Energy input to heat generator gen1 (part of energy use for heating):	$E_{H;gen,1;in}$
Auxiliary energy use for the whole heating system:	$W_{H;sys;aux}$
Heat output for heating of a heat generator:	$Q_{H;gen;out}$
Energy input to a common generator for heat and DHW:	$E_{HW;gen;in}$
Heat input into the common distribution subsystem 1 for heating and DHW:	$Q_{HW;dis,1;in}$
Recoverable part of the thermal losses of the whole heating system:	$Q_{H,sys,ls,rbl}$
Heat output of the distribution subsystem 1 for heating:	$Q_{H;dis,1;out}$
Heat output of solar water heater if renewable energy	$Q_{W;sol;out}$
Heat input into DHW distribution subsystem:	$Q_{W;dis;in}$
Energy (electricity) input to the entire lighting system:	$E_{L;sys}$
Energy (electrical) input to ventilation system:	E_{V}

C.2.6.4 Interactions across the assessment boundary

C.2.6.4.1 Un-weighted energy

These subscripts are indicated in ISO 52000-1:2017, Table C.3.

The first level indicates if the energy is delivered, exported, produced and/or used.

The second level indicates the type of energy carrier.

Level 3 is used for further qualifications of the energy flow according to the context such as:

— the related service,

— the origin of the energy carrier,

— the balance item.

The “cr” subscript is used in the sums to indicate a generic energy carrier.

EXAMPLES

Delivered gas for heating and domestic hot water	$E_{del;gas;HW}$
On-site produced electricity	$E_{pr;el;onst}$

C.2.6.4.2 Weighted energy

These subscripts are indicated in ISO 52000-1:2017, Table C.4.

The first level subscript indicates the type of weighting.

The “we” subscript is used to indicate a generic weighting criteria. Any formula where “we” is found can be interpreted as a formula that holds when “we” is replaced by any other subscripts for a defined weighting criterion, unless otherwise stated.

Renewable, non-renewable and total primary energy are three independent weighting criteria.

The second level can be one of the following:

— specification of the related un-weighted energy flow, which is done following the rules set out in ISO 52000-1:2017, Table C.3, including further sub-levels;

— specification of the origin or destination of the weighted energy flow;

— specification of the related service.

The second level is omitted when the result of the balance is reported.

NOTE EP is primary energy, expressed in (kW·h) (extensive property) whilst EP is the energy performance indicator expressed in (kW·h)/m² or similar (intensive property).

EXAMPLES

Total primary energy of delivered gas for heating and domestic hot water	$E_{\mathrm{Ptot;del;gas;HW}}$
CO_2 emission for heating	$E_{\mathrm{CO2;H}}$
Renewable primary of electricity delivered from nearby	$E_{\mathrm{Pren;del;el;nrby}}$
Non-renewable energy from delivered wood	$E_{\mathrm{Pnren;del;wd}}$

C.2.6.5 Further levels of subscripts

These are additional subscripts that can be appended to a subscript at any level, depending on the need to identify values for a specific context.

Subscripts referring to specific zoning are possible, like "hz" for heating zone or "vz" for ventilation zone. The "z" alone should be used only with thermal zones.

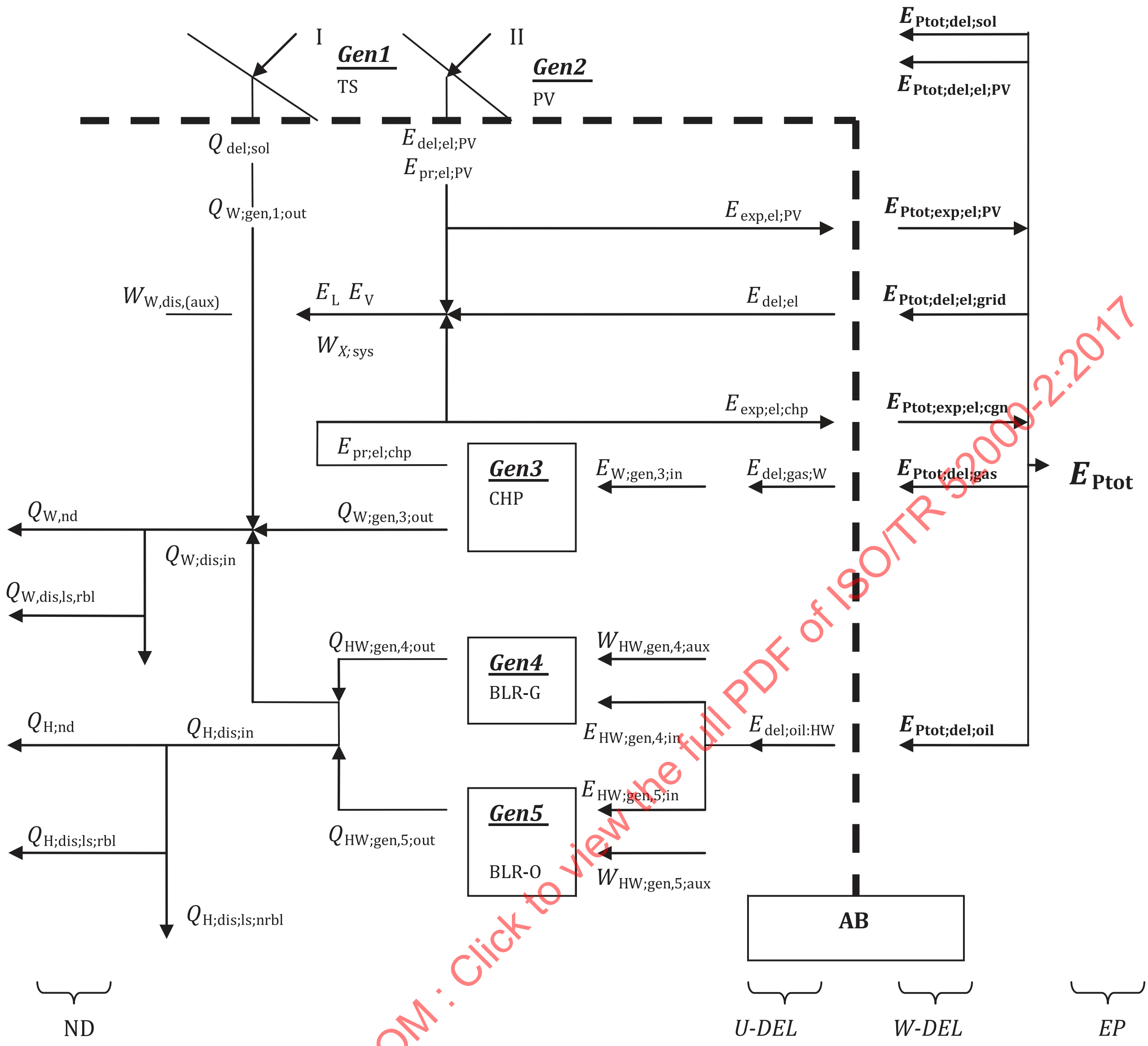
C.2.6.6 Other common subscripts

These are miscellaneous subscripts that are frequently used and therefore are uniform throughout the EPB standards.

They are indicated in this clause because they are not linked to some previously defined subscript structure.

C.2.6.7 Example of the use of subscripts

Figure C.1 is an example of the use of subscripts to name quantities in a complex technical system.



Key

CHP	combined heat and power	AB	assessment boundary
TS	thermal solar	ND	needs
PV	photovoltaic	U-DEL	un-weighted delivered energy
BLR-G	gas boiler	W-DEL	weighted delivered energy
BLR_O	oil boiler	EP	energy performance indicator

Figure C.1 — Example of the use of symbols and subscripts

C.3 Case identifiers

Case (and property) identifier is a type of symbols that handles options in a suitable form for software. Detailed rules are given in CEN/TS 16629[14].

“Case identifiers” indicate one possible value of a qualitative property indicated by a “property identifier”.

There are two main uses of case and property identifiers:

— specifying a value in a defined set, depending on a qualitative property;

— specifying an option influencing calculation procedure.

In the software implementation of the procedure will correspond respectively to:

— selecting a value from list;

— a condition for a programming structure, like conditions and loops (IF…THEN…ELSE, LOOP… UNTIL etc.).

The mnemonic code should be "self-speaking in English".

As an example of the use of identifiers, a calculation module could require the localization of an equipment item to decide which ambient temperature to use to calculate heat losses and to decide whether they are recovered or not.

If the equipment item is a boiler, a suitable code can be BLR. The additional code for localization can be LOC, so the property identifier code for boiler localization is: BLR_LOC.

Then the boiler could be installed externally, in the heated space, in an unheated space, etc. A code should be established for each case of the property. Since "int" and "ext" are already defined as subscripts, the same letters should be used for the mnemonic code of these two cases. An example of the possible resulting case identifiers is given in Table C.1:

Table C.1 — Sample identifiers for boiler localization

Code	Meaning
BLR_LOC_INT	Heated space
BLR_LOC_EXT	External (outdoors)
BLR_LOC_UNH	Unheated space
BLR_LOC_BLR	Boiler room

Using this type of identification whenever there are options or calculation alternatives helps transparency and enables to avoid loose ends in the procedure.

C.4 Abbreviations and codes to be used in connection with software

These abbreviations and codes are defined to give a first basis for standardization of the naming of quantities in the application software.

EXAMPLE Naming of quantities in XML files.

Annex D
(informative)

Calculation of measured energy performance

D.1 General

No additional information needed.

D.2 Buildings with delivered energy only

This will be the most common application.

D.3 Buildings with exported energy

No additional information needed

Annex E
(informative)

Calculation methods for energy performance indicators per part of a building and/or service

E.1 General

Annex E is referenced in ISO 52000-1:2017, 7.1, 7.4, 9.5.1, 9.9 and 11.2.

A separate indicator per building part or per service may be required for the following reasons :

— the layout of the energy certificate often includes energy needs, primary energy and CO_2 emissions per service;

— the layout of the certificate sometimes includes energy carriers per service;

— when heat cost allocation or individual metering is performed, the relevant information for the user is the energy performance of his building unit, that may differ strongly from that of the whole building.

Energy performance requirements are often specified for one service only (typically heating). The allocation of the overall energy performance to individual services and/or to parts of the building can be performed mathematically in two different ways that provide the same result:

— performing only one calculation but keeping a separate accounting of the energy related to each building service or building zone or "use item" that originated the calculation; this method is called "conventional counting".

— performing the calculation in two steps, this method is called "reverse calculation":

  — a first step going from the needs to the uses to get the overall performance (this is the usual EP calculation procedure);

  — a second step going from the uses back to the needs e.g. allocating the overall performance to the branches of the technical systems until the use items are reached again.

The two methods give the same results, provided that the general principles are correctly applied.

— The conventional accounting requires more variables because a separate accounting is kept for each individual use item.

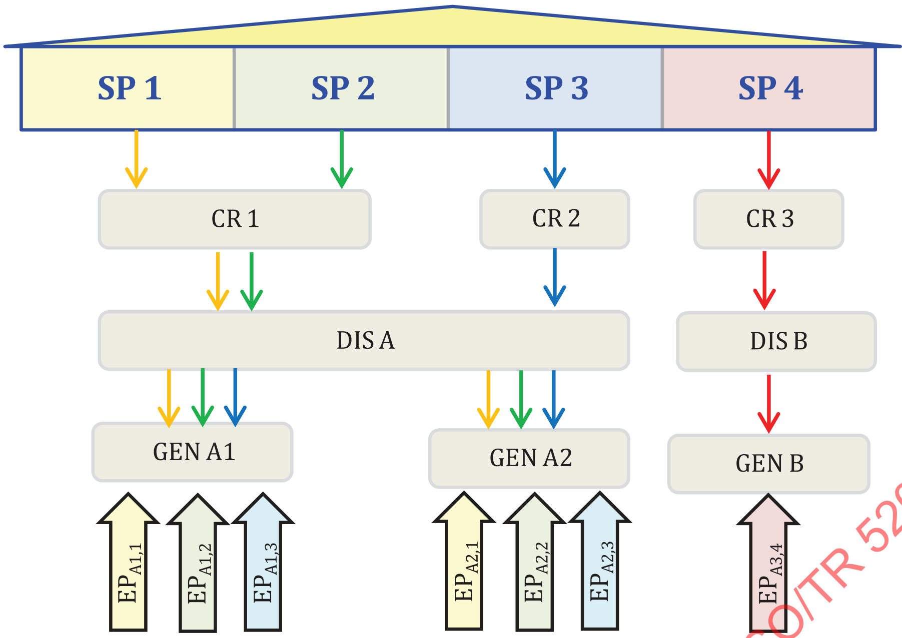
— The reverse calculation requires more calculations but uses less variables because energy required by partial services is aggregated and then disaggregated.

Selecting one of the two methods is only a question of available calculation resources.

E.2 Conventional accounting method

E.2.1 Principle

The principle of the conventional counting method is illustrated in Figure E.1. The arrows indicate the calculation process direction not the energy flow direction.



Key

SP X elementary space X

CR X circuit X

DIS X distribution collector (node) X

GEN X generator X

Figure E.1 — Principle of conventional accounting

At any calculation step, the energy flow is broken into components related to the connected parts: the output of generator A1 going to the distribution collector is broken into components related to the connected spaces, in this case spaces 1 to 3 (space 4 is not connected to generator A1 and A2).

E.2.2 Notation

This indexing of use items should be unique otherwise it is not easy to handle several services. In principle there is no difference between use items related to different services. One use item can also be one entire service.

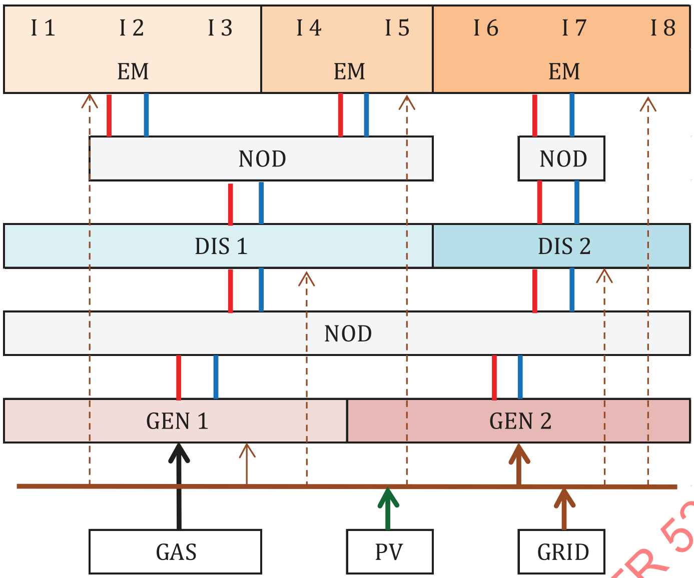
The use items are connected together in groups belonging to (heat/cold) emission subsystem, Then multiple (heat/cold) emission subsystems may be connected to one distribution. Then several distributions may be connected together and to several heat generators resulting in a tree with

— use items being the leaves;

— branches being subsystems;

— nodes being connection between subsystems.

The structure used in the example is repeated in Figure E.2.



Key

I X	use item X	GEN X	generation X
EM	emission and control subsystem	GAS	energy carrier gas
NOD	node	PV	energy carrier PV
DIS X	distribution X	GRID	energy carrier grid electricity

Figure E.2 — Sample complex technical system

Please note:

— the indexing of use items is 1…8;

— there are three (heat) emission and control subsystems, each connected to 2…3 use items;

— there are two distribution subsystems, one dedicated to one (heat) emission subsystem;

— both distribution are connected to two generators.

The example presented in K.4 has the same structure as in Figure E.2.

E.2.3 Calculation start

E.2.3.1 General

The general approach starting with the energy needs works for services like heating, cooling and domestic hot water, where the need is an energy.

The individual energy needs are used only to allocate the energy. For other services, the energy input to the subsystems are allocated according to other properties indicating the share of the services, considering the whole as a single subsystem.

EXAMPLE For ventilation the property identifying the share of service is the supplied air to each volume which is considered a separate use item. Therefore, electricity for the blower, auxiliary energy and the energy required by any coil or conditioning system of the ventilation may be allocated proportionally to the flow rate to the relevant ventilation use items.

E.2.3.2 Default allocation weight

The values of the needs of the individual use items are used to allocate the total subsystem thermal energy and auxiliary energy. The sum of the use items might be zero in some calculation intervals but there could be still auxiliary energy to be allocated. This can happen in case of stand-by operation if auxiliaries are still on or circulation is still active in a distribution network even if emitters are closed.

To avoid a division by zero, a default weight $X_{\mathrm{def};i}$ should be defined for each use item so that it is used as a replacement of $Q_{X;\mathrm{nd};i}$ when the total of a group of use items is zero.

A typical solution can be referring to the area, volume or air flow rate of the use items, depending on the type of service.

The default allocation weight need not to be consistent with the regular needs. They are used to split a contribution only if all regular needs are zero and only the ratio of an individual weight to the total of weights (e.g. a pure number) is used in the calculation.

E.2.4 Sub-systems rule

For each subsystem Y, the quota of the output thermal energy for each use item $Q_{X;Y;\mathrm{out},i}$ is a known data:

— because it is the sum of the connected use items, for a (heat/cold) emission subsystem;

— because it was calculated using the node rule for other subsystems.

For each subsystem Y, the total input $Q_{X;Y;\mathrm{in}}$ and the total auxiliary energy $W_{X;Y;\mathrm{aux}}$ are also known data given by the normal calculation of the subsystem Y.

The allocation of input thermal energy and auxiliary energy is based on the output or on the default weighting parameters if the total output is zero. Formulae (E.6) and (E.7) are needed to avoid a division by zero.

A division by zero would occur if the service is not required in the current calculation interval. This would the case for heating in summer but also in the week-end for an office if a time schedule is taken into account (e.g. intermittency). Even if a service is not required, there can still be some stand-by losses or auxiliary energy use to be allocated to the idle use-items. Therefore a default weight was introduced.

E.2.5 Node rule

Formula (E.8) often simplifies when:

— there is only one feeding subsystem (n=1), which a common case;

— both n and m are equal to 1, which is the case of systems without branching.

E.2.6 Step A weighted energy performance per use item

Formulae (E.9) and (E.11) simply state that each generator input per use item is a contribution to the delivered energy per use item and all auxiliary energy contributions to the same use item should be summed together.

For the delivered only energy carriers, the weighting factor $f_{\mathrm{we;cr},j}$ is unique and is a calculation data.

Note that the value of the energy performance is already known and $E_{\mathrm{we;A}}$ can also be calculated as the sum of the $E_{\mathrm{we;A},i}$ for all use items.

E.2.7 Allocating energy carriers

No additional information needed.

E.2.8 Other services

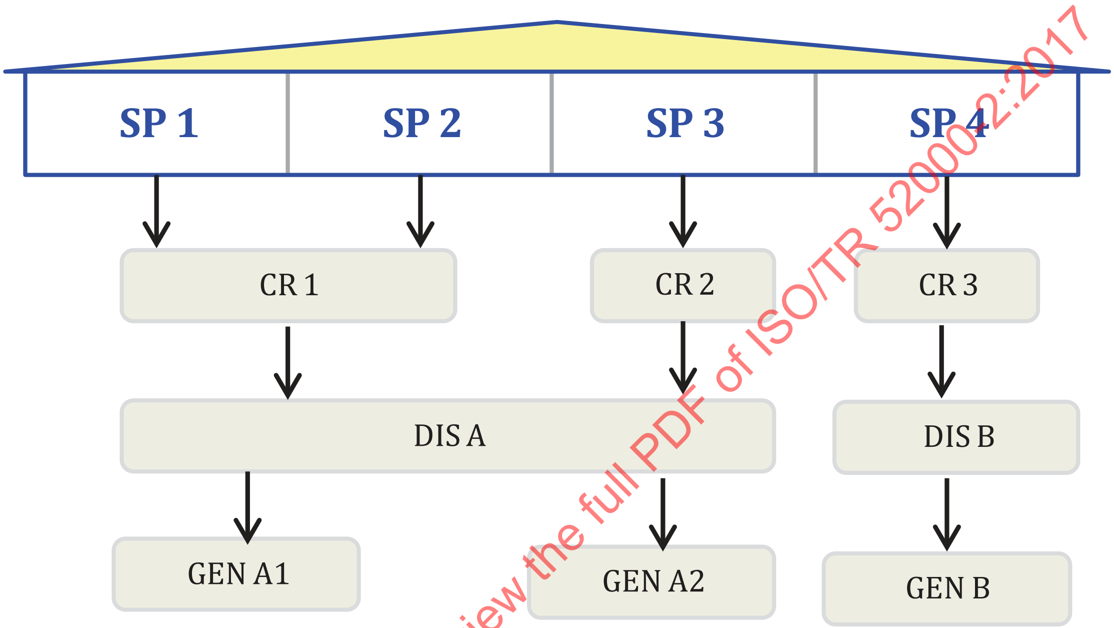
No additional information needed.

E.3 Reverse calculation method

E.3.1 Principles

The reverse calculation method provides another way of allocating the weighted energy performance. It allows allocate the step A weighted energy performance, then the final weighted energy performance is obtained using the same method as specified in E.2.7.

The principle of the reverse calculation is illustrated in Figures E.3 and E.4. The arrows indicate the calculation direction not the energy flow direction.

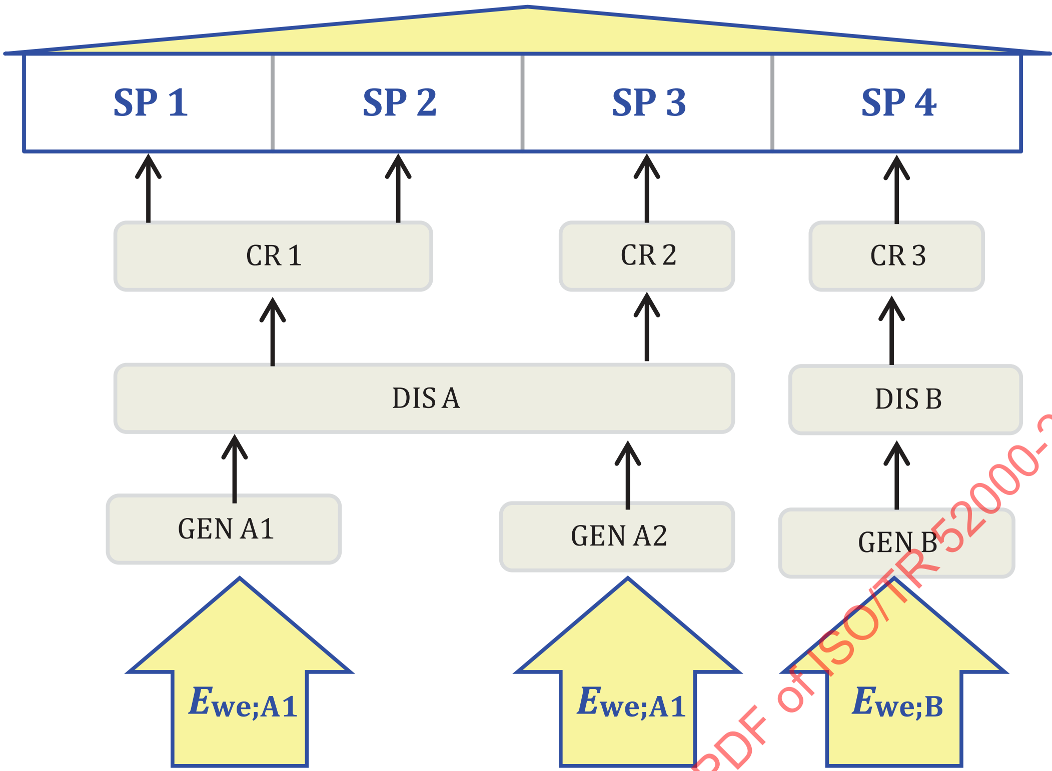


Key

SP X elementary space X
CR X circuit X
DIS X distribution collector (node) X
GEN X generator X

Figure E.3 — The first step of the reverse calculation method

The first step of the reverse calculation method is the usual calculation from the needs to the energy performance. It is not necessary to keep track of which part of each energy flow is related to each of the connected spaces.



Key

SP X elementary space X

CR X circuit X

DIS X distribution collector (node) X

GEN X generator X

$E_{we;x}$ weighted energy of generator x

Figure E.4 — The second step of the reverse calculation method

The second step of the reverse calculation method is the allocation of the weighted energy (or the amount of energy carriers or of auxiliary energy or other quantities) back to the connected spaces.

E.3.2 Notation

No additional information needed.

E.3.3 Calculation start

No additional information needed.

E.3.4 Sub-systems rule

The weighted energy coming from the subsystem input is increased by the weighted auxiliary energy used i the sub-system to give the weighted energy at the sub-system output.

E.3.5 Node rule

The weighted energy coming from the feeding subsystem(s) is distributed to the connected subsystems proportionally to the actual thermal input to each of them.

There is no change of the overall amount of weighted energy in the node, it is only redistributed and associated to the inputs of the load subsystems.

E.3.6 Attribution of weighted energy to use items

No additional information needed.

E.3.7 Weighted energy performance per use item

No additional information needed.

E.3.8 Allocating energy carriers and other quantities

No additional information needed.

Annex F
(informative)

Alphabetic index of terms

No explanation, justification or examples needed.

Annex G
(informative)

Electrical grid related indicators

G.1 Load matching indicators

G.1.1 Use matching fraction

The use matching fraction is the relation between the electric energy produced on-site and directly used, and the total electric energy use. It is also referred to as “degree of autarchy”.

ISO 52000-1:2017, Formula (G.1) includes the non-EPB use in the directly used electricity.

With an annual value of electric energy produced on-site, which is equal to the total annual electric energy use, the use matching factor does not become equal to 1, because a part of the produced energy is not directly used, but makes the detour through the grid.

ISO 52000-1:2017, Formula (G.1) only delivers a proper value for the use matching factor for hourly calculation intervals. In case of monthly calculations, the value becomes different by directly using the formula, because the non-coincidence of production and use are partly equalled out. In this case, the factor could be defined as a statistical factor to overcome this problem.

G.1.2 Production matching fraction

The production matching fraction is the relation between the electric energy produced on-site and directly used, and the total electric energy produced on-site. It is also referred to as “degree of self-use”.

The same restrictions as for the use matching factor apply for this indicator.

G.1.3 Grid interaction indicators

G.1.4 Reuse production matching fraction

The same restrictions as for the use matching factor apply for this indicator.

Annex H
(informative)

Proposal of indicators for the assessment of nearly Zero-Energy Buildings (NZEB)

H.1 General principles

At the time of developing this document, definitions of NZEB are varying a lot. Therefore a coherent and common definition of NZEB is needed:

— to be able to understand the content of the numerical indicator and the related requirements in the different building codes;

— to guide the industrials in the development of solutions and to give them the possibility showing the impact of the developed solution in a transparent manner.

However, the proposal in ISO 52000-1:2017, Annex H is not meant as a new rule or requirement, it is just an example to show what a common definition could look like.

The use of only one requirement, e.g. the numeric indicator of primary energy use, is misleading. In ISO 52000-1 different requirements are combined to a coherent assessment of nearly Zero-Energy Building (NZEB).

A NZEB should be a building that has a very low amount of energy required associated with a typical use of the building including energy used for heating, cooling, ventilation, hot water and lighting), taking into account:

— indoor climatic conditions;

— thermal characteristics of the building, building elements having a significant impact on the energy performance of the building envelope;

— HVAC installation, hot water supply, built-in lighting installation, optimizing the energy use of technical building systems;

— active solar systems and other systems based on energy from renewable sources;

— district or block heating and cooling systems.

The very low amount of energy required by a nearly zero-energy building should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby.

A nearly zero-energy building is characterized by a numerical indicator of primary energy use expressed in kW·h/m^2 per year.

CEN proposes to combine the different requirements in a coherent assessment of NZEB. The proposed assessment methodology goes step by step 'from the needs to the overall energy performance expressed in primary energy use'. Only if the requirement of each step is reached, then the building can be qualified at the end as 'NZEB'. This approach is comparable to a hurdle race.

The annex in the overarching EPB standard is only an informative methodological proposal. A complete worked out reporting scheme is therefore not provided.

H.2 First requirement: the building fabric (Energy needs)

The first requirement is reflecting the performance of the building fabric characterized by the energy needs. The energy needs are based on local conditions and the designated function of the building.

They take into account:

— the quality of the building envelope (e.g. insulation, windows);

— the bioclimatic design (e.g. solar gains, natural lighting),

— the inertia, the partitioning;

— the need to guarantee adequate indoor climatic conditions in order to avoid possible negative effects such as poor Indoor Air Quality (due to lack of ventilation).

The energy needs are calculated with ISO 52016-1[10].

H.3 Second requirement: The total primary energy use

The second requirement is reflecting the performance of the technical building systems (HVAC installation, domestic hot water supply, built-in lighting installation) characterized by the energy use.

Technical building systems are linked to one or more energy carrier (e.g. gas boiler; auxiliary consumption). To sum up the different energy carriers in a coherent way the second requirement is expressed in total primary energy.

If badly insulated houses can be avoided by requirements on building envelope (First requirement: The energy needs) the bad energy efficiency of technical building system can be solved by the total primary energy factor. If the efficiency of the technical building system would be linked to the non-renewable primary energy factors, then the efficiency of a biomass boiler would have no impact on the energy performance. But energy (even renewable) should not be wasted in bad systems.

The total primary energy use is also a coherent way for setting technical building system requirements because some systems (e.g. direct electrical emitters) have parts of their systems losses outside the building assessment boundary (e.g. electricity generation). The total primary energy factor takes into account the losses outside the assessment boundary.

Only energies delivered through the assessment boundary from nearby and/or distant are taken into account to link the total primary energy use with the energy counters and also to avoid that the energies are counted twice (e.g. heatpumps).

The total primary energy use is calculated according to ISO 52000-1[1].

H.4 Third requirement: Non-renewable primary energy use without compensation between energy carriers

The third requirement is reflecting the contribution of energies from renewable sources (e.g. active solar systems), characterized by the non-renewable primary energy consumption.

This requirement takes into account only the energy that is required to provide on-site services (heating, ventilations, etc.)

The non-renewable primary energy use is calculated with ISO 52000-1.

H.5 Final NZEB rating: Numerical indicator of non-renewable primary energy use with compensation

Only at this stage is taken into account:

— the compensation between different energy carriers for example between gas and on-site PV production;

— the effect of exported energy.

The numerical indicator of non-renewable primary energy is calculated with ISO 52000-1.

EXAMPLE Table H.1 illustrates the approach with an example. In this example there would be no NZEB rating (even if the NZEB rating result is lower than requirement) because the third requirement is not reached.

Table H.1 — Example illustrating the proposal in ISO 52000-1:2017 for NZEB rating

	Calculation direction		
1st requirement	**2nd requirement**	**3rd requirement**	**Final NZEB Rating**
Build. fabric	Tech. Build. systems + related energy carrier **only nearby, distant!!**	Renewable source **on-site, nearby, distant**	Compensation by exporting **on-site, nearby, distant**
Energy needs a)	**Total primary energy use** $f_{P,tot}$ b)	**Non-renew. Prim.Energy** $f_{P,nren}$ b)	**Tot + nren. Prim.energy** $f_{P,nren}$, k_{exp} c)
Heating : 60	Gas × $f_{P,tot}$: 80 × 1,05= 84	Gas× $f_{P,nren}$: 80 × 1,05= 84	Gas× $f_{P,nren}$: 80 × 1,05= 84
Cooling : 20	PV × $f_{P,tot}$: 40 × 1,00= 40	PV × $f_{P,nren}$: 40 × 0,00= 0	PV × $f_{P,nren}$: 40 × 0,00= 0
Lighting: 10	∑120 (needs+losses)		PV_{prod}. 60, k_{exp}=1 > exported: 60×1 - 40= 20
For information only: DHW: 20	NOTE: DHW added		PV_{exp} × $f_{P,nren}$: 20 ×2,5=50
Result: 90	**Result: 124**	**Result: 84**	**~~NZEB rating: 34~~**
Requirement:100	**Requirement:125**	**Requirement:80**	**Requirement: 50**
fulfilled	**fulfilled**	**Not fulfilled**	**No NZEB rating**

a) Services linked to building fabric only (e.g. envelope, partition, inertia, etc.).

b) Example of primary energy factors $f_{P,tot}$ = total primary energy factor , $f_{P,nren}$ = non-renewable primary energy factor.

c) Part of exported energy (production related!) between 0-1.

Annex I
(informative)

Lighting systems

Module 9 is covered entirely by EN 15193-1.[24] It specifies the method for calculating the monthly and annual energy use for lighting in non-residential buildings taking into account the different relevant lighting technologies. The method includes the zoning of a building into zones as required for lighting technology purposes, determination of the specific electrical installed power of the electric lighting system, considerations on the way in which daylight is utilized as well as the effects of light control systems.

To achieve lighting energy efficiency, suitable lighting and lighting control systems should be employed and the available daylight should be utilized to the best possible extent. The method described in Module 9 only deals with the lighting systems needed to achieve minimum lighting requirements according to EN 12464-1 “Light and lighting. Lighting of work places. Indoor work places” and EN 12193 “Light and lighting. Sports lighting”. According to the provisions of EN 12464-1 and EN 12193, a lighting system should be designed in such a way that the lighting requirements of a specific activity or task are met without needlessly increasing the energy use. At the same time, the energy use should not be reduced to the detriment of the quality of the lighting conditions.

The covered relevant technologies are:

— *Electric lighting:* Lighting solutions based on standard lamp technologies (incandescent, fluorescent, high pressure discharge lamps and the specific ballasts) can be used as well as emerging solid state lighting technologies (LED light sources). The methods will comply with EN 12464-1 and EN 12193 regarding the required lighting conditions, e.g. regarding the concepts of task area, maintenance factor and unified glare rating (UGR).

— *Daylighting:* Dynamic façade systems, i.e. façade consisting of glazing layers in combination with active shading systems, which are activated as function of insolation, can be evaluated in their effect on effective operation times. This evaluation is to be performed as function of the buildings location and climatic boundary condition. Vertical façades as well as roof light based systems are covered.

— *Lighting controls:* Methods to cope with constant illuminance control, presence detection systems and daylight dependent controls are provided.

Lighting in Module 9 can conceptually be subdivided into the submodules according to Table 1 in the overarching EPB standard:

— 9.2: *“Needs”:* Method to determine the net energy demand for illumination, which expresses the equivalent energy to provide the necessary light flux compliant to meet the requirements as defined in EN 12464 and EN 12193.

— 9.3: *“Maximum Load and Power”:* The submodule allows for the determination (calculation and measurement alike) of the required installed electric power of the electric lighting system including parasitic power.

— 9.4: *“Ways to express energy performance”:* Lighting energy performance in absolute terms can be expressed in the part of EN 15193-1[24] corresponding to submodule 9.4 as final energy demand $Q_{l,f}$, as LENI, and also as benchmark values. In relative terms the overall efficiency of the lighting system (electric lighting and lighting controls) itself can be described as function of expenditure factors.

NOTE Installed power is not an indicator of energy efficiency. It is for cable and supply sizing.

— 9.5: *"Emission and control"*: This submodule provides assessment approaches to control the electric lighting system. Methods to describe and rate constant illuminance control, presence detection systems and daylight dependent controls are provided.

— 9.6: *"Distribution and control"*.

— 9.7: *"Storage and control"*: This is "void", the module is shaded in ISO 52000-1:2017, Table 1.

— 9.8: *"Generation and control"*: Aside from electric lighting, this module contains the description of daylight as "natural light generation".

— 9.9 *"Load dispatching and operating conditions "*. This is "void", the module is shaded in ISO 52000-1:2017, Table 1.

— *9.10: "Measured Energy Performance"*: Methods to measure the installed electric power and the lighting energy consumption in existing buildings are provided in this submodule.

— *9.11: "Inspection"*: This submodule contains approaches and means to perform inspections of existing lighting installations. This serves to identify potentials resulting for instance from bad maintenance of installations (i.e. neglected cleaning of lamps and luminaires) or poor design and operating lighting scheme.

Annex J
(informative)

Calculation examples

J.1 General

This annex provides calculation examples that demonstrate the use of ISO 52000-1 and of its options.

The following calculation examples are presented in this annex:

— examples of simplified energy balances, to highlight the use of primary energy weighting factors and of the controlling parameter k_{exp}.

— a calculation example on 12 intervals, to highlight the identification of delivered and exported energy components and the two step weighting procedure;

— an example of the application of Annex E, providing the energy performance per building part.

J.2 Simplified energy weighting demonstration

J.2.1 Introduction

In this clause some simple examples are developed to demonstrate:

— the use of renewable and non-renewable primary energy factors;

— the use of the k_{exp} parameter;

— the meaning of step A – step B approach.

All examples are illustrated by a picture where:

— a simple drawing shows the actual energy flow;

— the table below the example gives the energy balance details;

— each row corresponds to one delivered or exported energy flow;

— for each row, the actual value of the energy flow, the weighting factors, the weighted energy and the RER (where relevant) are displayed. In some examples the renewable energy and the RER are distinguished in total and on-site plus nearby,

— the step A energy balance is performed first and then the step B energy balance;

— the final energy performance is given at the bottom;

— there is only one calculation result (e.g. energy performance) depending on the choice of the parameter k_{exp}. The result at step A is the same that would be obtained setting k_{exp} = 0. In the examples k_{exp} is always set to 1 but the result with step A is displayed on the row “TOTAL STEP A” to allow a quick comparison between the alternatives k_{exp} = 1 (final result) and k_{exp} = 0 (intermediate “Total step A”).

For clarity, each example covers only one calculation interval. The calculation with multiple calculation interval is covered in the example in Clause J.3.

Unless otherwise stated, the following primary energy conversion factors are used:

— grid electricity: $f_{\mathrm{Pren;el}}$ = 0,5 and $f_{\mathrm{Pnren;el}}$ = 2,0;

— PV electricity: $f_{\mathrm{Pren;PV}}$ = 1,0 and $f_{\mathrm{Pnren;PV}}$ = 0,0;

— gas: $f_{\mathrm{Pren;gas}}$= 0,0 and $f_{\mathrm{Pnren;gas}}$ = 1,1.

NOTE The same examples and some additional ones can be found in an accompanying spreadsheet.

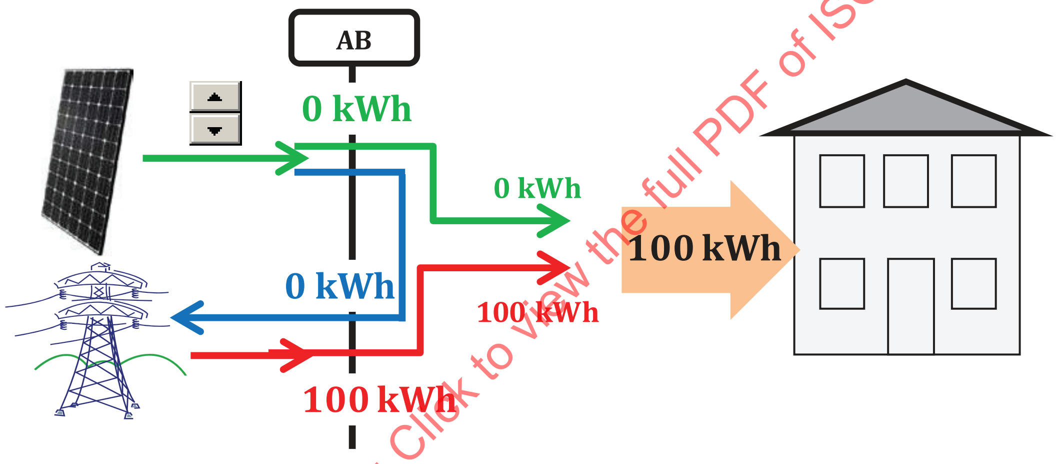
J.2.2 Example 1: Purely electrical system

J.2.2.1 Introduction

This example involves only one energy carrier: electricity.

All EPB systems in this example are assumed to use only electricity (e.g. heat pump + chiller). How to include the heat captured by the heat pump is covered in the specific heat pump example, see Clause K.2.4.

J.2.2.2 Base case



Key

AB assessment boundary

Figure J.1 — All electric system, all by the grid

Table J.1 — All electric system, all by the grid: weighted energy details

		E	f_{Pnren}	f_{Pren}	E_{Pnren}	E_{Pren} distant	E_{Pren} on-site	E_{Ptot}	RER	RER
		kW·h			kW·h	kW·h	kW·h	kW·h	tot	nrb-os
+ Delivered energy	PV	**0**	**0,0**	**1,0**	0		0	0		
- Exported energy	PV	**0**	0,0	1,0	0		0	0		
+ Delivered energy	GRID	**100**	**2,0**	**0,5**	200	50		250		
TOTAL STEP A					**200**	**50**	**0**	**250**	**0,20**	**0,00**
k_{exp}	**1,0**									
TOTAL STEP A					**200**	**50**	**0**	**250**		
+ Exported energy	PV	**0**	0,0	1,0	0		0	0		
- Avoided grid gen	GRID	**0**	2,0	0,5	0	0		0		
Energy performance					**200**	**50**	**0**	**250**	**0,20**	**0,00**
Energy available ext.		0	0,0	1,0	**0**		**0**	**0**	**n.a.**	**n.a.**

The base case is illustrated in Figure J.1 and Table J.1: there is no PV production.

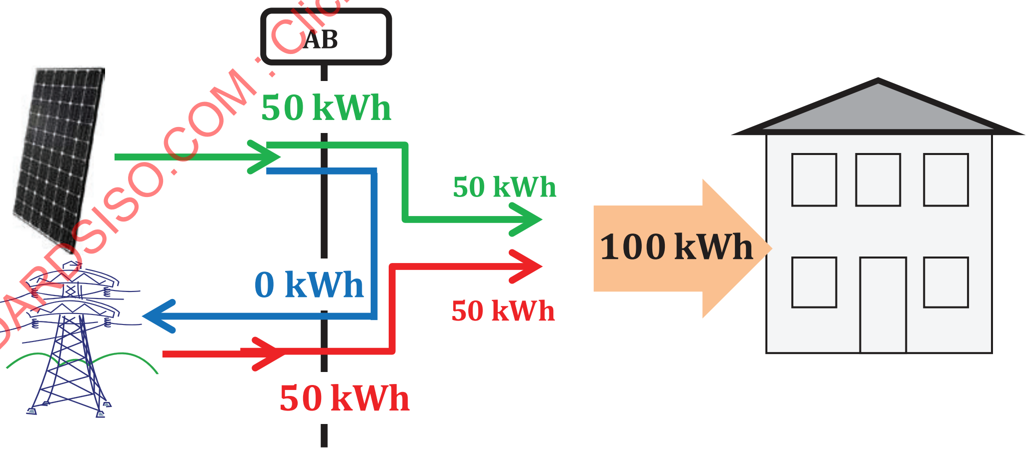
Comments

— there is only grid delivered electricity;

— the contribution to the RER comes only from the grid (distant renewable energy);

— the value of RER depends on the convention about which perimeter to consider for renewable energy. If the renewable energy from distant is not counted, then the RER is 0.

J.2.2.3 Partial coverage of electricity use with PV



Key

AB assessment boundary

Figure J.2 — All electric system, 50% covered by PV

Table J.2 — All electric system, 50% covered by PV: weighted energy details

		E	f_{Pnren}	f_{Pren}	E_{Pnren}	E_{Pren} distant	E_{Pren} on-site	E_{Ptot}	RER	RER
		kW·h			kW·h	kW·h	kW·h	kW·h	tot	nrb-os
+ Delivered energy	PV	**50**	**0,0**	**1,0**	0		50	50		
- Exported energy	PV	**0**	0,0	1,0	0		0	0		
+ Delivered energy	GRID	**50**	**2,0**	**0,5**	100	25		125		
TOTAL STEP A					**100**	**25**	**50**	**175**	**0,43**	**0,29**
k_{exp}	**1,0**									
TOTAL STEP A					**100**	**25**	**50**	**175**		
+ Exported energy	PV	**0**	0,0	1,0	0		0	0		
- Avoided grid gen	GRID	**0**	2,0	0,5	0	0		0		
Energy performance					**100**	**25**	**50**	**175**	**0,43**	**0,29**
Energy available ext.		0	0,0	1,0	**0**		**0**	**0**	**n.a.**	**n.a.**

This example is shown in Figure J.2 and calculation details are shown in Table J.2. The PV production is 50 kW·h and provides 50% of the actual electricity use in the building.

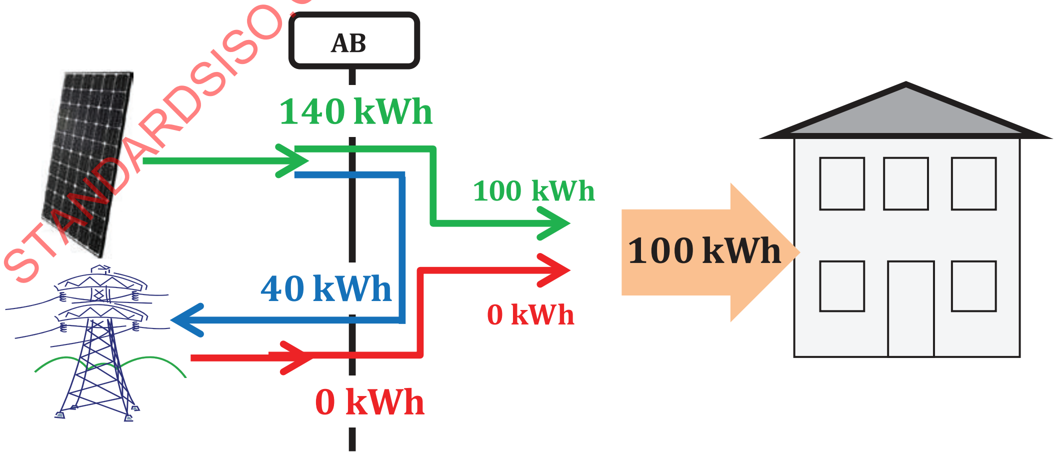
Comments:

— though half of the electricity comes from the PV, the RER is less than 50% because the total primary energy factor of PV is smaller than that of the grid;

— the contribution to the RER comes both from the grid (distant renewable energy) and from the PV (on-site renewable energy); Keeping a separate accounting for on-site, nearby and distant renewable energy provides the RER depending on the selected perimeter;

— even if k_{exp} is set to 1, there is no difference between step A and step B results because there is no exported energy to include (or not to include) in the energy performance. All produced electricity is used for EPD services.

J.2.2.4 PV production in excess of building use



Key

AB assessment boundary

Figure J.3 — All electric system, excess PV production

Table J.3 — All electric system, excess PV production: weighted energy details

		E	f_{Pnren}	f_{Pren}	E_{Pnren}	E_{Pren} distant	E_{Pren} on-site	E_{Ptot}	RER	RER
		kW·h			kW·h	kW·h	kW·h	kW·h	tot	nrb-os
+ Delivered energy	PV	**140**	**0,0**	**1,0**	0		140	140		
- Exported energy	PV	**40**	0,0	1,0	0		-40	-40		
+ Delivered energy	GRID	**0**	**2,0**	**0,5**	0	0		0		
TOTAL STEP A					**0**	**0**	**100**	**100**	**1,00**	**1,00**
k_{exp}	**1,0**									
TOTAL STEP A					**0**	**0**	**100**	**100**		
+ Exported energy	PV	**40**	0,0	1,0	0		40	40		
- Avoided grid gen	GRID	**40**	2,0	0,5	-80	-20		-100		
Energy performance					**-80**	**-20**	**140**	**40**	**3,00**	**3,50**
Energy available ext.		0	0,0	1,0	**0**		**0**	**0**	**n.a.**	**n.a.**

This example is shown in Figure J.3 and calculation details are shown in Table J.3. The PV production is further increased to 140 kW·h and exceeds the electric energy use in the building. 40 kW·h of produced electricity are exported.

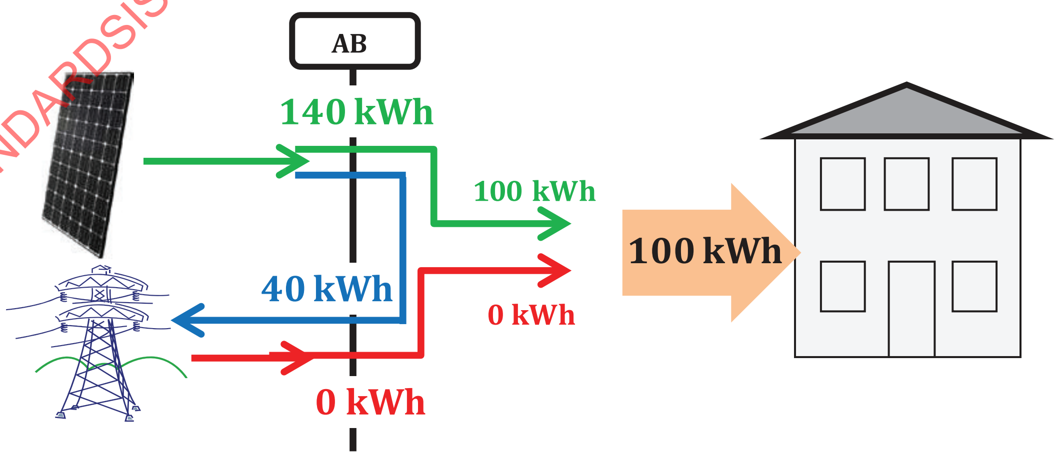
Comments

— When the PV production equals and then exceeds the EPB use, the step A energy performance (e.g. the energy performance calculated setting the parameter k_{exp} =0) stays constant (100 kW·h entirely renewable) and the RER is 1,0 because all the EPB uses are covered by PV electricity and the exported PV is not part of the energy performance of the building;

— Step B evaluation provides a negative non-renewable energy performance and a RER higher than 1,0. This is the effect of incorporating into the energy performance of the building the reduction of the primary energy required by grid generators because of the exported energy (40 kW·h);

— If the PV is further increased, the total primary energy at step B will become negative and the RER as well.

The complete result for the energy performance when setting k_{exp} =0 is shown in Figure J.4.



Key

AB assessment boundary

Figure J.4 — All electric system, excess PV production, detailed results with k_{exp} =0

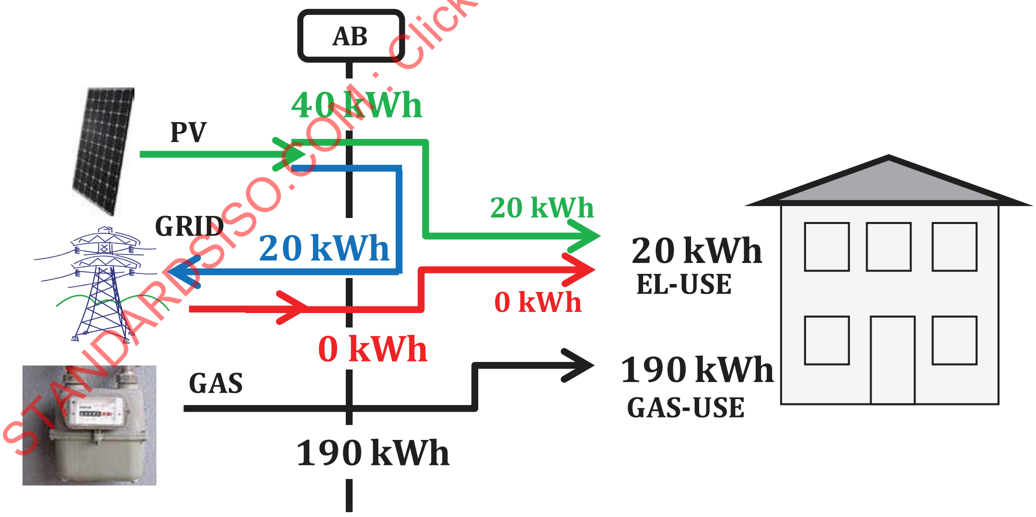
Table J.4 — All electric system, excess PV production: weighted energy details with k_{exp} =0

		E	f_{Pnren}	f_{Pren}	E_{Pnren}	E_{Pren} distant	E_{Pren} on-site	E_{Ptot}	RER	RER
		kW·h			kW·h	kW·h	kW·h	kW·h	tot	nrb-os
+ Delivered energy	PV	**140**	**0,0**	**1,0**	0		140	140		
- Exported energy	PV	**40**	0,0	1,0	0		-40	-40		
+ Delivered energy	GRID	**0**	**2,0**	**0,5**	0	0		0		
TOTAL STEP A					**0**	**0**	**100**	**100**	**1,00**	**1,00**
k_{exp}	**0,0**									
TOTAL STEP A					**0**	**0**	**100**	**100**		
+ Exported energy	PV	**0**	0,0	1,0	0		0	0		
- Avoided grid gen	GRID	**0**	2,0	0,5	0	0		0		
Energy performance					**0**	**0**	**100**	**100**	**1,00**	**1,00**
Energy available ext.		40	0,0	1,0	**0**		**40**	**40**	**1,00**	**1,00**

The result for the energy performance in Table J.4 (E_{Ptot} = 100 kW·h, E_{Pren}= 100 kW·h) is the same as step A in both Tables J.3 and J.4 but now the additional information about the energy available outside the building is displayed on the last line of Table J.4 This information is not available when setting k_{exp}=1 since the exported energy is already taken into account in the energy performance of the building and is not reported separately as available outside the building.

The exported 40 kW·h are not part of the energy performance, so they are reported separately together with their weighted energy content. This information can be used to determine the contribution of the assessed building in the context of a local grid connecting nearby buildings.

J.2.3 Example 2: gas boiler for heating and domestic hot water and PV for auxiliaries



Key

AB	assessment boundary	GAS	natural gas from the grid
PV	on site photovoltaic production	EL-USE	electricity use
GRID	electricity from and to the grid	GAS-USE	natural gas use

Figure J.5 — Gas boiler and PV for auxiliaries

Table J.5 — Gas boiler and PV for auxiliaries: weighted energy details

		E	f_{Pnren}	f_{Pren}	E_{Pnren}	E_{Pren}	E_{Ptot}	RER	RER
		kW·h			kW·h	kW·h	kW·h	tot	nrb-os
+ Delivered energy	PV	**40**	**0,0**	**1,0**	0	40	40		
- Exported energy	PV	**20**	0,0	1,0	0	-20	-20		
+ Delivered energy	GRID	**0**	**2,0**	**0,5**	0	0	0		
+ Delivered energy	GAS	**190**	**1,1**	**0,0**	209	0	209		
TOTAL STEP A					**209**	**20**	**229**	**0,09**	**0,09**
k_{exp}	**1,0**								
TOTAL STEP A					**209**	**20**	**229**		
+ Exported energy	PV	**20**	0,0	1,0	0	20	20		
- Avoided grid gen	GRID	**20**	2,0	0,5	-40	-10	-50		
Energy performance					**169**	**30**	**199**	**0,15**	**0,20**
Energy available ext.		0	0,0	1,0	**0**	**0**	**0**	**n.a.**	

The example shown in Figure J.5 and Table J.5 illustrates the energy balance for a heating and domestic hot water system with a gas boiler that uses 190 kW·h of gas and technical systems using 20 kW·h of auxiliary energy in total.

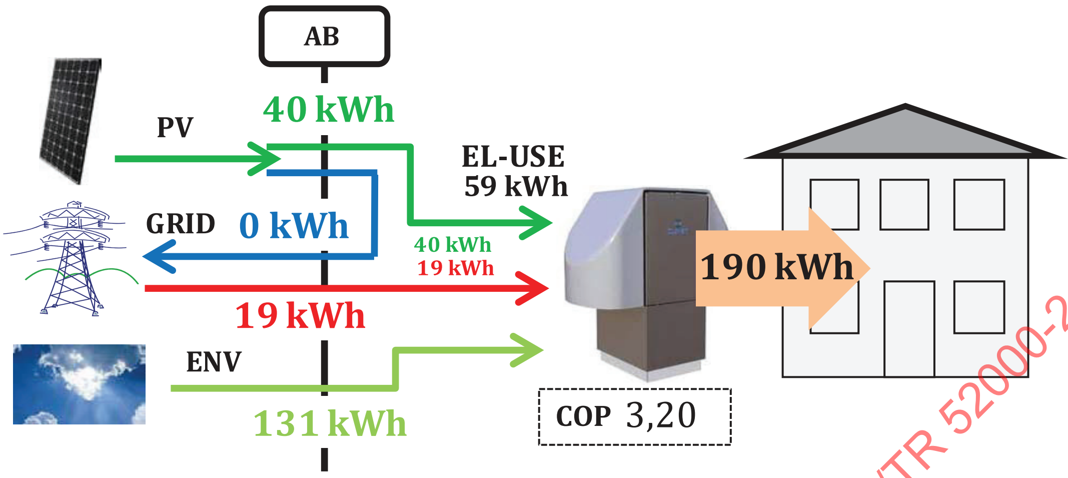
The PV panels produce 40 kW·h of electricity: 20 kW·h of electricity are exported to the grid.

Comments

— Setting k_{exp}=1 allows to take fully into account the contribution of exported electricity into the energy performance of the building. The use of non-renewable primary energy with gas is compensated by the non-renewable primary energy avoided by the grid generators. There is compensation between energy carriers (delivered gas and exported electricity).

— Setting k_{exp}=0 (Total Step A) a maximum of 20 kW·h of PV electricity are taken into account in the energy performance of the building. When the production of PV electricity is increased there is no further effect on energy performance when it exceeds the auxiliary energy used in the building. The PV production cannot reduce (e.g. improve) the energy performance contribution of the gas boiler. There is no compensation between energy carriers.

J.2.4 Example 3: Heat pump and PV



Key

AB	assessment boundary
PV	on site photovoltaic production
GRID	electricity from and to the grid
ENV	heat captured from the environment
EL-USE	electricity use
COP	coefficient of performance of the heat pump

Figure J.6 — Heat pump and PV

Table J.6 — Heat pump and PV: weighted energy details

		E	f_{Pnren}	f_{Pren}	E_{Pnren}	E_{Pren1}	E_{Pren2}	E_{Ptot}	RER	RER
		kW·h			kW·h	kW·h	kW·h	kW·h	tot	nrb-os
+ Delivered energy	PV	**40**	**0,0**	**1,0**	0		40	40		
- Exported energy	PV	**0**	0,0	1,0	0		0	0		
+ Environment heat	ENV	**131**	0,0	1,0	0		131	131		
+ Delivered energy	GRID	**19**	**2,0**	**0,5**	38	10		48		
TOTAL STEP A					**38**	**10**	**171**	**219**	**0,83**	**0,78**
k_{exp}	**1,0**									
TOTAL STEP A					**38**	**10**	**171**	**219**		
+ Exported energy	PV	**0**	0,0	1,0	0		0	0		
- Avoided grid gen	GRID	**0**	2,0	0,5	0	0		0		
Energy performance					**38**	**10**	**171**	**219**	**0,83**	**0,78**
Energy available ext.		0	0,0	1,0	**0**		**0**	**0**	**n.a.**	**n.a.**

The example shown in Figure J.6 and Table J.6 illustrates the energy balance when there is an electric heat pump and a PV panel contributing to the electricity use.

Comments

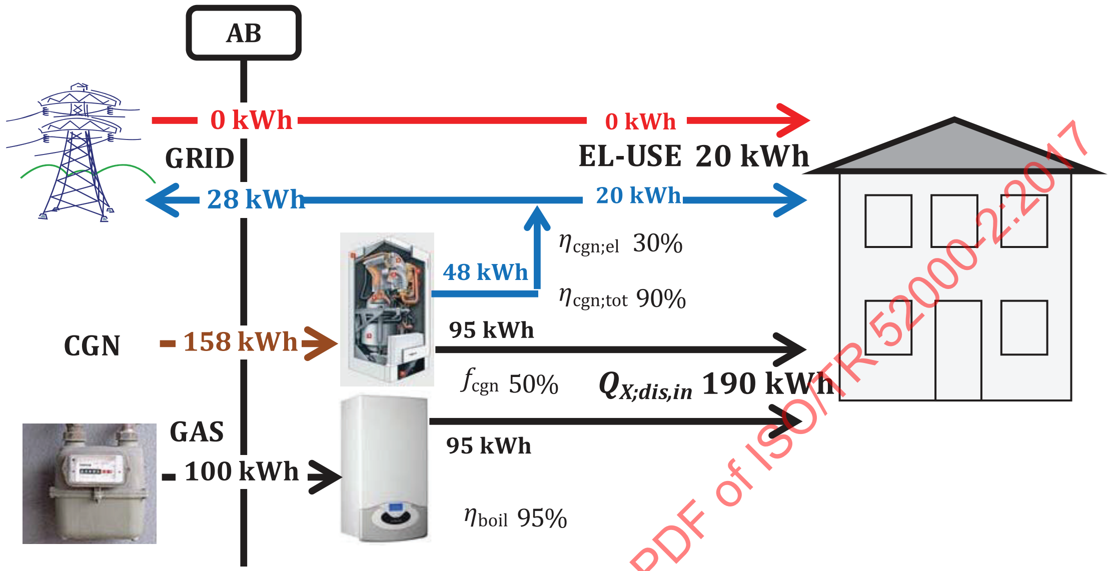
— The heat captured by the heat pump from the environment is taken into account as a delivered energy flow. It appears in the on-site RER;

— Even if there were no PV and the grid electricity were entirely non-renewable, there would still be a renewable energy contribution due to the heat captured from the environment;

— There is no difference between “Total step A” and the final result because there is no exported energy;

— If the same diagram were used for a chiller, the direction of the arrows for heat would be reversed and there would be no on-site renewable energy because the rejected heat is not considered as a delivered energy flow.

J.2.5 Example 4: Co-generator with fossil fuel and boiler



Key

AB	assessment boundary	$\eta_{cgn;tot}$	total efficiency of the cogenerator (electric + thermal)
GRID	electricity from and to the grid	f_{cgn}	fraction of required heat supplied by the cogenerator
CGN	fuel delivered energy to the cogeneration unit	η_{boil}	boiler efficiency
GAS	natural gas delivered to the boiler	EL-USE	electricity use
$\eta_{cgn;el}$	electrical efficiency of the cogenerator	$Q_{X;dis;in}$	heat required by the building (distribution input)

Figure J.7 — Gas boiler and co-generator

Table J.7 — Gas boiler and co-generator: weighted energy details

Allocation factors according to residual heat method					
Grid efficiency	%	44		*aw*	*aq*
Cogen electric efficiency	%	30		0,68	0,32
Cogen thermal efficiency	%	60			
Cogenerator conversion factors		**f_{Pnren}**	**f_{Pren}**	**f_{Ptot}**	
Fuel conversion factor		1,10	**0,00**	1,10	
Cogen heat weighting		0,58	0,00	0,58	
Cogen electricity weighting		2,50	0,00	2,50	

		E	**f_{Pnren}**	**f_{Pren}**	**E_{Pnren}**	**E_{Pren1}**	**E_{Pren2}**	**E_{Ptot}**	**RER**	**RER**
		kW·h			kW·h	kW·h	kW·h	kW·h	tot	nrb-os
+ Delivered energy	GAS	**100**	1,1	0,0	110		0	110		
+ Delivered energy	CGN	**158**	1,1	0,0	174		0	174		
- Exported energy	CGN	**28**	2,5	0,0	-69		0	-69		
+ Delivered energy	GRID	**0**	2,0	0,5	0	0		0		
TOTAL STEP A					**215**	**0**	**0**	**215**	**0,00**	**0,00**
k_{exp}	**1,0**									
TOTAL STEP A					**215**	**0**	**0**	**215**		
+ Exported energy	CGN	**28**	2,5	0,0	69		0	69		
- Avoided grid gen	GRID	**28**	2,0	0,5	-55	-14		-69		
Energy performance					**229**	**-14**	**0**	**215**	**-0,06**	**0,00**
Energy available ext.		0	2,5	0,0	**0**		**0**	**0**	**n.a.**	**n.a.**

The example shown in Figure J.7 and Table J.7 illustrates the energy balance with a co-generator working in parallel with a gas boiler.

The co-generator is contributing to 50% of the heat use of the building and it has an electric efficiency of 30% and a total efficiency of 90%.

Part of the cogenerated electricity (28 kW·h out of 48 kW·h produced) is exported to the grid.

Comments

— The weighting factors of electricity and heat produced by the co-generator should be calculated according to:

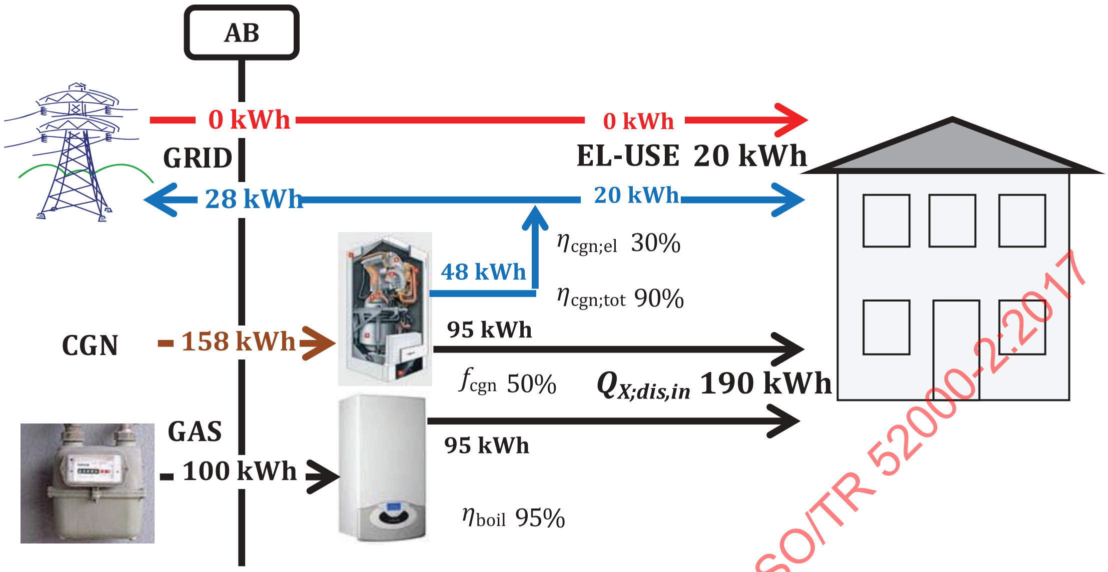
  — the weighting factors of the co-generator input (gas in this example);

  — an allocation method, residual heat method in this example;

  — the thermal and electrical efficiency of the co-generator;

— the RER can be negative if the renewable energy contents of avoided electricity production is taken into account.

J.2.6 Example 5: Co-generator with renewable fuel and boiler



Key

AB	assessment boundary	$\eta_{cgn;tot}$	total efficiency of the cogenerator (electric + thermal)
GRID	electricity from and to the grid	f_{cgn}	fraction of required heat supplied by the cogenerator
CGN	fuel delivered energy to the cogeneration unit	η_{boil}	boiler efficiency
GAS	natural gas delivered to the boiler	EL-USE	electricity use
$\eta_{cgn;el}$	electrical efficiency of the cogenerator	$Q_{X;dis;in}$	heat required by the building (distribution input)

Figure J.8 — Gas boiler and co-generator with renewable fuel

Table J.8 — Gas boiler and co-generator with renewable fuel: weighted energy details

Allocation factors according to residual heat method				
Grid efficiency	%	44	*aw*	*aq*
Cogen electric efficiency	%	30	0,68	0,32
Cogen thermal efficiency	%	60		
Cogenerator conversion factors		***f*Pnren**	***f*Pren**	***f*Ptot**
Fuel conversion factor		0,10	**1,00**	1,10
Cogen heat weighting		0,05	0,53	0,58
Cogen electricity weighting		0,23	2,27	2,50

		E	***f*Pnren**	***f*Pren**	***E*Pnren**	***E*Pren1**	***E*Pren2**	***E*Ptot**	**RER**	**RER**
		kW·h			kW·h	kW·h	kW·h	kW·h	tot	nrb-os
+ Delivered energy	GAS	**100**	1,1	0,0	110		0	110		
+ Delivered energy	CGN	**158**	0,1	1,0	16		158	174		
- Exported energy	CGN	**28**	0,2	2,3	-6		-63	-69		
+ Delivered energy	GRID	**0**	2,0	0,5	0	0		0		
TOTAL STEP A					**120**	**0**	**96**	**215**	**0,44**	**0,44**

k $_{exp}$	**1,0**									
TOTAL STEP A					**120**	**0**	**96**	**215**		
+ Exported energy	CGN	**28**	0,2	2,3	6		63	69		
- Avoided grid gen	GRID	**28**	2,0	0,5	-55	-14		-69		
Energy performance					**71**	**-14**	**158**	**215**	**0,67**	**0,74**
Energy available ext.		0	0,2	2,3	**0**		**0**	**0**	**n.a.**	**n.a.**

The example shown in Figure J.8 and Table J.8 illustrates the energy balance of the same system showed in Figure J.7 but with the co-generator fed with renewable fuel: a biogas with f_{Pren} = 1,0 and f_{Pnren} = 0,1.

All actual energy flows are the same, only the conversion factors change.

J.3 Calculation examples exported and delivered energy

J.3.1 Introduction

In this clause two examples are developed to demonstrate the calculation of the components of delivered and exported energy and their weighting.

One example includes the effect of taking into account a time matching factor between electricity production and use.

Each calculation is illustrated in a table where:

— each row is a calculation step. The reference to the corresponding formula in ISO 52000-1:2017 is given in the leftmost column;

— the calculation is repeated for 12 calculation intervals, labelled as months, to show the possible balances;

— there is one column for each time-step and one column for the calculation interval result labelled as "Year";

— the table simulates a monthly calculation for one year but the principle is valid for any number of calculation intervals.

Unless otherwise stated, the following primary energy conversion factors are used (they are shown in the tables where relevant:

— grid electricity: $f_{Pren;el} = 0{,}5$ and $f_{Pnren;el} = 2{,}0$;

— on-site produced electricity: $f_{Pren;PV} = 1{,}0$ and $f_{Pnren;PV} = 0{,}0$.

The example is developed only for electricity. To get meaningful results and to complete the calculation example, the delivered energy for the on-site electricity generator is taken into account as well (delivered PV electricity). Consideration of additional energy carriers that are exported would be easy, the weighted delivered amount are summed and there is no other interaction than summing an extra quantity of weighted delivered energy.

The presentation of the example follows the actual calculation order:

— identification of delivered and exported energy components;

— weighting;

— optional calculation of partial performance indicators.

The example is presented with constant weighting factors.

J.3.2 Identification of delivered and exported energy components

Table J.9 — Calculation details of delivered and exported energy components

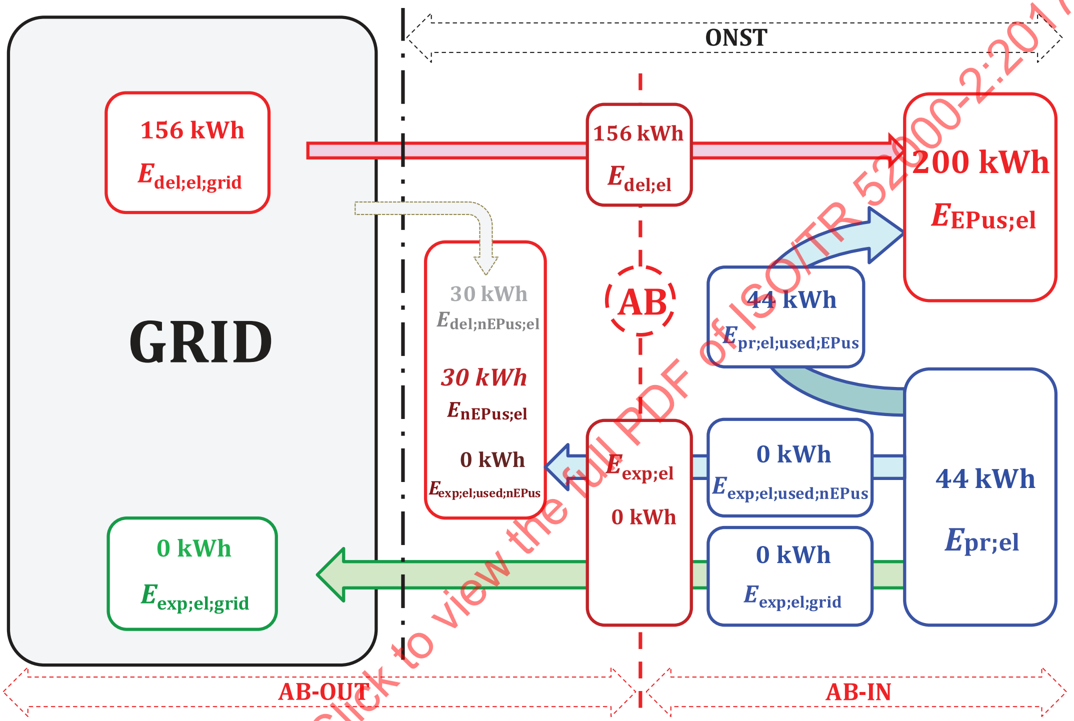
Eq. Nr.	DESCRIPTION	SYMBOL	UNIT	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
(29)	EPB uses	$E_{EPus;el,t}$	kW·h	**1 220**	200	160	100	90	50	60	80	70	50	80	120	160
	non EPB uses	$E_{nEPus;el,t}$		**360**	30	30	30	30	30	30	30	30	30	30	30	30
(30)	Produced electricity	$E_{pr;el,t}$	kW·h	**1 551**	44	55	77	110	187	209	220	198	176	132	88	55
(-)	Ratio produced/used				*0,22*	*0,34*	*0,77*	*1,22*	*3,74*	*3,48*	*2,75*	*2,83*	*3,52*	*1,65*	*0,73*	*0,34*
	Use matching factor?				*NO*											
(32)	Matching factor, t	f_{match}			*1,0*	*1,0*	*1,0*	*1,0*	*1,0*	*1,0*	*1,0*	*1,0*	*1,0*	*1,0*	*1,0*	*1,0*
(31)	EPB Used electricity	$E_{pr;el;used;EPus,t}$	kW·h	**799**	44	55	77	90	50	60	80	70	50	80	88	55
(33)	Exported electricity	$E_{exp;el,t}$	kW·h	**752**	0	0	0	20	137	149	140	128	126	52	0	0
(34)	Exported for non EPB uses	$E_{pr;el;used;nEPus,t}$	kW·h	**200**	0	0	0	20	30	30	30	30	30	30	0	0
(35)	Grid exported, t	$E_{exp;el;grid,t}$	kW·h		0	0	0	0	107	119	110	98	96	22	0	0
(36)	Grid exported, year	$E_{exp;el;grid;an}$	kW·h	**552**												
(37)	Grid delivered, t	$E_{del;el,t}$	kW·h		156	105	23	0	0	0	0	0	0	0	32	105
(38)	Grid delivered, year	$E_{del;el;an}$	kW·h	**421**												

Table J.9 shows the calculation procedure of to identify the value the components of the delivered and exported energy. The rows in the table are in the actual calculation order and refer to the formula numbers in ISO 52000-1:2017.

The required input data is in the first three row: EPB uses, non-EPB uses and production of electricity. This is an example with a high yearly on-site renewable generation (1 551 kW·h) that exceeds EPB uses (1 220 kW·h).

Non-EPB uses are included in this example (30 kW·h per calculation interval).

The matching factor is not considered in this calculation, therefore f_{match} = 1,0.



Key

AB	assessment boundary	AB-OUT	outside the assessment boundary
AB-IN	inside the assessment boundary	ONST	on-site

Figure J.9 — Energy balance in a time interval with low electricity production compared to use

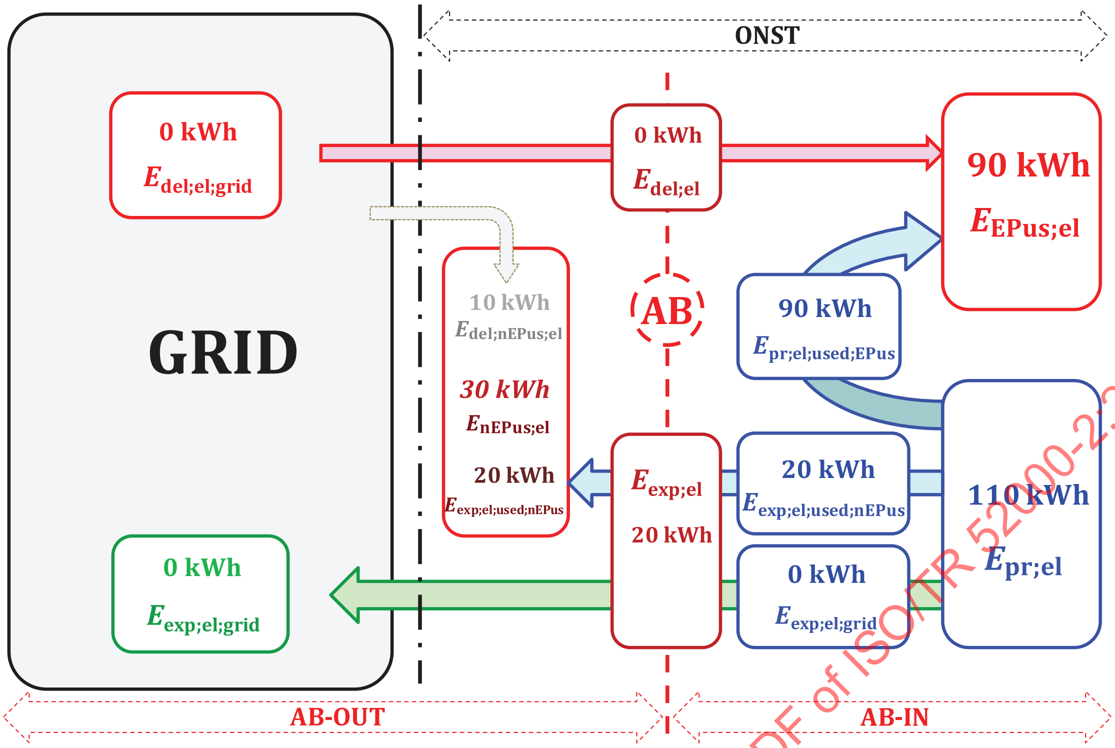
Figure J.9 shows the balance for a month with low on-site production (January).

Comments:

— On-site EPB uses (200 (kW·h)) are supplied partly by synchronous production (44 (kW·h)) and partly by the grid (156 (kW·h)).

— There is no produced electricity available for non-EPB uses.

  — the grid is supplying the missing 156 (kW·h) of electricity;



Key

AB	assessment boundary	AB-OUT	outside the assessment boundary
AB-IN	inside the assessment boundary	ONST	on-site

Figure J.10 — Energy balance in a time interval with electricity production comparable to use

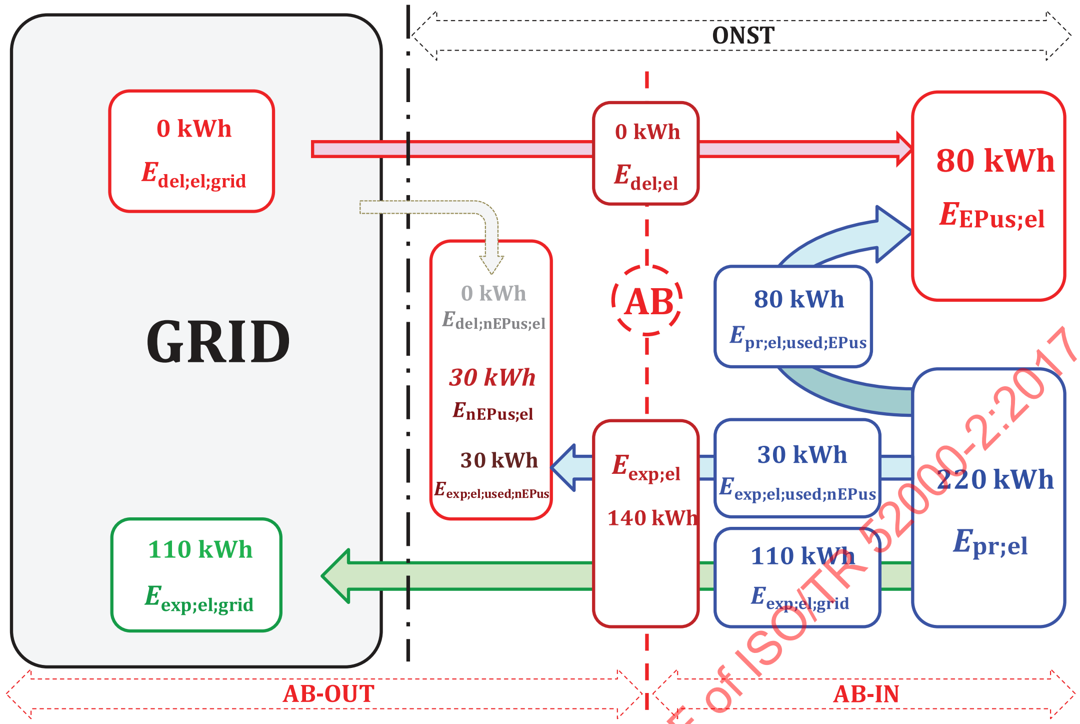
Figure J.10 shows the balance for a month (April) with a medium on-site production.

Comments:

— On-site EPB uses (90 (kW·h)) are entirely supplied by immediate use of part of the electric production (110 (kW·h)).

— The exceeding 20 (kW·h) of electric production are used with priority for on-site non-EPB immediate uses.

— There is no electricity exported to the grid since the sum of on-site EPB uses (90 (kW·h)) and non-EPB uses (30 (kW·h)) is higher than produced electricity.



Key

AB	assessment boundary	AB-OUT	outside the assessment boundary
AB-IN	inside the assessment boundary	ONST	on-site

Figure J.11 — Energy balance in a time interval with high electricity production compared to use

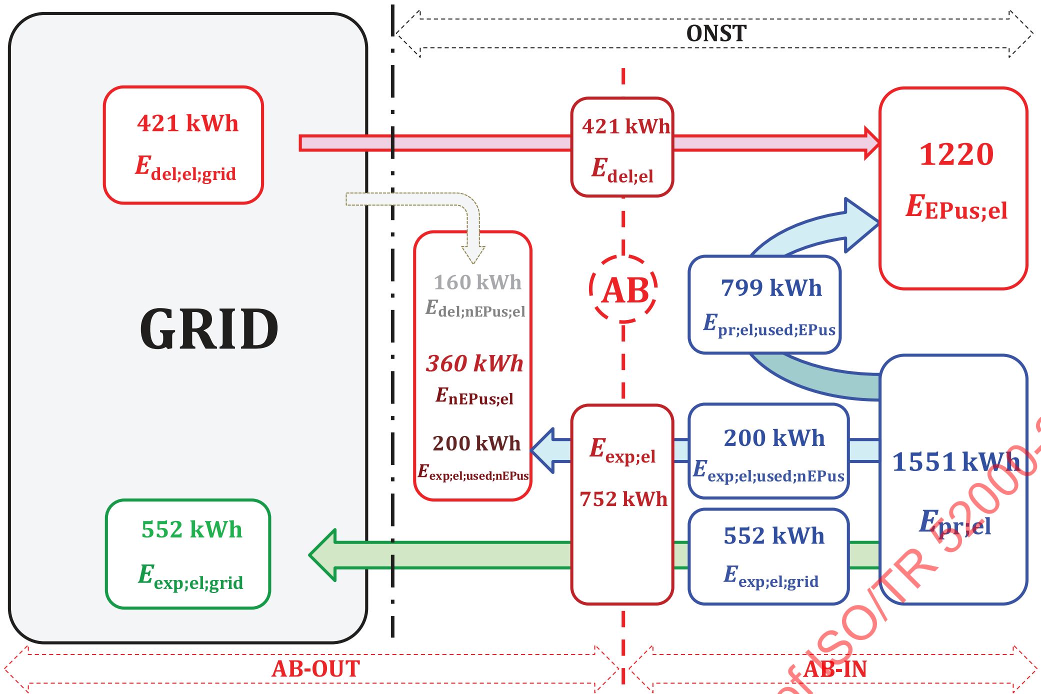
Figure J.11 shows the balance for a month (July) with very high on-site production.

Comments:

— On-site EPB uses (80 (kW·h)) and non-EPB uses (30 (kW·h)).are entirely covered by immediate use of on-site produced electricity (220 (kW·h)).

— The exported energy (140 (kW·h)) is used for on-site non-EPB uses first. The surplus (110 (kW·h)) is exported to the grid.

— There is no delivered energy since all on-site EPB uses are satisfied by immediate use of produced electricity.



Key

AB	assessment boundary	AB-OUT	outside the assessment boundary
AB-IN	inside the assessment boundary	ONST	on-site

Figure J.12 — Yearly balance without application of a matching factor

Figure J.12 shows the yearly balance without taking into account a matching factor between electricity produced and used.

Comments:

— The on–site production (1 551 (kW·h)) exceeds the sum of on-site EPB uses (1 220 (kW·h)) and the contribution to on-site non-EPB uses (200 (kW·h)). Therefore there is an export to the grid (552 (kW·h)).

— The contribution of produced electricity (200 (kW·h)) to on-site non-EPB uses (120 (kW·h)) is not complete, even if there is a yearly export to the grid (552 (kW·h)), because produced electricity is not always available in the right calculation interval.

— For the same reason (calculation interval mismatch between electricity production and on-site use) the grid delivers electricity during some month and an yearly delivered amount of electricity (421 kW·h) appears.

J.3.3 Weighting

Table J.2 shows the details of the weighting procedure that is applied after identification of delivered and exported energy components.

Table J.2 is the follow-up of Table J.1.

The weighting is performed independently for

— renewable primary energy;

— non-renewable primary energy (light grey cells);

so that the total RER can be calculated.

Table J.10 — Calculation details of the weighting of energy

Eq. Nr.	DESCRIPTION	SYMBOL	UNIT	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	Weighting factors for delivered energy															
	Produced electricity	$f_{\mathrm{Pren;pr;el},t}$			1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
		$f_{\mathrm{Pnren;pr;el},t}$			0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	Delivered energy	$f_{\mathrm{Pren;del;el},t}$			0,50	0,50	0,50	0,50	0,50	0,50	0,50	0,50	0,50	0,50	0,50	0,50
		$f_{\mathrm{Pnren;del;el},t}$			2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00
	Produced electricity	$E_{\mathrm{pr;el},t}$	kW·h	**1 551**	44	55	77	110	187	209	220	198	176	132	88	55
(30)		$E_{\mathrm{Pren;del;cr},t}$	kW·h	**1 551**	44	55	77	110	187	209	220	198	176	132	88	55
(30)		$E_{\mathrm{Pnren;del;cr},t}$	kW·h	**0**	0	0	0	0	0	0	0	0	0	0	0	0
	Grid delivered electricity	$E_{\mathrm{del;el},t}$	kW·h	**421**	156	105	23	0	0	0	0	0	0	0	32	105
(19)		$E_{\mathrm{Pren;del;el},t}$	kW·h	**211**	78	53	12	0	0	0	0	0	0	0	16	53
(19)		$E_{\mathrm{Pnren;del;el},t}$	kW·h	**842**	312	210	46	0	0	0	0	0	0	0	64	210
	Weighting factors for exported energy at step A															
	Calculation															
	Exported for non EPB uses	$E_{\mathrm{pr;el;used;nEPus},t}$	kW·h	**200**	0	0	0	20	30	30	30	30	30	30	0	0
		$f_{\mathrm{Pren;exp;el;stepA},t}$			1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
		$f_{\mathrm{Pnren;exp;el;stepA},t}$			0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
(24)		$E_{\mathrm{Pren;exp;el;used;nePus},t;A}$	kW·h	**200**	0	0	0	20	30	30	30	30	30	30	0	0
(24)		$E_{\mathrm{Pnren;exp;el;used;nePus},t;A}$	kW·h	**0**	0	0	0	0	0	0	0	0	0	0	0	0
	Grid exported electricity	$E_{\mathrm{exp;el;grid},t}$	kW·h	**552**	0	0	0	0	107	119	110	98	96	22	0	0
		$f_{\mathrm{Pren;exp;el;stepA},t}$			1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
		$f_{\mathrm{Pnren;exp;el;stepA},t}$			0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
(25)		$E_{\mathrm{Pren;exp;el;grid},t;A}$	kW·h	**552**	0	0	0	0	107	119	110	98	96	22	0	0
(25)		$E_{\mathrm{Pnren;exp;el;grid},t;A}$	kW·h	**0**	0	0	0	0	0	0	0	0	0	0	0	0
(23)	Step A weighted exported	$E_{\mathrm{Pren;exp;el},t;A}$	kW·h	**752**	0	0	0	20	137	149	140	128	126	52	0	0
(23)		$E_{\mathrm{Pnren;exp;el},t;A}$	kW·h	**0**	0	0	0	0	0	0	0	0	0	0	0	0
	Step A E_{Pren}			**1 010**	**122**	**108**	**89**	**90**	**50**	**60**	**80**	**70**	**50**	**80**	**104**	**108**
	Step A E_{Pnren}			**842**	**312**	**210**	**46**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**64**	**210**
	Step A E_{Ptot}			**1 852**												
	RER Step A			**0,55**												

Eq. Nr.	DESCRIPTION	SYMBOL	UNIT	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	Weighting factors for exported energy at step B															
	Exported for non EPBD uses	$f_{Pren;exp;el,t}$			0,50	0,50	0,50	0,50	0,50	0,50	0,50	0,50	0,50	0,50	0,50	0,50
		$f_{Pnren;exp;el,t}$			2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00
	Grid exported electricity	$f_{Pren;exp;el,t}$			0,50	0,50	0,50	0,50	0,50	0,50	0,50	0,50	0,50	0,50	0,50	0,50
		$f_{Pnren;exp;el,t}$			2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00
	Calculation															
(27)	Exported for non EPBD uses	$E_{Pren;exp;el;used;nePus,t;AB}$	kW·h	**-100**	0	0	0	-10	-15	-15	-15	-15	-15	-15	0	0
(27)		$E_{Pnren;exp;el;used;nePus,t;AB}$	kW·h	**400**	0	0	0	40	60	60	60	60	60	60	0	0
(28)	Grid exported electricity	$E_{Pren;exp;el;grid,t;AB}$	kW·h	**-276**	0	0	0	0	-54	-60	-55	-49	-48	-11	0	0
(28)		$E_{Pnren;exp;el;grid,t;AB}$	kW·h	**1 104**	0	0	0	0	214	238	220	196	192	44	0	0
(26)	Weighted exported inclusion	$E_{Pren;exp;el,t;AB}$	kW·h	**-376**	0	0	0	-10	-69	-75	-70	-64	-63	-26	0	0
(26)		$E_{Pnren;exp;el,t;AB}$	kW·h	**1504**	0	0	0	40	274	298	280	256	252	104	0	0
	Exported energy factor	k_{exp}	-	**1,0**												
(20)	Weighted exported	$E_{Pren;exp;el,t}$	kW·h	**376**	0	0	0	10	69	75	70	64	63	26	0	0
(20)		$E_{Pnren;exp;el,t}$	kW·h	**1 504**	0	0	0	40	274	298	280	256	252	104	0	0
(2)	**Weighted EP**	E_{Pren}	**kW·h**	**1 386**	122	108	89	100	119	135	150	134	113	106	104	108
(2)		E_{Pnren}	**kW·h**	**-662**	312	210	46	-40	-274	-298	-280	-256	-252	-104	64	210
		E_{Ptot}	**kW·h**	**724**												
	Renewable energy ratio	**RER**		**1,91**												

The delivered energy is weighted first:

— the produced electricity weighting factors depend on the type of generation device. It is assumed that electricity was generated by PV panels;

— the amount of produced electricity is a calculation result coming from other modules;

— the weighting factors of the grid delivered electricity is an input parameter;

— the grid delivered electricity is the corrected value.

Then the exported energy is weighted with the same weighting factors as produced electricity. The weighting factors of produced electricity are shown constant. They vary (e.g. they are time-step dependent) if:

— the efficiency of the generator changes;

— the generation combination changes (PV and cogeneration in parallel).

The results for step A are the same as the final result if the parameter k_{exp} is set to 0.

The weighting factors for exported energy at step B are an input parameter. The procedure gives the possibility to have independent weighting factors for each component of the exported energy:

— exported for non-EPB uses. This weighting factor might be different from the grid exported weighting factor e.g. if the non-EPB uses are not entirely supplied by the grid;

— grid exported, which is applied to the electricity that is exported to the grid.

J.3.4 Complete example taking into account a matching factor

The previous example shows that if there is a time mismatch between production and use of electricity, there are both delivered and exported electricity to the grid during the calculation period. Electricity produced by PV during summer cannot be accounted as used to run the heat pump in winter. This is true for both the monthly method and the hourly method but not for the yearly method. The duration of the calculation interval determines the allowed time mismatch (e.g. compensation time span) between production and use.

The monthly method implicitly allows a compensation between electricity produced at any time during the day and electricity used at any other time during the day. For the monthly method, the PV panels may produce electricity which is used during the night for lighting or in the evening for the air conditioner. This kind of type mismatch would be identified by an hourly calculation.

If the same result is desired for any calculation interval, then:

— a maximum compensation time-span should be decided or a maximum interval within which it is deemed that all operating conditions can be assumed as being truly constant (e.g. production and use rate of electrical energy is constant);

— a statistical matching factor is required whenever using longer calculation intervals. This is the role of the matching factor function that has been introduced in ISO 52000-1:2017, Formulae (31) and (32);

— a fictive buffer (like temporary exported and redelivered energy) is required if a shorter calculation interval is used (this case is mentioned for completeness, it is not currently the case since hourly intervals are the shortest calculation intervals used so far).

The basic assumptions are:

— the hourly time interval needs no correction, so the matching factor is set to 1,00 for the hourly time step; production and use rate are assumed to be at constant rate (power) during each hour;

