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Energy performance of buildings — Overarching EPB assessment —

Part 3: General principles for determination and reporting of primary energy factors (PEF) and CO_2 emission coefficients

Performance énergétique des bâtiments — Évaluation cadre PEB —

Partie 3: Principes généraux relatifs à la détermination et à la déclaration des facteurs d'énergie primaire (PEF) et des coefficients d'émission de CO_2

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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).

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

For an explanation of 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 www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 163, *Thermal performance and energy use in the built environment.*

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

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document is part of the ISO 52000 series of standards aimed at international harmonization of the methodology for the assessment of the energy performance of buildings (EPB).

For the correct use of this document, a normative template is given in Annex A to report the choices made on the possible options determining the PEF and CO_2 coefficient.

The target group of this document are all of the users of the series of standards related to the assessment of the EPB and especially national standardization experts or building authorities who are in charge of defining PEF and CO_2 emission coefficients.

In view of the complexity of the issue, the need for contextual knowledge and practicality of use, necessary comments and explanations have been included directly in the document. For the same reasons, parts taken from other standards are appropriate for inclusion in this document.

Table 1 shows the position (marked by "X") of this document within the modular structure as set out in ISO 52000-1.

The modules represent EPB standards, although one EPB standard may cover more than one module and one module may be covered by more than one EPB standard, for instance a simplified and a detailed method respectively.

Table 1 — Position of this document (M1–7) within the modular structure as set out in ISO 52000-1

		Overarching	Building (as such)				Technical building systems								
Submodule		**Descriptions**		**Descriptions**		**Descriptions**	**Heating**	**Cooling**	**Ventilation**	**Humidifi-cation**	**Dehumid-ification**	**Domestic hot water**	**Lighting**	**Building automation and control**	**PV, wind,..**
sub1			**M1**		**M2**		**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**	**M11**
1		General		General		General									
2		Common terms and defini-tions; symbols, units and subscripts		Building ener-gy needs		Needs									
3		Applications		(Free) Indoor conditions without sys-tems		Maximum load and power									
4		Ways to express energy performance		Ways to express energy performance		Ways to express energy performance									
5		Building categories and building boundaries		Heat transfer by transmis-sion		Emission and control									
6		Building occupancy and operating Conditions		Heat transfer by infiltration and ventilation		Distribution and control									

The shaded modules are not applicable.

Table 1 *(continued)*

		Overarching	Building (as such)				Technical building systems									
Submodule		Descriptions		Descriptions		Descriptions	Heating	Cooling	Ventilation	Humidification	Dehumidification	Domestic hot water	Lighting	Building automation and control	PV, wind,..
sub1			M1		M2		M3	M4	M5	M6	M7	M8	M9	M10	M11
7		Aggregation of energy services and energy carriers	X	Internal heat gains		Storage and control									
8		Building zoning		Solar heat gains		Generation and control									
9		Calculated energy performance		Building dynamics (thermal mass)		Load dispatching and operating conditions									
10		Measured energy performance		Measured energy performance		Measured energy performance									
11		Inspection		Inspection		Inspection									
12		Ways to express indoor comfort				BMS									
13		External environment conditions													
14		Economic calculation													

The shaded modules are not applicable.

Energy performance of buildings — Overarching EPB assessment —

Part 3: General principles for determination and reporting of primary energy factors (PEF) and CO_2 emission coefficients

1 Scope

This document provides a transparent framework for reporting on the choices related to the procedure to determine primary energy factors (PEFs) and CO_2 emission coefficients for energy delivered to and exported from the buildings as described in ISO 52000-1.

It does not include considerations on other topics, e.g. nuclear waste, atmospheric particulate matter, deforestation, food and bioenergy competition, depletion of raw material resources, depletion of the soil.

This document specifies the choices to be made to calculate the PEFs and CO_2 emission coefficients related to different energy carriers. PEFs and CO_2 emission coefficients for exported energy can be different from those chosen for delivered energy.

This document is primarily intended for supporting and complementing ISO 52000-1 as the latter requires values for the PEFs and CO_2 emission coefficients to complete the EPB calculation, however it can also be used for other applications.

2 Normative references

The following documents are referred to in the text in such a way that some or all their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 7345, *Thermal performance of buildings and building components — Physical quantities and definitions*

ISO 52000-1:2017, *Energy performance of buildings — Overarching EPB assessment — Part 1: General framework and procedures*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 7345, ISO 52000-1 and the following apply.

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

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

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

3.1
primary energy
energy that has not been subjected to any conversion or transformation process

Note 1 to entry: Primary energy can be related to non-renewable energy and renewable energy. If both are taken into account, it can be called “total primary energy”.

[SOURCE: ISO 52000-1:2017, 3.4.29, modified — "includes" is replaced by "can be related to" in Note 1 to entry.]

3.2
energy carrier
substance or phenomenon that can be used to produce mechanical work, electricity or thermal energy or to operate chemical or physical processes

[SOURCE: ISO 52000-1:2017, 3.4.9, modified — "or heat" has been replaced by "electricity or thermal energy".]

3.3
primary energy factor
PEF
ratio of the *primary energy* (3.1) to the energy delivered to, or exported from, the *assessment boundary* (3.5)

Note 1 to entry: Primary energy factor can refer to the total primary energy or to the renewable, or non-renewable primary energy. To be more precise it should be specified (e.g. non-renewable primary energy factor).

3.3.1
non-renewable primary energy factor for delivered energy carrier
non-renewable *primary energy* (3.1) for a given *energy carrier* (3.2), including the delivered energy and the considered non-renewable energy overheads of delivery to the points of use, divided by the delivered energy

[SOURCE: ISO 52000-1:2017, 3.5.17 modified — The term is completed by "for delivered energy carrier" and in the definition "non-renewable" is added before "energy overhead".]

3.3.2
non-renewable primary energy factor for exported energy carrier
non-renewable *primary energy* (3.1) for a given *energy carrier* (3.2), including the exported energy and the considered non-renewable energy overheads of producing and exporting to the collection points, divided by the exported energy

3.3.3
renewable primary energy factor for delivered energy carrier
renewable *primary energy* (3.1) for a given *energy carrier* (3.2), including the delivered energy and the considered renewable energy overheads of delivery to the points of use, divided by the delivered energy

[SOURCE: ISO 52000-1:2017, 3.5.21, modified — the term is completed by "for delivered energy carrier" and in the definition for "an energy carrier" the words "distant or nearby" have been deleted.]

3.3.4
renewable primary energy factor for exported energy carrier
renewable *primary energy* (3.1) for a given *energy carrier* (3.2) including the exported energy and the considered renewable energy overheads of producing and exporting to the collection points, divided by the exported energy

3.3.5
total primary energy factor
sum of renewable and non-renewable PEFs for a given *energy carrier* (3.2)

[SOURCE: ISO 52000-1:2017, 3.5.25]

3.3.6
renewable energy from renewable sources
energy whose source is naturally renewed and does not run out

EXAMPLE wind, solar, aerothermal, geothermal, ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases.

3.3.7
non-renewable energy
energy from non-renewable sources
energy from a source which is depleted by extraction

EXAMPLE Oil, natural gas, coal, uranium.

3.4
CO_2 emission coefficient
coefficient that describes the amount of CO_2 that is released from doing a certain activity

EXAMPLE Burning one tonne of fuel in a furnace is an example of application.

Note 1 to entry: The CO_2 emission coefficient can also include the equivalent emissions of other greenhouse gases (e.g. methane). To be more precise it should be specified by adding "equivalent" (e.g. CO_2 eq).

Note 2 to entry: In general, CO_2 emission coefficients from specific energy consumption (ISO 50001:2018, 3.5.2) are quantified based on CO_2 emission factors for use of the energy.

Note 3 to entry: CO_2 emission coefficients can differ by year.

Note 4 to entry: The CO_2 emission coefficient can also include the equivalent emissions of other greenhouse gases (e.g. methane).

[SOURCE: ISO 52000-1:2017, 3.5.4, modified — "such as burning one tonne of fuel in a furnace" has been moved from the end of the definition to an EXAMPLE. The original Notes 1 and 2 to entry have been deleted. Note 3 to entry is now Note 1 to entry with a new second sentence.]

3.5
assessment boundary
boundary where the delivered and exported *energy carriers* (3.2) are measured or calculated

[SOURCE: ISO 52000-1:2017, 3.4.2, modified — "energy" has been replaced by "energy carriers".]

3.6
energy flow
quantity of energy going from the energy source to the energy use

3.7
greenhouse gas
gas that absorbs and emits radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, the atmosphere and clouds

Note 1 to entry: Greenhouse gas can have natural and anthropogenic origins.

[SOURCE: ISO 14067:2018, 3.1.2.1, modified — "gaseous constituent of the atmosphere, both natural and anthropogenic" is simplified into "gas". Notes 1 to 3 to entry have been deleted and a new Note 1 to entry was added.]

3.8
biogenic carbon
carbon derived from biomass, but not fossilised

[SOURCE: ISO 14067:2018, 3.1.7.2, modified — "but not fossilised" has been added.]

3.9
fossil carbon
carbon that is contained in fossilized material

Note 1 to entry: Examples of fossilized material are coal, oil, natural gas and peat.

[SOURCE: ISO 14067:2018, 3.1.7.3]

4 Symbols, subscripts and abbreviated terms

4.1 Symbols

For the purposes of this document, the symbols listed in Table 2 apply.

Table 2 includes symbols that are needed for overall consistency in the ISO 52000 series.

Table 2 — Symbols and units

Symbol	Quantity	Unit
c	coefficient	various [a]
E	energy in general [b]	kW·h
f	factor (e.g. primary energy factor, ...)	– [a]
H	calorific value, net or gross (NCV or GCV),	kW·h/kg
K	CO_2 emission coefficient	kg/(kW·h)
Q	quantity of heat	kW·h
η	efficiency (factor)	– [a]
ε	expenditure factor	– [a]

[a] Coefficients have dimensions; factors are dimensionless.

[b] Including primary energy; Note that for heat the symbol Q and for auxiliary energy and work the symbol W is used.

4.2 Subscripts

For the purposes of this document, the subscripts listed in Table 3 apply.

Table 3 includes subscripts that are needed for overall consistency in the ISO 52000 series.

Table 3 — Subscripts

Subscript	Term	Subscript	Term
CO_2	CO_2 emission	nren	non-renewable
cr	energy carrier		
del	delivered	P	primary energy
dis	distribution	nren	non-renewable primary energy
el	electricity	pr	produced
exp	exported	pv	solar electricity (photovoltaic)
gen	generation	ren	renewable energy
i, j, k	indexes	tot	total
in	input	we	weighting
ls	losses	Out	output

4.3 Abbreviated terms

For the purposes of this document, the abbreviated terms listed in Table 4 apply.

Table 4 — Abbreviated terms

Abbreviated term	Term
CHP	combined heat and power
EPB	energy performance of buildings
GHG	greenhouse gases

Table 4 *(continued)*

Abbreviated term	Term
GWP	global warming potential
GCV	gross calorific value
LCA	live cycle analysis
NCV	net calorific value
PEF	primary energy factor
PV	photovoltaic
RES	renewables

5 General description of the methods and choices

5.1 Basic principles of the assessment methods

5.1.1 Primary energy factors (PEF)

5.1.1.1 Three fundamental types of PEF

For each delivered or exported energy carrier, there are three PEFs (see Figure 1) related to different energy contents of the energy carrier, to be assessed:

a) Non-renewable PEF ($f_{P;nren}$)

The primary energy taken into account in the non-renewable PEF covers only non-renewable energy flows (possibly including also, the non-renewable energy overheads of delivery to the point of use, according to the LCA method, see 6.4.4) required to deliver one unit of energy of the related energy carrier to the building. Therefore, the non-renewable PEF can be less than one if the unit of energy contains also renewable energy. It covers the whole non-renewable primary energy consumption, including those consumed by exploitation of the renewable sources when applicable.

b) Renewable PEF ($f_{P;ren}$)

The primary energy taken into account in the definition of renewable PEF covers only renewable energy flows (possibly including also, the renewable energy overheads of delivery to the point of use, according to the LCA method, see 6.4.4) required to deliver one unit of energy to the building per energy carrier. It covers all renewable primary energy including those consumed for the exploitation of the non-renewable sources (e.g. renewable energy used to produce electricity to drive an electric pump for pumping oil through a pipeline).

c) Total PEF ($f_{P;tot}$)

The total PEF is the sum of the non-renewable and renewable PEF.

5.1.1.2 PEF for delivered and exported energy

5.1.1.2.1 General

In accordance with ISO 52000-1, this document defines the PEF for delivered energy to the building through the assessment boundary and the energy produced “on-site” and exported through the assessment boundary.

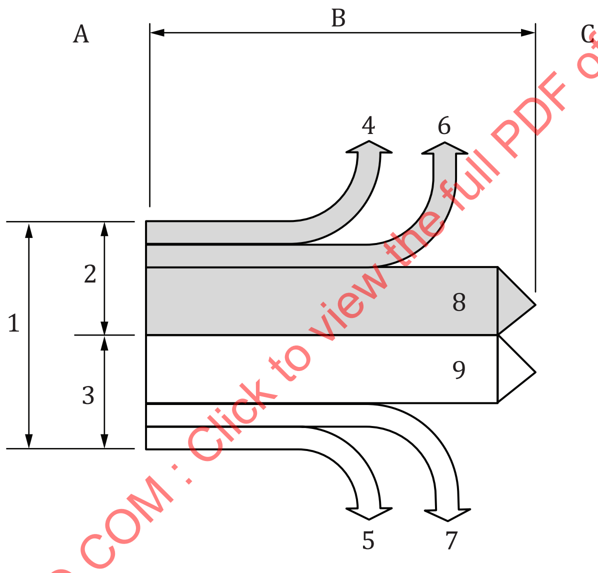
5.1.1.2.2 PEF for a delivered energy carrier cr

The PEF, f_{del}, for a delivered energy carrier cr from on-site, nearby or distant is defined as:

$$f_{we;del;cr} = \frac{\sum_j E_{we;del,j}}{E_{del;cr}} \tag{1}$$

where

$E_{we;del}$	is delivered energy, in kWh;
cr	is the subscript representing the type of the energy carrier;
we	is the subscript representing sequentially total, non-renewable or renewable attribute;
j	is the subscript accounting for different energy sources of same type, we, which concurs to produce the energy carrier.



Key

A energy source
B upstream chain of energy supply
C inside the assessment boundary
1 total primary energy
2 non-renewable primary energy
3 renewable primary energy
4 non-renewable infrastructure related energy (see also 6.4.4)
5 renewable infrastructure related energy (see also 6.4.4)
6 non-renewable energy to extract, refine, convert and transport
7 renewable energy to extract, refine, convert and transport
8 delivered non-renewable energy
9 delivered renewable energy

Figure 1 — PEFs for a two source (one non-renewable, the other renewable) energy carrier

5.1.1.2.3 PEF for an exported energy carrier cr

Energy that is produced on-site can be exported. In this case, ISO 52000-1:2017, 9.6.6 allows for either a PEF representing the resources avoided by the external grid or a PEF representing the resources used for producing the energy. The PEF for an exported energy carrier can be total, non-renewable or renewable.

5.1.1.3 Gross calorific value (GCV) and net calorific value (NCV)

The PEF can be expressed based on GCVs or NCVs.

5.1.1.4 In-use phase or life cycle analysis (LCA)

The PEF may focus only on the in-use phase or take into account also the embedded energy used (LCA, see 6.4.4), for example to manufacture wind turbines.

5.1.2 CO_2 emission coefficient

The LCA approach is used in EN 15978[7] for the assessment of environmental impacts of buildings (including climate change) during the life cycle of buildings (including operational energy use of buildings).

In EN 15978 and EN 15804[6] the LCA approach with GWP calculation rules have been aligned with ISO 14067[3] and the European Commission Product Environmental Footprint (PEF) calculation rules applying the GWP100 characterisation factors for the GWP calculations.

It is important that approaches in standards (and in regulations) are aligned in the construction sector, when they both use the LCA approach for CO_2 emissions (GWP) in order to direct the performance of buildings into the same direction, i.e. to mitigate climate change.

This document does not provide any GWP calculation rules but offers a standard template that helps in reporting the main methodological choices.

The CO_2 emission coefficient can also include the equivalent emission of other greenhouse gases (GHG) (e.g. methane, N_2O). To be more precise, it should be specified by adding “equivalent” (e.g. CO_2 eq).

The emission factors shall be coherent with the choice of referring to GCV or NCV.

In accordance with ISO 52000-1, in this document the CO_2 emission coefficients are applied to the energy delivered to the building or exported through the assessment boundary.

For the energy produced on-site and which can be exported, ISO 52000-1:2017, 9.6.6 allows for either a CO_2 emission coefficient representing the resources avoided by the external grid or a CO_2 emission coefficient representing the resources used for producing the energy. Subclause 6.3.4 defines both options.

5.1.3 CO_2 emission coefficient for an exported energy carrier cr

Energy that is produced on-site can be exported. As for the PEF calculation, ISO 52000-1 allows for either a CO_2 emission coefficient representing the resources avoided by the external grid or a CO_2 emission coefficient representing the resources used for producing the energy.

5.1.4 Assessment boundary

To start the determination and reporting of PEF and CO_2 emission coefficient, the perimeter of the assessment shall be set. It shall be clearly stated where the specific technical energy system ends (e.g. “inside” – see hereafter) and where the assessment of the PEF and CO_2 emission coefficient starts (e.g. “outside” – see hereafter).

The assessment boundary is the boundary where the delivered and exported energy are measured or calculated to assess the building energy performance. The assessment boundary is also the limit between the energy use (needs) and the energy supply. In ISO 52000-1, the assessment boundary delimitates two systems:

— “inside” the assessment boundary where the energy losses and auxiliary energy are taken into account explicitly as energy amounts. However, in ISO 52000-1, CO_2 emissions are not explicitly taken into account inside the assessment boundary. Therefore, the CO_2 emissions factors of combustible energy vectors include the CO_2 emissions of a perfect combustion process. The real efficiency is calculated inside the assessment boundary.

— “outside” the assessment boundary where the energy losses and auxiliary energy necessary to deliver one unit of the energy carrier to the building are taken into account in the PEFs per energy carrier. The PEF of delivered energy carriers shall only take into account losses and auxiliary related to the energy carrier. Otherwise, the PEF and CO_2 emission coefficient could not be applied in a coherent way to all buildings.

Therefore, the placement of the assessment boundary is important to clearly define what to take into account in the PEF and the CO_2 emission coefficient. Examples on possible placements of the assessment boundary are provided in Annex B.

NOTE In ISO 52000-1:2017, 9.5.1, the assessment boundary is defined as the output of active solar, wind or water energy systems. By convention, no primary energy losses are counted beyond this boundary for the upstream energy flow.

5.1.5 Origin of delivered energies

The delivered energies are classified according to the following source perimeters:

— on-site;

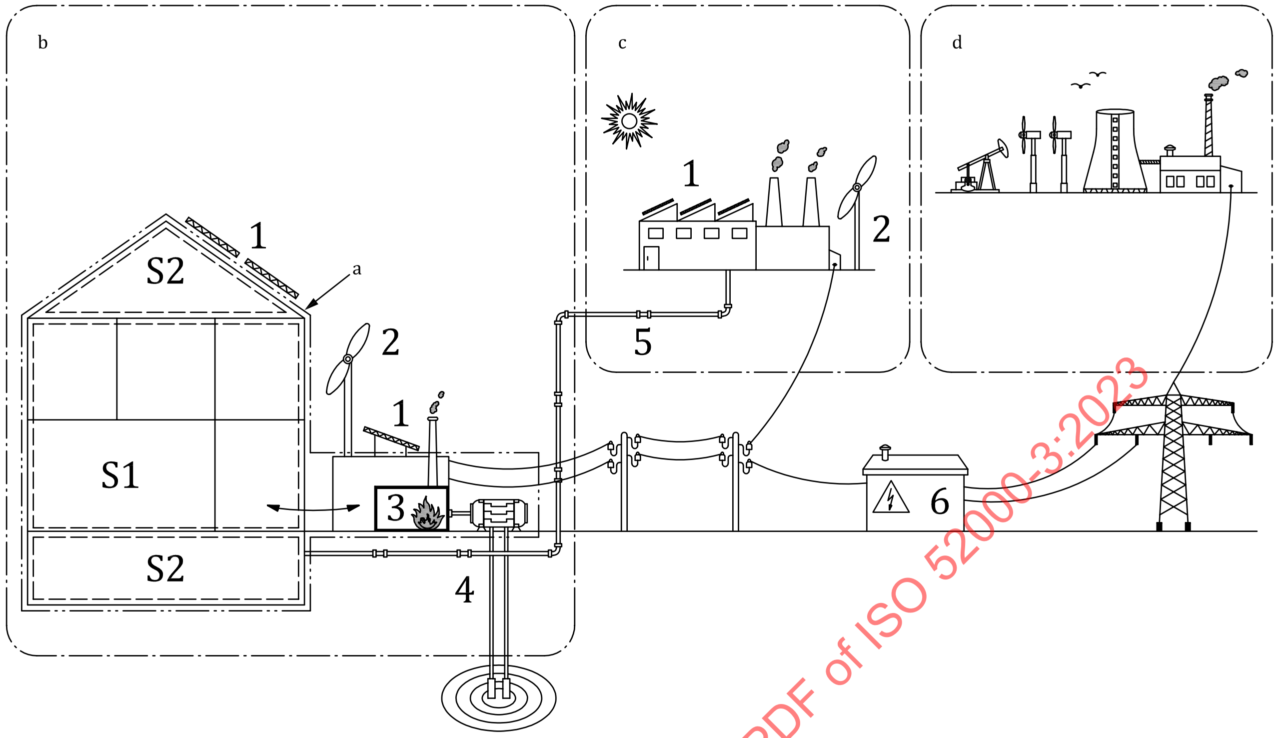
— nearby;

— distant.

Refer to ISO 52000-1:2017, 9.5.1 for a complete description of the origin of delivered energies.

These perimeters refer to the production site localisation and do not necessarily coincide with the geographical perimeter.

The concept of on-site, nearby and distant is schematically shown in Figure 2. A similar figure can be made for the gas grid.



Key

S1	thermally conditioned space	1	PV, thermal solar
S2	space outside thermal envelope	2	wind
a	Assessment boundary (use energy balance).	3	boiler room
b	Perimeter: on-site.	4	heat pump
c	Perimeter: nearby.	5	district heating/cooling
d	Perimeter: distant.	6	substation (low/medium voltage and possible storage)

Figure 2 — Example of a scheme of the concept of assessment boundary and origin of delivered energy

PEF and CO_2 emission coefficients are defined for each energy flow delivered or exported through the assessment boundary, considering the origin for delivered and the destination for exported energy.

5.1.6 Accounting methods

5.1.6.1 General

The assessment of the PEF and CO_2 emission coefficient for an energy carrier can be done by:

— following the reverse energy flow (from the building to the primary energy source);

— a global evaluation (inventory of primary energy inputs in the geographical perimeter).

Both approaches should lead to the same results notwithstanding calculation or inventory approximations.

The selection of the approach mainly depends on the kind of data available. It can also depend on the size of the geographical perimeter and the interconnection between the energy sources in case of multi-source energy carriers.

Additional methodologies are provided to allocate the input energy carriers to the delivered energy carrier and to the output energy carriers for:

— multi energy input system for a delivered energy carrier;

— multi energy output system.

NOTE At this stage, the treatment of multi-output systems where one or more outputs are not an energy carrier (for example, if it is a chemical feedstock or non-energy material) is not explicitly taken into account.

In addition to the methods mentioned before, which focus on the “in-use” phase, a method based on LCA (e.g. taking into account the embedded energy for construction and deconstruction of the energy carrier infrastructure, see 6.4.4) may be used to assess the PEF and the CO_2 emission coefficient of an energy carrier within the geographical perimeter.

5.1.6.2 Calculation approach — Reverse energy flows by energy carrier

Each energy carrier is connected to a building through a network of wires, pipes, trucks and ships. If the energy flow of an energy carrier from the energy source to the building is well defined, then the calculation procedure may go backward (with respect to energy flow direction), starting by a unit of delivered energy to the building and gathering information upstream related to primary energy consumption and CO_2 emissions. Throughout this calculation, several choices shall be made.

In the energy operational flow of each energy carrier, several components can be distinguished in the energy network: extraction, conversion and transport. Not all energy carriers can have all components in the network (e.g. conversion).

Identify for each network component the:

— energy inputs;

— auxiliary energy consumption;

— mass losses impacting global warming or the energy content (e.g. leakage), or both;

— thermal losses;

— energy output.

All the primary energy consumption, with a distinction between renewable and non-renewable primary energy use, and CO_2 emissions, are added up.

NOTE In some cases, CO_2 emissions taken into account for an energy carrier are determined by the energy carrier itself rather than the specific transformation process (e.g. combustion of gas within the building).

For additional explanation and reporting, see C.1.

5.1.6.3 Inventory approach — Global evaluation — Production

In case of multiple source energy carriers (e.g. electricity), large, centralised network (e.g. gas network) or energy carriers that are not provided by a network (e.g. heating oil), it may not be possible to follow the reverse energy flow. But it is possible that the input primary energy to the geographical perimeter is available.

In such cases, a global evaluation approach can be used to calculate PEF and CO_2 emission coefficients. The inventories of all primary energy inputs and CO_2 emissions occurring within the geographical perimeter can be used. In addition, an LCA approach (see 6.4.4) can also be used to take into account primary energy consumption and CO_2 emissions occurring outside the geographical perimeter related to the different considered energy carriers.

5.2 Short description of the choices

To limit the assessment methods (e.g. input data, perimeter), various choices need to be made. For each choice, a set of options is defined (see Clause 6) to facilitate the reporting of the choices and to make the content of PEF and CO_2 emission coefficients more transparent.

Annex A shall be used as a template to specify the choices made allowing the calculation of PEF and CO_2 emission coefficient of each energy carrier.

The choices to be made in the assessment of PEF and CO_2 emission coefficients are resumed hereafter and structured in the following main categories:

a) Choices related to the perimeter of the assessment:

- geographical perimeter which defines the boundaries within which PEF and CO_2 emission coefficients apply.

b) Choices related to calculation conventions:

- time resolution;
- sources of the data used;
- NCVs or GCVs.

c) Choices related to the data:

- energy sources to be considered (available energy sources);
- type of CO_2 emission coefficients;
- GHG taken into account, time horizon for the GWP;
- biogenic carbon;
- conventions related to energy conversion;
- conventions for PEF related to exported energy.

d) Choices related to the assessment methodologies:

- energy exchanges with other geographical perimeters;
- calculation approaches for multisource generation mix;
- allocation of multi energy output system;
- life cycle analysis (LCA).

6 Set of different choices related to PEF and CO_2 emission coefficient

6.1 Choices related to the perimeter — Geographical perimeter

The geographical perimeter is the perimeter of the energy use to which:

- a PEF and a CO_2 emission coefficient are applicable;
- the related data is used for its calculation.

The geographical perimeter may be different from the perimeter for the energy production.

Each energy carrier can have its own geographical perimeter. For example, a biomass source can be evaluated at a local perimeter, while a nuclear power plant distant energy carrier can be evaluated at a national scale.

The options available are:

— Option 1: International (specify the borders taken into account, e.g. political, geographic);

— Option 2: National (country, without overseas regions if applicable);

— Option 3: Regional (sub national level);

— Option 4: Local (nearby);

— Option 5: Other.

6.2 Choices related to calculation conventions

6.2.1 Time resolution

The time resolution is the time period of the outputs (i.e. the PEF and CO_2 coefficient).

The different options are:

— Option 1: Hourly;

— Option 2: Monthly;

— Option 3: Annual;

— Option 4: Other.

The PEF and CO_2 emission coefficient can be provided at an hourly, monthly, annual or other output period with respect of the availability of input data.

If the calculation interval of the input data is smaller than the time resolution, the input data shall be added up until the interval of the time resolution is reached. These data are then used for the calculation for energy and CO_2 emissions.

If the time resolution of the input data is smaller than the calculation interval, the input data shall be added up until the calculation interval is reached.

6.2.2 Sources (time horizon) of the data used

For each energy carrier, the type of data source shall be chosen between the following options:

— Option 1: Real historic, when real data are used;

— Option 2: Simulated historic, when data from a calculation based on past situations is used;

— Option 3: Forward looking, when data from simulation on forward-looking situations is used;

— Option 4: Other.

For each energy carrier, the range of years used shall be specified (and the source of data should be indicated).

NOTE A too frequent update of the PEF and CO_2 emission coefficients values can make comparisons more difficult; however, it can result in the observation of the possibly rapid evolution (technological or economical) of an energy carrier.

6.2.3 Net calorific value (NCV) or gross calorific value (GCV)

The delivered energy and the related PEF can be expressed based on GCV or NCV. The choice between net and gross caloric value shall be maintained for the energy performance assessment of all systems and the PEFs of all energy carriers without mixing net and gross values.

The choice related to NCV or GCV influences the denominator of the ratio related to the PEF or CO_2 emission coefficients. For example, depending on the choice, the kWh included in 1 m^3 of gas will not be the same.

The following choices should be made. The choices shall be the same for all fuels:

— Option 1: NCV;

— Option 2: GCV.

6.3 Choices related to the data

6.3.1 Energy sources to be considered (available energy sources)

According to ISO 52000-1, on-site produced energy can be taken into account in the energy performance of the building as self-consumption. In that case, this energy produced is not available for the general grid outside the assessment boundary.

Therefore, the self-consumed on-site production should not be included in the calculation of the PEF and CO_2 emission coefficient of the general grid as part of energy production. This double counting (counting for self-consumption and in the general grid) should be avoided. This can be extended to energy dedicated to specific communities as well.

Exported energy, even if already valorised in the building energy performance, can be counted in the PEF and CO_2 emission coefficient of the energy carrier, because the energy source is available.

NOTE This can provide a double benefit to exported on-site energy generation.

The following options should be reported:

— Option 1: Include all energy sources per energy carrier in the geographical perimeter x;

— Option 2: Exclude self-consumed on-site energy generation;

— Option 3: Exclude energy per energy carrier covered by dedicated delivery contracts or otherwise not available for the general grid;

— Option 4: Other.

Option 2 and 3 are not mutually exclusive.

6.3.2 Type of CO_2 emission coefficients

6.3.2.1 General

These choices apply to CO_2 emission coefficient only.

It aims to clarify what is included and not included in the CO_2 emissions.

Two choices are defined:

— GHG considered and the time horizon considered for each GHG (see 6.3.2.2);

— Biogenic carbon (see 6.3.2.3).

6.3.2.2 Greenhouse gases (GHG) taken into account and time horizon for GWP

The greenhouse gas emission coefficient shall be expressed in kg of CO_2 equivalent per kWh. It may also include the equivalent emissions of other greenhouse gas emissions, e.g. methane, nitrous oxide. The conversion factors shall be coherent with the choice of referring to GVC or NCV.

The GWP of each GHG depends on the time horizon. The time horizon influences the results, especially for energy carriers that emit other GHG than CO_2 (e.g. CH_4, N_2O), because the CO_2 is the reference gas.

CO_2, by definition, has a GWP of 1 regardless of the time horizon used, as it is the reference gas. CO_2 remains in the climate system for a very long time (thousands of years).

Other GHG can have a shorter lifetime. The net effect of the shorter lifetime and higher energy absorption is reflected in the GWP. As an example, CH_4 remains in the climate system only about a decade in average. But CH_4 absorbs much more energy than CO_2.

For this category, the possible choices are:

— Option 1: CO_2 only.

Only CO_2 (fossil or biogenic) is considered, other GHG are excluded;

— Option 2: CO_2 equivalent (all GHG), GWP for 20 years.

All GHG as defined by Intergovernmental Panel on Climate Change (IPCC) are considered. The indicator corresponds to the weighted sum of the mass of all GHG multiplied by their respective GWP.

The time horizon for GWP is set to 20 years;

— Option 3: CO_2 equivalent (all GHG), GWP for 100 years;

— Option 4: Other.

6.3.2.3 Biogenic carbon

Biogenic carbon emissions correspond to the combustion (CO_2 emissions) or the degradation (CH_4 emissions) of biomass products, whereas fossil carbon emissions correspond to the combustion (CO_2) or the degradation or leaks (CH_4), or the transformation of fossil products (e.g. cracking).

Even if there is no physical difference between the molecules (fossil or biogenic) there is a major difference regarding the evaluation of their respective impacts on climate change. It takes a few years for atmospheric carbon to be absorbed by the biosphere (e.g. forest, algae). Therefore, it can be considered that biogenic CO_2 is compensated by sequestrated CO_2 of the related biomass. This is not the case for fossil carbon where it takes millions of years to be absorbed by fossil reservoirs. That is the reason why the two carbon emissions may be treated differently.

The possible options are:

— Option 1: Carbon neutrality is applied.

All biogenic CO_2 emissions are compensated by the equivalent amount of CO_2 sequestrated. Biogenic CH_4 is accounted for;

— Option 2: Biogenic CO_2 and biogenic CH_4 emitted are accounted.

Biogenic CO_2 stored by biomass is not accounted for;

— Option 3: Other.

Fossil carbon CO_2 emissions to the atmosphere are always counted.

6.3.3 Conventions related to energy conversion

In this subclause, "conversion" refers to the process of transforming an input energy carrier (in the sense of the energy flow) into a different output energy carrier in the energy chain, both located outside the assessment boundary (e.g. electrical power plant, power to gas and gas to power, H_2 generation, cracking).

The conventions related to each conversion process shall be made transparent.

Different conventions exist to characterize the conversion between the input source (in the sense of energy flow) and the energy output.

The choices related to the conversion conventions are the following:

— Option 1: Zero equivalent convention.

This convention excludes any renewable primary energy consumption for the production of the energy carrier. Only the non-renewable energy is accounted. Option 1 applies only to energy from renewable sources (combustible and non-combustible);

To be coherent with this document, the zero equivalent convention [12] requires that the following convention in this document is also chosen: Non-renewable primary energy factor $f_{\mathrm{P;nren}} = 0$.

— Option 2: Direct equivalent convention.

The convention is to take into account an efficiency of 100 % ($\eta_{\mathrm{gen}} = 1$). No losses are taken into account for these types of energy conversion;

Option 2 can be chosen when the energy content of the input fuel (energy carrier):

— is difficult to estimate;

— is considered as not relevant, e.g. because the energy source will be available for use in any case;

— to underline the climate change benefit of the energy carrier;

— Option 3: Technical conversion efficiencies convention.

The conversion uses the efficiency of the technologies to determine the energy input to generate one kWh of useful energy output ($\eta_{\mathrm{gen}} \neq 1$);

EXAMPLE Conversion efficiency of electricity coming from an energy source $\eta_{\mathrm{gen}} = 0{,}33$; $f_{\mathrm{P;el}} = 3$.

— Option 4: Physical energy content (primary energy) convention.

The first energy (downstream) for which multiple uses are possible (e.g. the electricity produced by PV panels) is defined as "primary energy";

— Option 5: Other.

The options can be different when applied to different energy carriers.

For additional explanation and reporting see C.3.

6.3.4 Conventions for PEF related to exported energy

The aim of this option is to clarify which method has been chosen to calculate the content of the PEF and CO_2 emission coefficient by the following options:

— Option 1: Resources used to produce the exported energy carrier;

— Option 2: Resources avoided by the external grid due to export of the energy carrier;

— Option 3: Other.

6.4 Choices related to the assessment methodologies

6.4.1 Energy exchanges with other geographical perimeters

Exchanges are imported or exported energy between the assessment boundary and other geographical perimeters.

It can happen that the calculation of PEF and CO_2 emission coefficient are mainly based on data related to the production of energy, rather than on the demand of energy, for reasons of data availability. But the PEF and CO_2 emission of a national production is not strictly speaking the PEF and CO_2 emission of the national demand as import and export can happen through the border.

Data can then be corrected by taking into account the imported and exported energy per carrier with their associated PEF and the CO_2 emission coefficients or by using net energy exchanges by selecting the associated PEF and the CO_2 emission coefficients accordingly.

If the energy carrier exchange, for a specific geographical perimeter and energy carrier, is considered not significant, it is possible to ignore such energy exchange and to consider only the energy flow inside that geographical perimeter.

The PEF and CO_2 emission factors shall be calculated according to one of the following options:

— Option 1: Ignoring exchanges with other geographical perimeters

Only considering the energy flow within the geographical perimeter and ignoring the exchanges with other geographical perimeters through the borders.

— Option 2: Net exchanges with other geographical perimeters

Considering the net energy exchanges with other geographical perimeters.

The net exchanges equal the total of imports minus total of exports.

"Net" means that the imported energy is withdrawn from the exported energy in the considered time resolution or vice versa. Net energy exports and net imports are multiplied with the related PEF and CO2 coefficients.

When imports and exports occur simultaneously with other geographical perimeters, energy can transit across a geographical perimeter, without being used for demand within this geographical perimeter. This applies in particular where networks within the geographical perimeter are well developed. Energy transits should not be taken in consideration within the geographical perimeter. Energy transit is neutralized by this option.

— Option 3: Gross exchanges with other geographical perimeters

Considering energy exchanges with other geographical perimeters, by taking into account the exchanges with different associated PEF and CO_2 emission coefficients calculated over all the borders between the geographical perimeter considered and other geographical perimeters in the considered time resolution. Imported and exported energy sources are weighted by the related PEFs and CO_2 emission coefficients;

NOTE 1 When energy imports and exports occur simultaneously with other geographical perimeters, it is possible that some or all imports can be used for demand within the geographical perimeter, and some inland production is simultaneously exported. This applies in particular where networks within the geographical perimeter are not well developed. In this option, all imports and all exports are considered separately. It means that all energy imports are used for demand within the geographical perimeter, and all energy exports are considered as coming from inland production.

— Option 4: Other.

The exchanges can be calculated at various time resolutions.

NOTE 2 If an imported energy (e.g. gas) is transformed (e.g. into electricity) within the geographical perimeter, then this imported energy is usually taken into account inside the geographical perimeter as a use related to that imported energy.

For additional explanation and reporting see C.4.

6.4.2 Calculation approaches for multisource generation mix

6.4.2.1 General

For a large network where several different energy sources respond to an energy demand (multi-plant generation, e.g. for electricity, district heating) there are different calculation approaches to determine the CO_2 emission coefficient and the PEF by weighting the contribution of the different energy sources.

The calculation approach needs to be associated to the different parameters (e.g. energy carrier, delivered or exported energy, energy use).

The possible choices available are:

— Option 1: Average calculation approach;

— Option 2: Other (e.g. marginal; specify approach and scientific or technical reference).

The option chosen may be different for energy delivered or exported by a building.

6.4.2.2 Average calculation approach

The average calculation approach is the most commonly used to determine the energy and environmental performance of buildings.

The average factor or coefficient reflects the average emission and primary energy consumption of all plants delivering energy (directly or indirectly) to the building over a specified period of time. The primary energy consumption and CO_2 emissions of all plants are added up and divided by the total energy delivered by all generations.

System average values can be time varying (e.g. hourly) to more precisely reflect the time-varying factors of an energy carrier that is a mix of different resources or processes, with a changing energy balance (e.g. availability of renewable energies, hourly load curves).

6.4.2.3 Other approaches (e.g. marginal)

Hereafter only one other approach is described, but others are possible, and shall be described if used.

EXAMPLE Marginal calculation approaches.

These approaches are used in specific actions and aim to measure the impact of a change in production or demand. A marginal factor (PEF or CO_2 emission coefficient) calculated in a specific context (e.g. for a specific production mode as cogeneration) should not be extrapolated to any other context.

The marginal approach considers that if the energy demand is reduced (or increased), not all generation units (plants) are affected equally. Some approaches assume that the operation of "base load" plants may be unchanged and only the "peak load" plants may be affected by the change. To identify the priority in the energy production, a priority order needs to be defined reflecting the switch-on/switch-off of the different plants.

The marginal factor or coefficient considers only generation units that are affected (e.g. switched on, switched off, displaced) by the changes in energy demand (e.g. heating use) or production (e.g. exported energy by a building).

In addition, a distinction can be made between a short-term marginal factor and a long-term one.

— The short-term marginal factor corresponds to the change in CO_2 emissions or primary energy consumption relating to a unit change, where there is assumed to be no structural change in the energy production system being analysed.

— Where the change in demand can lead to a structural change in the energy production system (the production system evolves in coordination with changes in demand), a long-term marginal factor should be developed. The long-term marginal factor can be defined as the change in CO_2 emissions or primary energy consumption from a system due to a change in demand, however taking into account both the structural change in that system and the operation of the system, due exclusively to the changes in demand.

As there are several possible marginal calculation approaches, the scientific or technical reference shall be specified.

6.4.3 Allocation of multi energy output system

Multi-output generation systems such as cogeneration units or trigeneration of heating, cooling and electricity deliver more than one energy carrier. The output energy carriers can be delivered to the same geographical perimeter or exported to another geographical perimeter.

To assess the PEF and the CO_2 emission coefficient, the following options can be made. For heat and electricity from CHP units, the calculation rules and options are described in EN 15316-4-5.[5] The options for cogenerated heat are:

— Option 1: Power bonus;

— Option 2: Power loss simple;

— Option 3: Power loss;

— Option 4: Power loss ref;

— Option 5: Carnot;

— Option 6: Alternative production;

— Option 7: Residual heat;

— Option 8: Other.

The data sources shall be mentioned in the reference documents.

In trigeneration systems, cogenerated heat is converted to cold. The assessment of this cold in district cooling systems also follows the rules in EN 15316-4-5[5] as well as cold from free cooling, compression chillers and heat pumps.

For additional explanation and reporting related to the allocation of multi-energy input systems, see C.5.

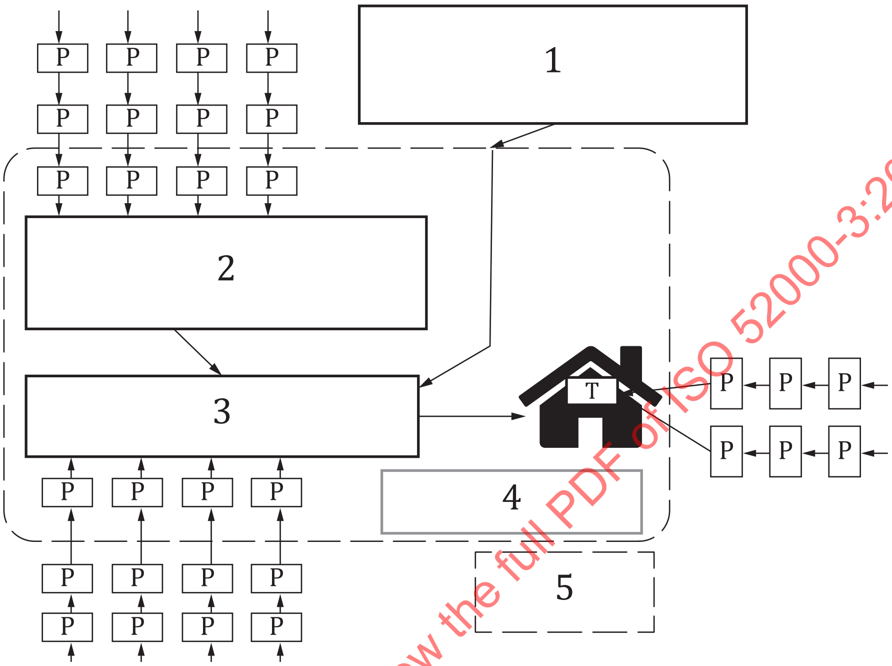
For additional explanation and reporting related to the allocation of multi-energy output systems, see C.6.

6.4.4 Life cycle method

In addition to the methods described above, which focus on the in-use phase, the LCA approach may be used to calculate the PEF and the CO_2 emission factor (see EN 15804 and BP X30-323).

This type of approach considers all the processes occurring across the supply chains needed to produce 1 kWh of delivered energy. It is a method that sums up all resource and energy consumption and all emissions that happen in each process involved. A process, as defined in ISO 14044, is a set of interrelated or interacting activities that transforms inputs into outputs. The LCA approach describes complex models such as networks of interrelated processes.

The purpose of this document is not to explain how to perform an LCA. There are many ways to describe processes that are considered and or omitted in the assessment. Figure 3 shows the basic structure of the LCA approach of an energy carrier and some of the topics related to a full LCA (option 1). If only some, but not all, of these topics are included in the LCA, it is a partial LCA (option 3).



Key

1 production or conversion processes outside the geographical perimeter (imports)

2 production or conversion processes inside the geographical perimeter (imports)

3 networks inside the geographical perimeter (infrastructure and losses)

4 1 kWh of energy delivered at the assessment boundary

5 geographical perimeter

T transformation process inside the building

P process

Figure 3 — Basic structure of the LCA approach of an energy carrier

To assess the PEF and the CO_2 emission coefficient, the following options can be chosen:

— Option 1: No LCA;

— Option 2: Full LCA;

— Option 3: Other (e.g. partial LCA).

The chosen option should be the same for all energy carriers (for the PEF and for the CO_2 emission coefficient) for consistency and comparability purposes.

If an LCA approach has been chosen for the energy carrier (PEF and CO_2), then the same approach should be chosen also inside the assessment boundary.

Annex A
(normative)

Template for reporting the choices in the calculation of PEF and CO_2 emission coefficient

A.1 Reporting template for choices per energy carrier

When the choice of "Other" is made, it shall be explicitly described in the reference document.

NOTE Other layouts, including spreadsheets, can be used for reporting. Only the content (choices) is normative.

Reference document (document describing the quantification of PEF and CO_2)				
(ref)				
Energy carrier	$f_{P;nren}$	$f_{P;ren}$	$f_{P;tot}$	K_{CO_2}

Choices related to the perimeter of the assessment (6.1)										
Name of geographical area:										
Geographical Perimeter	☐	International	☐	National	☐	Regional	☐	Local	☐	Other

Choices related to calculation conventions (6.2)								
Period considered for calculation:								
Time resolution	☐	Hourly	☐	Monthly	☐	Annual	☐	Other
Data source	☐	Real historic	☐	Simulated historic	☐	Forward looking	☐	Other
Net or Gross Calorific Value	☐	Net calorific value	☐	Gross calorific value				

Choices related to data (6.3)								
Available energy sources	☐	include all energy sources	☐	exclude self-consumed on-site generation	☐	exclude dedicated delivery contracts	☐	Other
GHG considered	☐	CO_2 only	☐	CO_2 equivalent 20 years	☐	CO_2 equivalent 100 years	☐	Other
Biogenic carbon	☐	carbon neutrality			☐	biogenic CO_2, CH_4 accounted	☐	Other

Conventions energy conversion	☐	Zero equivalent ($f_{P;nren}$ = 0)	☐	Direct equivalent ($f_{P;we}$ = 1)	☐	Technical efficiencies	☐	Physical energy content	☐	Other
Conventions PEF exported energies	☐	resources used to produce			☐	resources avoided			☐	Other

Choices related to the assessment methods (6.4)																
Energy exchanges	☐	Ignoring exchanges		☐	Net exchanges			☐	Gross exchanges						☐	Other
Multisource generation	☐	Average calculation approach						☐	Other (e.g. marginal) specify approach and technical reference							
Multi energy output system	☐	Power bonus	☐	Power loss simple	☐	Power loss	☐	Power loss ref	☐	Carnot	☐	Alter. Prod.	☐	Resid. heat	☐	Other
Life cycle analysis (LCA)	☐	no LCA						☐	full LCA						☐	Other

Annex B
(informative)

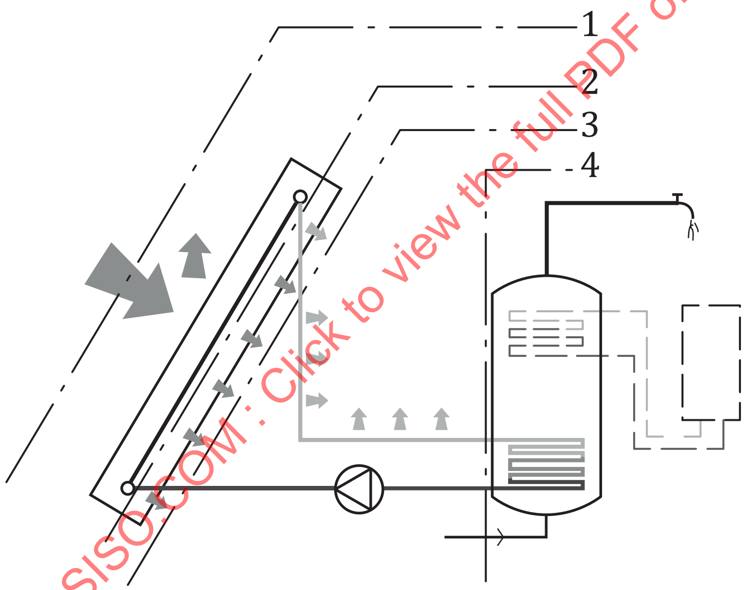
Examples of assessment boundaries

Figure B.1 illustrates where the assessment boundary can be placed related to a solar collector.

— EXAMPLE 1 For solar heat

Assessment boundary placed at the incident solar irradiation ("1" in Figure B.1):

The assessment boundary can be placed at the primary energy source (the incident solar irradiation). If it is placed on other places (e.g. the captured solar radiation "2" in Figure B.1 or the panel output "3 in Figure B.1"), it is including one or more building specific technical systems because the efficiency of the solar panel (e.g. characteristics of the panel surface reflected incident solar irradiation, the efficiency to transform the captured solar irradiation to electricity at the panel output) is panel specific. (See also 6.3.3 "Conventions related to energy conversion").



Key

1 incident solar radiation
2 captured solar radiation
3 panel output
4 thermal solar output

Figure B.1 — Example of assessment boundary related to thermal solar energy carrier

Assessment boundary placed at panel output ("option 3" in Figure B.1):

In that case, it is considered that for active solar, wind or water energy systems, the incident solar irradiation on solar panels or the kinetic energy of wind or water is not part of the energy balance of the building and that the efficiency of all panels is 100 % ("Direct equivalent", see also 6.3.3, "Conventions related to energy conversion").

— EXAMPLE 2 For PV

The incident solar irradiation is 10 kWh.

The produced electricity is 2 kWh.

Very often, the assessment boundary is placed at option 2 in Figure B.1 (default option in ISO 52000-1). Therefore, only the 2 kWh of produced electricity are counted and multiplied by a PEF of 1 (tot, ren) or 0 (nren). The incident solar irradiation is not counted. But "physically" 10 kWh of the energy source is used.

This approach does not consider the real efficiency of the PV panel.

NOTE In 6.3.3, "Conventions related to energy conversion", this approach is also called "direct equivalent" approach.

Annex C
(informative)

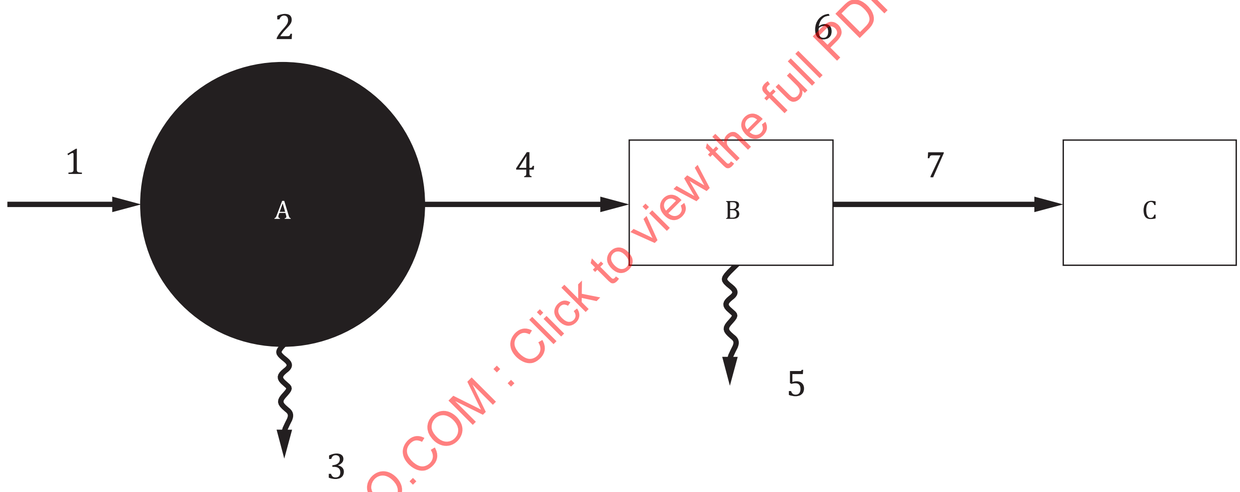
Additional explanation and reporting

C.1 General

The scope of this document is not to report data and give procedures to calculate PEF and CO_2 emission coefficients, but to report the main methodological choices. To come to a more quantified common reporting scheme, this Annex provides informative examples of more detailed reporting.

C.2 Calculation approach — Reverse energy flows by energy carrier (example related to 5.1.6.2)

Figure C.1 illustrates a decomposition of a simplified network feed only by one conversion component and a distribution component.



Key

A generation
B distribution
C buildings
1 $E_{P;ren;in}$
2 $f_{P;ren:pr:el} = 1/\eta$
3 $Q_{ls} = E_{P;ren;in}\,(1-1/\eta)$
4 $E_{pr;el}$
5 $Q_{ls,dis} = E_{pr;el}\,(1-1/\eta)$
6 $f_{P;ren:del:el} = f_{P;ren:pr:el} / \eta_{dis} = 1/(\eta_{dis})$
7 $E_{del;el}$

Figure C.1 — Simplified network

Assuming η is the overall conversion efficiency, the PEF for the produced energy carrier is just $1/\eta$.

For the distribution component, the primary energy overhead that has to be accounted for is due to the distribution losses plus some self-consumption for auxiliaries. Assuming η_{dis} is the overall distribution efficiency, accounting for all losses and self-consumption, the PEF for the delivered energy carrier to the final user, the building, is just the production PEF multiplied by the distribution PEF.

The PEF can be determined by counting the absolute values of all overheads or by determining the efficiencies.

In that case the PEF for delivered energy carriers, $f_{we;del}$, is given by the reciprocal of the product of the overall efficiency η_j of each component j, i.e.:

$$f_{we;del;cr} = \frac{1}{\Pi_j \eta_{j,cr}} \tag{C.1}$$

where

we is the subscript as placeholder for, sequentially, non-renewable or renewable attribute;

cr is the subscript describing the energy carrier;

j is the index for the component.

The PEF for delivered energy carriers can also be calculated with absolute values.

Reference documents should provide additional transparency to the assessment of PEF and CO_2 emission coefficient. Reporting should be as shown in Table C.1:

Table C.1 — Reporting related to the energy flow approach

Network component	Efficiency	Comments / data source
e.g. distribution	η_{dis}	
e.g. conversion	η_{gen}	
other		

The data sources should all be mentioned in the reference documents.

C.3 Conventions related to energy conversion (example related to 6.3.3)

C.3.1 Example of possible PEF values for power generation

Table C.2 provides an example of possible PEF values for power generation based on the conventions described in 6.3.3.

Most of the values mentioned in Table C.2 are conventional values based on the selected options. Even the technical conversion efficiencies can be conventional, but they can also be calculated with regards to the real process.

These values are related to the conversion process and therefore do not explicitly make the difference between energy from non-renewable sources (nren), from renewable sources (ren) and tot, even if the counting of renewables and non-renewables are expressed by the options.

Table C.2 — Example of possible PEF values for power generation,

	Option 1 Zero equivalent	Option 2 Direct equivalent	Option 3 Technical conversion efficiencies	Option 4 Physical energy content
Hydro, Wind	0	1	[a]	1
Solar, PV	0	1	[a]	1
Geothermal	0	1	[a]	Real values
Biomass	0	-	Real values	Real values
Nuclear	-	1	Real values	Real values
Fossil	-	-	Real values	Real values

[a] Technical conversion efficiency are also available for these technologies but are not mentioned in the Fraunhofer annual report (2016) [12].

C.3.2 Efficiency of conversion processes

C.3.2.1 General consideration

This subclause is relevant for PEFs only.

The efficiency of the conversion process is part of the whole calculation process of the PEF and can be structured according to the following simplified formula. In this subclause, only the conversion process is considered. If the entire supply chain is taken into account, LCA based approaches can be used (see 6.4.4).

$$\mathrm{PEF}_{\mathrm{cr}} = \mathrm{PEF}_{\mathrm{in,cr}} / \eta_{\mathrm{gen}}$$

The conversion process can be characterized by its efficiency η_{gen} or as an expenditure factor ε.

$$\eta_{\mathrm{gen}} = \frac{E_{\mathrm{out}}}{E_{\mathrm{in}}} \tag{C.2}$$

$$\varepsilon_{\mathrm{gen}} = \frac{E_{\mathrm{in}}}{E_{\mathrm{out}}} \tag{C.3}$$

where

η_{gen} is the efficiency of the conversion process;

$\varepsilon_{\mathrm{gen}}$ is the expenditure factor of the conversion process;

E_{out} is the energy output of the conversion process, in kWh;

E_{in} is the energy input to the conversion process, in kWh.

A primary energy factor f_{P} is an expenditure factor that is calculated with primary energy as energy input:

$$f_{\mathrm{P}} = \frac{E_{\mathrm{P;in}}}{E_{\mathrm{out}}} \tag{C.4}$$

where

f_{P} is the primary energy factor of the conversion process;

E_{out} is the energy output of the system;

$E_{\mathrm{P;in}}$ is the primary energy input to the conversion process.

In 6.3.3 the options for the conversion of energy carriers are described for accounting the conversion, e.g. for electricity from nuclear energy, for non-combustible renewables, such as wind, solar, hydro, as well as for combustible renewables (e.g. wood).

The different methods are applied by various different organisations (e.g. International Energy Agency, Eurostat).

The options described in 6.3.3 are explained depending on the fuels in C.3.2.2, C.3.2.3 and C.3.2.4:

— Fossil fuels (i.e. oil);

— Renewables (non-combustible RES, and combustible RES);

— Non-combustible non-renewable fuels (i.e. nuclear).

If, in the different choices, the LCA approach related to the entire supply chain is chosen, not only the primary energy of the fuel consumption, but also all other primary energy flows used to deliver one unit of energy to the building (e.g. losses and infrastructure) shall be taken into account.

C.3.2.2 Fossil fuel

- Technical conversion efficiency convention (Option 3)
  - PEF input fuel =1;
  - η_{gen} = from >0 to <1.

Regarding fossil fuels, technical efficiencies of the conversion technologies are used to calculate the PEF.

In case of combustible fuel, heat and electricity E_{in} and E_{out} can also be determined, for example, by energy meters. η_{gen} can then be calculated. The result ranges from $0 < \eta_{gen} < 1$ and is designated in 6.3.3 as technical conversion efficiency convention (Option 3).

C.3.2.3 Renewable energy (RES)

This subclause is relevant for PEFs only.

If the entire supply chain is taken into account, LCA-based approaches can be used in addition.

- Zero equivalent convention (Option 1)
  - PEF input fuel = 0. The "Zero equivalent method" sets the PEF for electricity from non-combustible RES to 0;
  - η_{gen} = not relevant;
- $E_{P;el} = 0$. By this convention, the primary energy input to the conversion devices is mathematically set to zero. It is designated in 6.3.3 as Zero equivalent convention. The "Zero equivalent method" accounts no primary energy at all for the use of RES in electricity generation.
- Direct equivalent convention (Option 2)
  - PEF input fuel = 1. "Direct equivalent method" sets the PEF of RES to 1;
  - $\eta_{gen} = 1$, means that the conversion process has no losses by convention. It is designated in 6.3.3 as Direct equivalent convention.
- Technical conversion efficiency method (Option 3)
  - PEF input fuel = 1. The "Technical conversion efficiency method" defines the PEF of the (renewable) fuel as 1;
  - η_{gen} = real, uses the conversion efficiencies of the technologies to determine the primary energy demand to generate one kWh of electricity.
- Physical energy content convention (Option 4)
  - PEF input fuel = 1;
  - η_{gen} = depending on the energy carrier.

The “Physical energy content method” is used by Eurostat. The general principle of this method is that the primary energy form should be the first energy form in the production process which is used for various energy purposes.

— For directly combustible energy products (e.g. coal, crude oil, natural gas, biomass, waste) it is their energy content based on NCV.

— For products that are not directly combustible, the application of this principle leads to

  — the choice of heat as the primary energy form for nuclear, geothermal and solar thermal;

  — the choice of electricity as the primary energy form for solar PV, wind.

In case of electricity and heat generated from geothermal energy, if the actual amount of geothermal heat is not known, the primary energy equivalent is calculated assuming an efficiency of (Source: Eurostat):

— 10 % for electricity production ($f_{P,\,ren}$ = 10);

— 50 % for derived heat production ($f_{P,\,ren}$ = 2).

In cases when the amount of heat produced in the nuclear reactor is not known, the primary energy equivalent is calculated from the electricity generation by assuming an efficiency of 33 % ($f_{P;nren}$ = 3).

If only the in-use phase of the conversion devices is considered and the energy embedded in the materials and the energy for the construction and the deconstruction is not part of the PEF (No LCA), the different conventions result in the values shown in Table C.3:

Table C.3 — Resulting values for an energy carrier from renewable energy

		$f_{P;tot}$	$f_{P;nren}$	$f_{P;ren}$
Option 3	$0 < \eta_{gen} < 1$	> 1	0	> 1
Option 2	$\eta_{gen} = 1$	1	0	1
Option 1	$E_{P;el} = 0$	0	0	0

The physical energy content (primary energy) convention (Option 4) in 6.3.3 states that $E_{P;el} = E_{pr;el}$, so this convention neglects the conversion process. It yields the same results as the direct equivalent convention in Table C.4. The difference with the direct equivalent convention is that the generated energy carrier is considered as the primary energy.