

Feature 4

Real energy consumption

Guidelines

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EXECUTIVE SUMMARY

This document describes the method and provides accompanying guidelines, that – together with the Excel spreadsheet calculation tool – allows executioners of the tool, both public authorities' representatives in the implementation of the feature as the EPC Practitioners, to implement it and these documents also serve as a basis in the training of qualified experts.

This method description contains a description of the general principles of the method, the formula structure, methodological options and definitions of input parameters and output indicators. It also provides guidance on how to obtain the input parameters to be inserted in the calculation tool and gives basic information on the output to facilitate correct interpretation of the results.



1 INTRODUCTION TO THE CALCULATION METHOD

The calculation method of Feature 4 – real energy consumption - is based on principles and calculation modules of different existing methods, such as the approach for standard measured energy performance of EN 52000-1: 2017 and the Swedish energy performance determination method based on measured energy use data.

You will find more information about the feature "Real Energy Consumption" of the EU X-tendo project in the following link: <https://x-tendo.eu/toolboxes/real-energy-consumption/>

The actual energy data is by default corrected to standard outdoor climatic conditions;

- ⦿ heating degree-days (application space heating only);
- ⦿ cooling degree-days (application space cooling only).

The actual energy data of solar systems is optionally corrected to standard outdoor climatic conditions;

- ⦿ solar irradiation (solar systems only).

The actual energy data is optionally corrected to standard use;

- ⦿ indoor temperature during heating season (application space heating only);
- ⦿ domestic hot water energy use (application domestic hot water only).

The method developed for Feature 4 can be applied to residential and non-residential buildings (not for multiple buildings). It requires data obtained from energy monitoring infrastructure including submetering (depending on the configuration of technical installations of the building). The monitoring infrastructure needs to be present or installed in the building (unit) submit to energy performance assessment. The meters included in the monitoring infrastructure can consist of electricity, gas, oil, heat meters or several of those.

The calculation procedure contains two main parts:

- In the first part (step 1, 2, 3 and 4) the input data of measured final energy per energy carrier and per application with corresponding start and end date are corrected to represent the energy use of the actual building of one year with standard climate and standard use.
- In the second part (step 5) the energy performance indicators are determined based on the total corrected final energy per energy carrier through calculation of the weighted energy balance equation according to EN 52000-1.



2 METHODOLOGICAL OPTIONS

The method incorporates different options to determine the energy performance of the building unit. These options are related to the correction modules (apply correction or not) or to the calculation method itself (for instance correction based on a fixed value or as function of additional input(s)). In general, these methodological choices have to be made by the Member States implementing bodies, but it can also be chosen to leave certain choices optional in the method and to be made by the EPC Practitioner for each building unit.

The following options are available in the method:

- Ⓞ Optional module: correction for solar irradiation: "Apply correction for solar irradiation?" (yes/no)
 - In case "no" is selected, monthly values for solar irradiation on a horizontal plane for the standard (reference) year L_{soLSTD} serve to translate the solar energy data for the period not equal to one year to a period of one year. In this case there is no need for values of L_{soLhor} of the most recent years as an input to be provided by MS.
 - In case "yes" is selected, the solar energy data obtained in a period with actual solar irradiation is corrected to represent solar energy data of a one year period with standard (reference) solar irradiation. This additionally requires input by MS of monthly values of solar irradiation on a horizontal plane L_{soLhor} of recent years.
- Ⓞ Optional module: correction for domestic hot water: "Apply correction for domestic hot water energy?" (yes/no)
 - In case "no" is selected, no further info is needed related to this optional module.
 - In case "yes" is selected; the following question is posed:
 - "Total system efficiency of domestic hot water is known?" (yes/no);
 - In case 'yes' is selected, the following question is posed:
 - "Total system efficiency of domestic hot water is a fixed average value or from a linear model?" (fixed value/linear model)
 - In case "fixed value" is selected, the requested input is a fixed input value for the system efficiency of the domestic hot water system [-].
 - In case "linear model" is selected, the requested input is the following:
 - Linear model coefficient a [-]
 - Linear model coefficient b [-]
 These coefficients determine the linear relationship between the net energy use for domestic hot water $Q_{net_STD_DHW}$ and the total system efficiency for domestic hot water $E_{ta_sys_DHW}$ described by the

following equation; $\text{Eta}_{\text{sys_DHW}} = a \times Q_{\text{net_DHW}} + b$

- ⊙ Optional module: correction for indoor environmental conditions: "Apply correction for indoor temperature in heating season?" (yes/no)
 - In case "yes" is selected, the energy delivered for application space heating for each of the energy carriers associated with the application space heating is corrected by a factor as function of the indoor air temperature [°C].
 - In case "no" is selected, no correction for indoor environmental conditions deviating from standard indoor environmental conditions is applied.

3 INPUT

3.1 Introduction

The input can be divided in two categories:

- ① Input that is requested on the level of the building unit that is to be assessed;
- ② Input that is requested on the level of the member states implementing region.

The first category consists mainly of administrative data, information describing the building and it's use and monitoring data. In some cases this data needs preprocessing to obtain the requested input parameter. In that case the required preprocessing approach is described in this document.

An example of input of the first category is gas use for space heating in case there is only one production unit that solely provides thermal energy for space heating. This data is to be supplemented by the corresponding start and end date of the monitoring period.

Another example of the first category – one that requires preprocessing of the data to obtain the requested input parameter - is the final energy use per energy carrier for space heating in case one or more of the production systems is applied also for an application other than space heating, e.g. domestic hot water production. This data is also to be supplemented by the corresponding start and end date of the monitoring period. In this case submetering is required that allows division of the final energy delivered to it over the various applications.

Some examples of input of the second category:

- ① Data of the heating degree-days;
- ② A model valid for the regional context describing the average number of building users as function of the size of the building or other determining parameter(s).

3.2 Input parameters

List of input parameters

The following table contains a list of the input parameters with their abbreviation, unit, name, type and entity that has to provide it.

If default values are available, these are indicated in the column "Default value/Remarks" (tab "F4_Main") or pre-inserted in the input cell (tab "F4_Tables_&_Assumptions") for use in case no national or regional values are available.

Table 1 – List of input parameters

Abbreviation	Unit	Name	Type	Entity*
f_Pnren	kWh _{prim} /kWh _{fin}	Conversion factor to non-renewable primary energy	Value per energy carrier	MS
f_Pren	kWh _{prim} /kWh _{fin}	Conversion factor to renewable primary energy	Value per energy carrier	MS

f_Ptot	kWh _{prim} /kWh _{fin}	Conversion factor to total primary energy	Value per energy carrier	MS
K_CO2	g/kWh _{fin}	Conversion factor to CO ₂ equivalent emissions	Value per energy carrier	MS
k_exp	-	Factor to control which part of exported energy is included in the EP of the building	Value	MS
-	-	Climate zone	Text (multiple climate zones possible)	MS
HDD	-	Heating degree-days	Value per month per year and per month for the standard year	MS
CDD	-	Cooling degree-days	Value per month per year and per month for the standard year	MS
I _{soL} hor	kWh/m ²	Solar irradiation on a horizontal plane	Value per month per year and per month for the standard year	MS
T _i STD _H	°C	Standard indoor temperature (standard use) during the heating season	Value per subtype of building	MS
Δ _T gains _H	°C	Temperature offset for heat gains in heating season (standard year)	Value per subtype of building	MS
T _e repres _H	°C	Representative outdoor temperature during the heating season (standard year)	Value per climate zone	MS
A _{STD} p	m ² /person	Standard area per building user	Value per subtype of building	MS
Q _{STD} net _{DHW} A	kWh/(m ² .year)	Annual standard net energy use for DHW per unit of useful floor area	Value per subtype of building	MS
x	-	Coefficient x for calculation of residential reference DHW use	Value	MS
y	-	Coefficient y for calculation of residential reference DHW use	Value	MS
T _{dhw}	°C	Specified mixed DHW delivery temperature	Value	MS
T _{cw}	°C	Specified cold water delivery temperature	Value	MS
-	-	Apply correction for indoor temperature in heating season (optional)?	Selection list (Yes/No)	MS
-	-	Apply correction for DHW energy (optional)?	Selection list (Yes/No)	MS



-	-	Total system efficiency of DHW is known?	Selection list (Yes/No)	MS/P
-	-	Total system efficiency of DHW is a fixed average value or from a linear model?	Selection list	MS/P
-	-	Building name	Text	P
-	-	Building identifier	Value	P
-	-	Building address	Text	P
-	-	Building year of construction	Text	P
-	-	Building year of renovation	Text	P
-	-	Building picture	Picture	P
-	-	EPC Practitioner name	Text	P
-	-	EPC Practitioner identifier	Value	P
-	-	EPC Practitioner address	Text	P
-	-	EPC Practitioner signature	Signature	P
-	-	Country	Selection list	P
-	-	Region	Selection list	P
-	-	Type of building	Selection list	P
-	-	Subtype of building	Selection list	P
n	-	Number of residential units in MFH	Value	P
A _{use}	m ²	Building useful floor area	Value	P
Q _{act_i_cr}	kWh	Actual energy delivered (or exported) per energy carrier and per application for monitoring period per energy carrier	Value	P
-	-	Monitoring period start date	Date (possible per energy carrier)	P
-	-	Monitoring period end date	Date (possible per energy carrier)	P
-	-	Energy carrier type (in case of energy carrier Fuel or Fuel for CHP)	Selection list	P
-	-	Energy carrier subtype (in case of energy carrier Fuel or Fuel for CHP)	Selection list	P
-	-	Technology (in case of energy carrier electrical energy from on-site)	Selection list	P
n _{act_p}	-	Actual number of building users	Value	P
Eta _{DHW}	-	Total system efficiency for DHW	Value	P
a	-	Linear model coefficient a	Value	P
b	-	Linear model coefficient b	Value	P
T _{i_act_H}	°C	Actual indoor temperature during the heating season	Value	P

*Entity: MS= Member States national or regional implementation body

P=EPC Practitioner

Text style italic: Input depending on choice of methodological options

Definitions and information on how to obtain the input parameters

Weighting factors

Weighting factors to convert final to primary energy and to CO₂ equivalent emissions are defined according to EN ISO 52000-1: 2017.

Primary energy factors f_{Pren} , f_{Pnren} and f_{Ptot} and CO₂ conversion factors K_{CO2} are to be specified by the regional implementing bodies reflecting the local context taking into account the origin of the delivered and the destination for exported energy. The factors can be different for delivered and exported energy, also per energy carrier.

Default values are available and pre-inserted. These correspond with the informative default values provided in Table A.16 and Table B.16 of EN ISO 52000-1: 2017 [EN 52000-1: 2017]. It is strongly advised to replace these by values that better represent the local context.

Member States Implementing bodies may choose to introduce additional weighting factors to favorize or penalize specific energy carriers.

Factor for exported energy weighting

The factor to control which part of exported energy is included in the energy performance of the building k_{epx} is to be specified by the Member States. The default value for k_{exp} according to EN ISO 52000-1: 2017 is equal to 1 and as such pre-inserted in the calculation tool.

Values between and including 0 and 1 are valid. A value of 0 corresponds with weighting of the exported energy with the same weighting factor values as used for the delivered energy of the same energy source, e.g. PV, Wind or CHP, meaning that the energy delivered to the building that is exported is not accounted for (it is added to the delivered and subtracted in the exported terms of the energy balance equation, resulting in zero in the energy balance equation). A value of 1 results in accounting for the exported energy using weighting factors (primary energy, CO₂,...) that reflect energy delivered from distant and thus accounts for the avoided resources. Standard

The factor for exported energy weighting k_{exp} controls which part of exported energy is included in the energy performance of the building. Standard ISO TR 52000-2 [CEN; 2017b] contains examples illustrating the principle.

Heating degree-days

Monthly values of the heating degree-days and monthly values for the standard (also referred to as normal or reference) year is to be inserted by the Member states. It concerns values for time periods in the past. Multiple sets of these parameter values may be required, one for each region within the member state with different climatic conditions.



National values of yearly or monthly HDD and CDD are available from Eurostat¹.

Cooling degree-days

Monthly values of the cooling degree-days and monthly values for the standard (reference) year is to be inserted by the Member states. It concerns values for time periods in the past. Multiple sets of these parameter values may be required, one for each region within the member state with different climatic conditions.

National values of yearly or monthly HDD and CDD are available from Eurostat (see Heating degree-days).

Solar Irradiation on a horizontal plane

Monthly values of the solar irradiation on a horizontal plane I_{soLhor} and a value for the standard (reference) year I_{soLSTD} is to be inserted by the member states implementing bodies. It concerns values for time periods in the past. Such data can be obtained from a weather station that includes a pyranometer or it can be retrieved online. Multiple sets of these parameter values may be required, one for each region within the member state with different climatic conditions, more specifically solar irradiation levels.

Values are available for monthly solar irradiation on a horizontal plane of the standard (reference) year I_{soLSTD} for all location via PVGIS². One set of data of I_{soLSTD} (reference period 2005-2016) for each MS is included as a default in the calculation tool.

Monthly values of I_{soLhor} are only required as an input in case "Yes" is selected as an answer to the question "Apply correction for solar irradiation?". There are no default values available for Monthly solar irradiation on a horizontal plane I_{soLhor} (recent years).

Standard indoor temperature during the heating season

The standard indoor temperature (standard use) in heating season $T_{i_std_H}$ [°C] is to be specified by the member states per subtype of building.

In case no value is available for the standard indoor temperature (standard use) in heating season, values of indoor setpoint temperature in winter can be adopted from EN ISO 13790: 2008, table G.12 and implemented as the standard indoor temperature (normal use) during the heating season for the respective building subtype. The respective part of the table is adopted here;

¹ <https://ec.europa.eu/eurostat/web/energy/data/database>.

If differentiation within national regions is required because of heterogenous climatic conditions, NUTS 2 values are also available from the same source from which values for the various regions can be determined. Also, historical data dating back to 1979 is available, allowing to construct a reference "normal" year.

² JRC Photovoltaic geographical information system (PVGIS); https://re.jrc.ec.europa.eu/pvg_tools/en/#TMY. Above 60N use PVGIS-ERA5 instead of PVGIS-SARAH.

Table 2 – Internal setpoint temperature in winter (Source : EN ISO 13790: 2008 [CEN; 2008])

Building type	Internal setpoint temperature in winter [°C]
Single-family houses	20
Apartment blocks	20
Offices	20
Educational buildings	20
Hospitals	22
Restaurants	20
Trade services	20
Sports facilities	18
Meeting halls	20
Industrial buildings	18
Warehouses	18
Indoor swimming pool	18

The values for building subtype Multifamily house and apartment are taken equal to the value for building type Apartment blocks.

These values are pre-inserted in the calculation tool. It is advised that member states implementing bodies replace these by values that better represent the local context.

This parameter is used to calculate the correction for indoor temperature. More specifically when "Yes" is selected for "Apply correction for indoor temperature?".

Temperature offset for heat gains during the heating season

When calculating the energy demand for space heating, the temperature difference between indoor and outdoor often is corrected to account for a preheating due to solar and internal heat gains. This corresponds with the temperature offset for heat gains during the heating season $\Delta T_{\text{gains}_H}$.

The temperature offset for heat gains during the heating season (standard year) $\Delta T_{\text{gains}_H}$ [°C] is to be specified by the member states implementing bodies per building subtype. The default value is equal to 3°C for all building subtypes. This value is pre-inserted in the calculation tool. It is advised that member states implementing bodies replace this value by a value that better represent the local context.

This parameter is used to calculate the correction for indoor temperature. More specifically when "Yes" is selected for "Apply correction for indoor temperature?".

Representative outdoor temperature during the heating season

The representative outdoor temperature during the heating season (standard year) $T_{e_repres_H}$ [°C] is the outdoor air temperature representative for the heating season with standard climatic conditions (normal year). $T_{e_repres_H}$ is to be specified by the member states implementing bodies. Multiple values of this parameter may be required, one for each region within the member state with different climatic conditions. A default value is automatically inserted for the climate zone of the selected location. Each location is

assigned to one of three climatic zones as function of the standard HDD value of the location by use of the following rules (according to the Aldren project [Bendzalova J. et al.; 2019]);

Table 3: Climatic zones

Climatic zone	Definition	Represented by	T _{e,repres,H} [°C]
Warm	HDD_STD ≤ 1200	Palermo	13,4
Moderate	1200 < HDD_STD ≤ 4000	Bratislava	5,0
Cold	HDD_STD > 4000	Helsinki	2,2

The value for the respective climatic zone is pre-inserted in the calculation tool. It is advised that member states implementing bodies replace the pre-inserted value by a value that better represents the local context.

This parameter is used to calculate the correction for indoor temperature. More specifically when "Yes" is selected for "Apply correction for indoor temperature?".

Standard area per building user

The standard area per building user A_{std,p} [m²/person] is to be specified by the member states implementing bodies per subtype of building.

In case no value is available for the standard area per building use, values of the standard area per person can be adopted from EN ISO 13790: 2008, table G.12 and implemented as the standard area per building user for the respective building subtype. The respective part of the table is adopted here;

Table 4 – Standard area per person (Source : EN ISO 13790: 2008 [CEN; 2008])

Building type	Standard area per person [m ² /person]
Single-family houses	60
Apartment blocks	40
Offices	20
Educational buildings	10
Hospitals	30
Restaurants	5
Trade services	10
Sports facilities	20
Meeting halls	5
Industrial buildings	20
Warehouses	10
Indoor swimming pool	20

The values for building subtype Multifamily house and apartment are taken equal to the value for building type Apartment blocks.

These values are pre-inserted in the calculation tool. It is advised that member states implementing bodies replace these by values that better represent the local context.

This parameter is used to calculate the correction for DHW energy use. More specifically when "Yes" is selected for "Apply correction for DHW?".

Annual standard net energy use for DHW per unit of useful floor area

The annual standard net energy use for domestic hot water per unit of useful floor area $Q_{STD_net_DHW_A}$ [$kWh_{net}/(m^2 \cdot year)$] is the energy demand for DHW (net energy level) that is considered representative for standard use for the respective building subtype and is expressed per unit of useful floor area A_{use} .

In case no value is available for the standard net energy use for DHW per unit of useful floor area, values of the heating need for hot water per conditioned floor area can be adopted from EN ISO 13790: 2008, table G.12 and implemented as the annual standard net energy use for DHW per unit of useful floor area for the respective building subtype. The respective part of the table is adopted here;

Table 5 – Heating need for hot water per conditioned floor area (Source : EN ISO 13790: 2008 [CEN; 2008])

Building type	Heating need for hot water per conditioned floor area ^a [kWh/m^2]
Single-family houses	10
Apartment blocks	20
Offices	10
Educational buildings	10
Hospitals	30
Restaurants	60
Trade services	10
Sports facilities	80
Meeting halls	10
Industrial buildings	10
Warehouses	1,4
Indoor swimming pool	80

a: These figures refer to the gross conditioned area, calculated with external building dimensions. This area includes all conditioned space contained within the thermal insulation layer. For example, an internal unheated (but indirectly heated) staircase is included, but a cellar is not.

These values are pre-inserted in the calculation tool. It is advised that member states implementing bodies replace these by values that better represent the local context. Alternatively, member states implementing bodies can replace the values for the annual standard net energy use for DHW by a model to determine the annual standard net energy use for DHW representative for the local context.

This parameter is used to calculate the correction for DHW energy use in case the system efficiency is available. More specifically when "Yes" is selected for "Apply correction for DHW?" and "Yes" is selected for "Total system efficiency is known?". It is only implemented for building type "non-residential".

Coefficient x for calculation of residential reference DHW use

The coefficient x represents a value of volume of DHW delivered per person and per day at the specified temperatures. These temperatures are also to be inserted in the calculation

tool (see chapters "Specified mixed DHW delivery temperature" and "Specified cold water delivery temperature" below. The net energy use for DHW is calculated as the minimum of the net energy use for DHW determined based on coefficient x and that based on coefficient y (see following chapter).

The coefficient x for calculation of residential reference DHW use $x [-]$ is taken equal to the default value included in standard EN12831-3: 2017 [CEN; 2017g]; 40,71. This value is pre-inserted in the calculation tool. The possibility is included in the calculation tool for member states implementing bodies to replace this by a value that better represent the local context. It is only allowed to insert a positive value. Alternatively, member states implementing bodies can also replace the model to determine the annual standard net energy use for DHW by a model to determine the annual standard net energy use for DHW or a fixed value better representative for the local context.

Coefficient y for calculation of residential reference DHW use

The coefficient y represents a value of volume of DHW delivered per day at the specified temperatures expressed per unit of habitable floor area. These temperatures are also to be inserted in the calculation tool (see chapters "Specified mixed DHW delivery temperature" and "Specified cold water delivery temperature" below. The net energy use for DHW is calculated as the minimum of the net energy use for DHW determined based on coefficient x (see previous chapter) and that based on coefficient y.

The coefficient y for calculation of residential reference DHW use $y [-]$ is taken equal to the default value included in standard EN12831-3: 2017 [CEN; 2017g]; 3,26. This value is pre-inserted in the calculation tool. The possibility is included in the calculation tool for member states implementing bodies to replace this by a value that better represents the local context. It is only allowed to insert a positive value. Alternatively, member states implementing bodies can also replace the model to determine the annual standard net energy use for DHW by a model to determine the annual standard net energy use for DHW or a fixed value better representative for the local context.

Specified mixed DHW delivery temperature

The specified mixed domestic hot water delivery temperature $T_{dhw} [^{\circ}C]$ is the average tapping temperature level at the draw-off locations.

The default value is adopted from EN 12831-3: 2017, table B.6 [CEN; 2017g] and equal to 42°C. This value is pre-inserted in the calculation tool. The possibility is included in the calculation tool for member states implementing bodies to replace this by a value that better represents the local context. Alternatively, member states implementing bodies can also replace the model to determine the annual standard net energy use for DHW by a model to determine the annual standard net energy use for DHW or a fixed value better representative for the local context.



The parameter is used to calculate the standard net DHW energy use in residential buildings. More specifically for building type "Residential" and in case "Yes" is selected for "Apply correction for DHW?".

Specified cold water delivery temperature

The specified cold water delivery temperature T_{cw} [°C] is the average temperature of the cold water supply at the entry of the building.

The default value is adopted from EN 12831-3: 2017, table B.6 [CEN; 2017g] and equal to 10°C. This value is pre-inserted in the calculation tool. The possibility is included in the calculation tool for member states implementing bodies to replace this by a value that better represents the local context. Usually (underground cold water distribution system) the specified cold water delivery temperature is taken equal to the average of the standard outdoor air temperature. Alternatively, member states implementing bodies can also replace the model to determine the annual standard net energy use for DHW by a model to determine the annual standard net energy use for DHW or a fixed value better representative for the local context.

The parameter is used to calculate the standard net DHW energy use in residential buildings. More specifically for building type "Residential" and in case "Yes" is selected for "Apply correction for DHW?".

Year of renovation

The year of renovation is the most recent year construction works have been conducted that have a significant improvement on the energy performance of the building (unit). Examples of such construction works include thermal insulation of (large part of) the building envelope or replacement of the heating system (at least: replacement of the production system and recommissioning of the heating system).

This parameter is reported as output.

Type of building

The type of building is to be selected by the EPC Practitioner from a pre-defined list containing the following options to select from:

- Residential;
- Non_residential.

The selected type of building is also reported as output.

Subtype of building

The subtype of building is to be selected by the EPC Practitioner from a pre-defined list depending on the type of building.

For type of building is "Residential", the list contains the following options to select from;



- ⊙ Single-family houses;
- ⊙ Apartment;
- ⊙ Multifamily house.

For type of building is "Non_residential", the list contains the following options to select from:

- ⊙ Office;
- ⊙ Education building;
- ⊙ Hospital;
- ⊙ Restaurant;
- ⊙ Trade service;
- ⊙ Sports facility;
- ⊙ Meeting hall;
- ⊙ Industrial building;
- ⊙ Warehouse;
- ⊙ Indoor swimming pool;
- ⊙ Other non-residential.

The types included in these lists relate to the standard characteristics for the optional correction methods for indoor temperature in heating season and domestic hot water reference use.

Member states can replace the subtypes and the corresponding standard characteristics by alternatives that better reflect the local context.

The selected subtype of building is also reported as output.

Number of residential units in MFH

The number of residential units in a multifamily house (MFH) n is the amount of residential building units in a building entity in which more than one residential unit is contained.

This input parameter is only required in case type of building is Multifamily house.

This parameter is also reported as output.

Building useful floor area

Building useful floor area A_{use} [m^2] is the gross surface area of the floors of the building (unit). It is based on external building dimensions. Member States can decide to use another metric for the size of the building (e.g. useful floor area based on internal dimensions). In that case, following adjustments are required to the calculation sheet:

- ⊙ The values for A_{std_p} [m^2/p] and $Q_{std_net_DHW}$ [$kWh/(m^2 \cdot year)$] need to be adjusted so that these values are related to the correct dimensions (e.g. via a correction factor that represents the ratio of the useful floor area according to the new metric to the useful floor area based on external dimensions). Alternatively, the model to determine the annual standard net energy use for DHW can be replaced by another model to

determine the annual standard hot energy use for DHW representative for the local context.

- ⊙ The explanation in the "default/remarks" column of tab "F4_Main" for row 20 ("Building useful floor area" needs to be altered accordingly.
- ⊙ It is advised to report the definition of the useful floor area that is implemented in the method together with the energy performance indicators.

The area corresponds with the useful floor area of the subtype building (e.g. apartment versus multifamily house).

This parameter is also reported as output.

Actual energy delivered (or exported) per energy carrier and per application

The actual energy delivered (or exported) per energy carrier and per application is to be inserted together with the monitoring period per energy carrier, the specification of the energy carrier type and subtype or the technology. The specification of the energy carrier type is required for the following energy carriers:

- ⊙ Fuel;
- ⊙ Fuel for CHP.

For both energy carriers, the selection options for the type are the same:

- ⊙ Liquid;
- ⊙ Gaseous;
- ⊙ Solid.

For these energy carrier types, the selection options for the subtype are the same:

- ⊙ Fossil;
- ⊙ Bio.

The specification of the technology is required for energy carrier Electrical energy from on-site. The selection options for the technology type are:

- ⊙ PV;
- ⊙ Other.

PV is selected in case the technology consists of one or more photovoltaic system(s).

Other is to be selected in case another technology is delivering electrical energy from on-site except a combined heat and power system. This can be for instance wind turbines generating electrical energy.

The energy delivered (or exported) is to be inserted per application for the following applications separately:

- ⊙ Space heating;
- ⊙ Domestic hot water;
- ⊙ Space cooling;

- ⊙ Other;
- ⊙ Electrical energy production;
- ⊙ Exported electrical energy.

Not all cells need to be completed. It depends on the system configuration of the building unit.

It is not allowed to insert negative values. This means that for cooling, by convention, the heat that is rejected is considered positive (e.g. energy carrier environment delivered from on-site to application cooling is considered positive when heat is transferred from the condenser of the cooling system to the environment).

Energy delivered for application other should only include EPC-related energy uses. All non-EPC related energy uses, e.g. energy use of appliances (plug loads), cooking equipment, mechanical escalators, elevators, should be excluded from the input.

Energy delivered for application electrical energy production can only be inserted for energy carrier Fuel for CHP.

In case of CHP, a non-zero value should be inserted for fuel for CHP delivered for electrical energy production and at least one of the thermal applications (space heating, domestic hot water, space cooling and or other).

Special cases of CHP (e.g. because of malfunctioning);

In case a CHP system has zero actual energy delivered for electrical energy production during the monitoring period and thus no fuel for CHP delivered for electrical energy production, it should be treated as an energy carrier fuel and not fuel for CHP (thus similar to a combustion boiler).

In case a CHP would not deliver energy for thermal applications (and thus zero values for fuel delivered for those applications are to be inserted) it cannot be included in the F4 calculation tool. The electrical energy produced by the CHP should in that case best be treated as energy carrier electrical energy.

Exported electrical energy can only be inserted for energy carriers Electrical energy produced by CHP and Electrical energy from on-site. This should also include the part that is used on-site for non-EPC related uses.



The energy delivered (or exported) is the final energy³, except for energy carrier Electrical energy produced by CHP. For energy carrier Electrical energy produced by CHP the energy delivered is the electrical energy output of the combined heat and power system(s)⁴.

The energy delivered (or exported) is the energy corresponding with the monitoring period defined by start date and end date and expressed in kWh. For energy carriers Fuel and Fuel for CHP, the procedures as described in EN 15378-3: 2017 [CEN; 2017c] can be followed to obtain the requested parameter values in kWh.

Uninterrupted monitoring results for a time period in which at least 12 entire months are included are required. It is advised not to further shorten the monitoring period (and use extrapolation (e.g. based on HDD for space heating etc...), especially in climatic zones with milder winters. The monitoring period is limited to maximum 2 years. The time lag between the last month of monitoring and the assessment report is not allowed to be more than x months (e.g. x=12). This is to be evaluated at the level of each input (final energy use per application and per energy carrier), as the measurement interval of the various input parameters may be asynchronous.

In case of changes to the building physical characteristics, changes to or malfunctioning of the technical installation or changes in the use of the building (e.g. number of building users, occupancy profiles), since or during (part of) the monitoring period, this should be reported on. Depending on the nature of the changes, these can be corrected for in the measurement values or in case that is not feasible, values from another monitoring period should be inserted.

The monitoring period start date and end date are to be specified for each energy carrier. It is strongly advised to use monitoring data of the same monitoring period for all the energy carriers associated with the building (unit) that is to be assessed. This is not a necessity and the possibility is incorporated in the calculation tool to insert energy data for different monitoring periods for the various energy carriers associated with the building.

No significant changes should have occurred in the building or the building use in the period between the earliest start date and the most recent end date of all the energy carriers for the respective building (unit), otherwise the data cannot be allowed for the assessment.

³ Final energy is the energy delivered to the building's technical systems. It sometimes is referred to as "purchased" energy. For solar systems (thermal or photovoltaic) the system boundaries exclude the collectors, so the final energy is not the solar irradiation on the aperture area of the collectors, but the energy delivered by the collectors to the system of the building unit. This implies that the efficiency of the collectors is not part of the analysis and evaluation. Similarly for electrical energy delivered on-site by wind turbines.

⁴ Note that the sum of energy delivered to all applications of energy carrier Electrical energy produced by CHP is not equal to the energy delivered for Electrical energy production of energy carrier Fuel for CHP. The difference represents the production system losses for Electricity production of the CHP system(s).



Monitoring infrastructure should be present or is to be installed that enables the monitoring of all the energy delivered for EPC-related uses per energy carrier and for the specified applications. This consists of meters at final energy level per energy carrier and submetering for each of the applications per energy carrier if required (depending on the configuration of the technical system). In case the technical system configuration of the building (unit) that is to be assessed does not contain an application or one or more of the energy carriers, the respective input should be omitted (leave blank or insert zero).

A separation of energy use over different production units and or applications may be required. An energy carrier can serve more than one production unit of which one or more can serve more than one application. Furthermore, an application can be provided by energy input from different production units that may have different energy carriers and each of those may serve different applications. An approach following the energy use from application (net energy use) to the delivery (final energy use) (and the other way around) allows for this separation. The separation can be done assuming equal efficiency of the same technology disregarding the application it serves or can be weighted according to the efficiency of the respective applications (if information on these efficiency values is available). For instance, a heat pump serving both space heating and domestic hot water that has meters at the level of gross energy use (output of the production system) for both applications, the end energy consumption can be divided according to the share of the output for the respective applications (in case of assumption of equal efficiency) or these shares can be weighted according to the respective efficiencies.

The principles of such separation procedures are described in annex E of standard EN 52000-1: 2017 [CEN; 2017a].

Actual number of building users

The actual number of building users $n_{act,p}$ [-] is the number of building users that have been using the building during the monitoring period. In case this information is not available, the design value can be inserted as a proxy for the actual number of building users.

This input parameter is only required in case "Yes" is selected for "Apply correction for DHW?" and "No" is selected for "Total DHW system efficiency is known?".

Total system efficiency for DHW

The total system efficiency for domestic hot water η_{DHW} [-] is the ratio of the net energy use for DHW to the final energy use for DHW. The total system efficiency can be calculated from measurements of final energy use for DHW and net energy use for DHW.

Note that the final energy use for DHW should include also the renewable energy delivered to application DHW. For instance, in case of a heat pump, the environment energy delivered to the heat pump and associated with the production of DHW must be included in the final energy use for DHW in the calculation of η_{DHW} .

Usually, the net energy use for DHW will not be available and if measurement at that level is present it mostly will not be in energy quantity but in DHW volume. The DHW volume



together with assumptions on the average (both in space and time when tapping occurs) difference between the temperature of the cold water supply and the tapping temperature (prior to mixing) allows to have an estimate of the net energy demand for DHW.

In case the system efficiency of DHW can be determined for all components except the distribution system (e.g. from measurements of final and gross energy use for DHW), only the distribution system efficiency is needed to calculate the total DHW system efficiency.

The distribution system efficiency can be determined based on calculation starting from thermophysical characteristics of the distribution system as described in EN 15316-3: 2017 [CEN; 2017h] or it can be determined experimentally. Experimental determination can be done for instance by monitoring of supply and return temperatures of the DHW circulation system at conditions sufficiently corresponding with steady state during which no tapping occurs. This could be executed on relative short term (e.g. a couple of hours). In case of combi circuits delivering heat for both space heating and DHW, the total distribution losses need to be divided between space heating and DHW applications, this could be done by weighting the total losses according to the gross energy demand for space heating and DHW and potentially additionally taking the temperature level of the respective applications into account. In a distribution system structure with (tree-branched) single line pipes to the tapping locations, this would require temperature measurements at the tapping locations and the determination of the downtime losses, e.g. represented by a timefactor.

In case no value for the total system efficiency for DHW is available and it cannot be derived from measurements of the net energy use for DHW and the final energy use for DHW, "No" is to be selected for "Total system efficiency of DHW is known?".

This parameter is used to calculate the correction factor for DHW energy use. It is only required as an input in case "Yes" is selected for "Apply correction for DHW?" and "Yes" is selected for "Total system efficiency of DHW is known?" and "Fixed value" is selected for "Total system efficiency of DHW is a fixed average value or from linear model?".

Linear model coefficient a

The linear model coefficient a is used to calculate the standard DHW energy use. It is only required as an input in case "Yes" is selected for "Apply correction for DHW?" and "Yes" is selected for "Total system efficiency of DHW is known?" and "Linear model" is selected for "Total system efficiency of DHW is a fixed average value or from linear model?".

The linear model coefficient is used to determine the total system efficiency of DHW Eta_{DHW} as function of the net standard energy use for DHW. The linear relationship between the net energy use for domestic hot water $Q_{\text{net_STD_DHW}}$ and the total system efficiency for domestic hot water $\text{Eta}_{\text{sys_DHW}}$ described by the following equation:

$$\text{Eta}_{\text{sys_DHW}} = a \times Q_{\text{net_DHW}} + b$$

This equation is to be determined based on linear regression (least squares method or minimum quadratic error (see EN 15378-3: 2017 [CEN; 2017c] for a description)) of net energy

use for DHW and total system efficiency of DHW. The total system efficiency of DHW is equal to the ratio of the net energy use for DHW to the final energy use for DHW. Measurements are required to obtain value sets for the net energy use for DHW and final energy use for DHW. These are ideally representative for standard tapping profiles; including low DHW demand as well as higher DHW demand.

Linear model coefficient b

The linear model coefficient b is used to calculate the standard DHW energy use. For further explanation see Linear model coefficient a.

Actual indoor temperature during the heating season

The actual indoor temperature during the heating season $T_{i_act_H}$ [°C] is the average of air temperature measurements in one room, considered representative for the indoor temperature of the entire building (unit).

The average⁵ actual indoor air temperature $T_{i_act_H}$ can be derived from measurements in two steps:

- ① A monthly average indoor temperature is calculated from the measurements during the heating season of the indoor air temperature;
- ② A representative value for the actual indoor temperature for the heating season is calculated as the average weighted⁶ according to the standard degree-days of the months included in the heating season from the monthly average indoor temperatures (calculated in the previous step) of the months included in the heating season.

The method requires measurement results for indoor temperature in at least one room considered to be representative for the entire building unit. It also requires the heating season period to be defined during which indoor temperature measurements are to be considered.

Ideally, the measurements occur in the same heating season as comprised in the monitoring results for energy delivered for application space heating for all associated energy carriers. This is not a necessity, as the average indoor temperature of another heating season can also be considered to be representative for the use of the building in relation to the

⁵ There are some notes to be made on intermittent heating (periods with variable heating temperature setpoints and/or with periods of switch-off). Here it is opted to use the time averaged value. See also note 1 on p. 111 of EN ISO 52016-1: 2017 [CEN; 2017f]. Furthermore, the monthly values are used to calculate the average value for the entire heating season in which the importance in relation to the heating energy demand is reflected by weighting according to the HDD of the corresponding month for all months included in the heating season.

⁶ Notice that a small deviation occurs, as the base temperature also lowers by the same amount as the difference between actual and standard indoor temperature. This leads to a slight overestimation of the weight for months with lower amount of HDD (and slight underestimation for months with high amount of HDD). In any case it results in a better distribution of the effect of deviating indoor temperature over the heating season.



established temperature levels. No considerable differences in occupancy profiles of the building between the two distinct heating seasons are allowed in that case.

Measurement of indoor temperature can be done in one room, considered to be representative for the indoor temperature of the entire building unit that is certified. In case measurements of indoor temperature are available from multiple rooms, one value can be derived by weighting according to the useful floor area of the zones for which the temperature measurements are considered representative.

The heating season period is represented in a simplified manner by start month and end month considered comprised in the heating season, e.g. for start month=October and end month=May, the heating season length comprises 8 entire months. The definition is required for each distinct climatic region within the implementing regions of the members states.

As a proxy for the actual indoor temperature, thermostat setpoint value(s) can be used to replace the actual indoor temperature.

This parameter is used to calculate the correction factor for indoor temperature. It is only required as an input in case "Yes" is selected for "Apply correction for indoor temperature?".

4 CALCULATION PROCEDURE

4.1 Overview of the calculation procedure

The calculation procedure consists of five steps executed consecutively:

1. Calculation of the correction factors and standard inputs;
2. Calculation of the standard energy required to be delivered;
3. Calculation of the standard energy available by energy carriers of type 1;
4. Calculation of the standard energy delivered and exported;
5. Calculation of the energy performance indicators.

In the first step the correction factors are calculated used to correct the energy data from measurements to represent energy of the actual building under standard conditions of use and climate. For application domestic hot water, the standard net energy for DHW is calculated and to be used as a standard input in case the total DHW system efficiency is known.

In a second step, the total energy required to be delivered to the building under conditions of use and climate is determined per application. In this step no distinction is made in the type of energy carriers. This can be considered as the total final energy required to be delivered under conditions of standard use and climate disregarding the energy carrier that is delivering it. It is related to the demand of the building and also represents the efficiencies of the technologies that transfer the final energy to (the location of) the net demand.

In a third step, the standard energy available by energy carriers of type 1 is calculated per application. This can be interpreted as the maximum amount of energy from energy carriers of type 1 that can be delivered to meet the total required standard energy or part of it for the respective application. In the method, all energy carriers delivered from on-site are considered energy carriers of type 1, all energy carriers delivered from distant and energy carriers delivered from nearby are considered energy carriers of type 2.

In the fourth step the results of step 1 and 2 are brought together to calculate the energy delivered by energy carriers of type 2. This is equal to the remainder of the required standard energy to be delivered to the respective application if only part of the required standard energy can be met by energy carriers of type 1 for the respective application. If the total standard energy required to be delivered to the building can be met by energy carriers of type 1, the standard energy delivered by energy carriers of type 2 is equal to zero.

The standard energy available by energy carriers of type 1 (calculated in step 3) is considered as a fixed contribution to the delivered energy of the application but limited to the total standard energy required to be delivered to the building (calculated in step 2).

Any remainders of the standard energy available by energy carriers of type 1 after fulfilling the standard energy required to be delivered to the building is for all applications added to the standard energy exported.

In the fifth and last step, the energy performance indicators are calculated.



4.2 Step 1: Calculation of the correction factors and standard inputs

Correction to standard outdoor climatic conditions

Outdoor climatic conditions during heating season (HDD)

Heating degree-days method is applied on energy data for application space heating only. It is used to extrapolate or interpolate energy data for monitoring period deviating from one year or to translate the energy data to a representative value for a year with standard outdoor climatic conditions (reference year with standard heating season).

Outdoor climatic conditions during cooling season (CDD)

Cooling degree-days method is applied on energy data for application space cooling only. It is used to extrapolate or interpolate energy data for monitoring period deviating from one year or to translate the energy data to a representative value for a year with standard outdoor climatic conditions (reference year with standard cooling season).

Solar irradiation

The following correction factors are used in case "Yes" is selected for "Apply correction for solar irradiation?" and only applied on the actual energy data for the following energy carriers:

- ☉ electrical energy from on-site: technology PV;
- ☉ solar thermal energy delivered from on-site.

The correction factor $f_{I_{soL1_year}}$ is calculated by the following equation:

$$f_{I_{soL1_year}} = I_{soL1_year} / I_{soLmonper}$$

in which:

I_{soL1_year} is the sum of I_{soLhor} of the most recent twelve months comprised in the monitoring period.

$I_{soLmonper}$ is the sum of I_{soLhor} of all the months comprised in the monitoring period.

The correction factor $f_{I_{soLSTD}}$ is calculated by the following equation:

$$f_{I_{soLSTD}} = I_{soLSTD} / I_{soL1_year}$$

in which:

I_{soLSTD} is the value for I_{soLhor} for the standard year.

In case "No" is selected for "Apply correction for solar irradiation?" only the factor $f_{I_{soL1_year_STD}}$ is calculated by the same equation as above for $f_{I_{soL1_year}}$ but using standard values (reference year). The equation then becomes:

$$f_{I_{soL1_year_STD}} = I_{soL1_year_STD} / I_{soLmonper_STD}$$

in which:

$I_{soL1_year_STD}$ is I_{soLSTD} of one standard (reference) year.

$I_{soLmonper_STD}$ is the sum of I_{soLSTD} of all the months comprised in the monitoring period.

The factor $f_{I_{soL1_year}(STD)}$ is applied to the actual energy data for the following energy carriers:

- ⊙ electrical energy from on-site: technology PV;
- ⊙ solar thermal energy delivered from on-site.

The factor $f_{I_{soLSTD}}$ is not applied in this case.

Correction to standard use

Domestic hot water energy use

The parameters calculated are only used in case "Yes" is selected for "Apply correction for DHW energy?" and only in relation to energy data for application domestic hot water only.

The standard net energy use for domestic hot water $Q_{STD_net_DHW}$ [kWh/year] is calculated as follows;

In case of building type "Residential";

$$Q_{STD_net_DHW} = V_{STD_DHW} \times \rho \times c_p \times (T_{dhw} - T_{cw})$$

In which;

V_{STD_DHW} is calculated according to formula (B.5) of Annex B of standard EN 12831-3: 2017 [CEN; 2017g], in which the habitable area is taken equal to the useful floor area.

$\rho = 994 \text{ kg/m}^3$ (average density of water at conditions representative for water in the DHW system);

$c_p = 0,00116 \text{ kWh/(kg.K)}$ (average thermal capacity of water at conditions representative for water in the DHW system).

In case of building type "Non-residential";

$$Q_{STD_net_DHW} = Q_{STD_net_DHW_p} \times n_{std_p}$$

In which;

$$Q_{STD_net_DHW_p} = A_{std_p} \times Q_{STD_net_DHW_A}$$

$$n_{std_p} = A_{use} / A_{std_p}$$

The standard net energy use for domestic hot water $Q_{STD_net_DHW}$ is only used in case "Yes" is selected for "Total system efficiency of DHW is known?".

The correction factor for domestic hot water energy use f_{DHW} is calculated as follows;

$$f_{DHW} = n_{std_p} / n_{act_p}$$

in which;

$$n_{std_p} = A_{use} / A_{std_p}$$

Correction factor f_{DHW} is only used in case "No" is selected for "Total system efficiency of DHW is known?".

Indoor temperature during the heating season

The correction factor is only used in case "Yes" is selected for "Apply correction for indoor temperature?" and only in relation to energy data for application space heating.

The correction factor f_{T_i} is calculated as follows;

$$f_{T_i} = (T_{i_STD_H} - \Delta T_{gains} - T_{e_repres_H}) / (T_{i_act_H} - \Delta T_{gains} - T_{e_repres_H})$$

Note that the average value of the actual temperature offset during a heating season is assumed equal to the standard temperature offset during heating season of a normal year, so no input value is required for the actual temperature offset.

4.3 Step 2: Calculation of the standard energy required to be delivered

In the first step the total energy required to be delivered per application i for standard use and climate $Q_{req_STD_i_tot}$ and the relative shares of energy carriers of type 2 in the total energy required to be delivered by energy carriers of type 2 per application i for standard use and climate $S_{req_STD_i_cr2}$ are calculated. This is done for applications space heating, domestic hot water, space cooling and other.

In a preliminary step the energy required to be delivered to application i for standard use and climate $Q_{req_STD_i_cr}$ [kWh/year] is calculated per application, for each of the energy carriers separately:

Space heating:
$$Q_{req_STD_H_cr} = Q_{act_H_cr} \times f_{HDD_1_year} \times f_{HDD_STD} \times f_{T_i}$$

Domestic hot water:

Preliminary calculation for one year of not standard use of the total energy required for DHW and the shares of contribution to the energy required for DHW per energy carrier:

$$Q_{req_1_year_DHW_cr} = Q_{act_DHW_cr} \times f_t$$

$$\text{in case } Q_{req_1_year_DHW_tot}=0; S_{req_1_year_DHW_cr}=0$$

$$\text{Otherwise: } S_{\text{req}_1\text{year_DHW_cr}} = Q_{\text{req}_1\text{year_DHW_cr}} / Q_{\text{req}_1\text{year_DHW_tot}}$$

$$\text{In which: } Q_{\text{req}_1\text{year_DHW_tot}} = \text{sum}_i(Q_{\text{req}_1\text{year_DHW_cr}})$$

In case "Apply correction for domestic hot water energy (optional)?" = "No";

$$Q_{\text{req_STD_DHW_cr}} = Q_{\text{req}_1\text{year_DHW_cr}}$$

In case "Apply correction for domestic hot water energy (optional)?" = "Yes";

In case "Total system efficiency of DHW is known?" = "yes";

$$Q_{\text{req_STD_DHW_cr}} = Q_{\text{STD_net_DHW_cr}} / \text{Eta_DHW_tot}$$

$$\text{In which: } Q_{\text{STD_net_DHW_cr}} = S_{\text{req_DHW_cr}} \times Q_{\text{STD_net_DHW_tot}}$$

$$\text{In which: } S_{\text{req_DHW_cr}} = S_{\text{req}_1\text{year_DHW_cr}}$$

$Q_{\text{STD_net_DHW_tot}}$ is calculated in step 1.

In case "Total system efficiency of DHW is known?" = "no";

$$Q_{\text{req_STD_DHW_cr}} = Q_{\text{req}_1\text{year_DHW_cr}} \times f_{\text{DHW}}$$

f_{DHW} is calculated in step 1.

$$\text{Space cooling: } Q_{\text{req_STD_C_cr}} = Q_{\text{act_C_cr}} \times f_{\text{CDD}_1\text{year}} \times f_{\text{CDD_STD}}$$

$$\text{Other: } Q_{\text{req_STD_OTH_cr}} = Q_{\text{act_OTH_cr}} \times f_t$$

In which $Q_{\text{act}_i\text{cr}}$ [kWh] is the input value of application i for energy carrier cr corresponding with the monitoring period between start date and end date.

Note that the calculation of the energy required to be delivered per application and per energy carrier is done on the energy carriers of type 1 as well as on the energy carriers of type 2.

Then, the total energy required to be delivered to application i for standard use and climate $Q_{\text{req_STD}_i\text{tot}}$ [kWh/year] is calculated per application:

$$\text{Space heating: } Q_{\text{req_STD_H_tot}} = \text{Sum}_i(Q_{\text{req_STD_H_cr}})$$

$$\text{Domestic hot water: } Q_{\text{req_STD_DHW_tot}} = \text{Sum}_i(Q_{\text{req_STD_DHW_cr}})$$

$$\text{Space cooling: } Q_{\text{req_STD_C_tot}} = \text{Sum}_i(Q_{\text{req_STD_C_cr}})$$

$$\text{Other: } Q_{\text{req_STD_OTH_tot}} = \text{Sum}_i(Q_{\text{req_STD_OTH_cr}})$$

Note that the total energy required to be delivered per application calculated here also includes energy carriers of type 1 and type 2.

Furthermore, the relative shares of the energy required to be delivered for standard use and climate by energy carriers of type 2 per application i $S_{req_STD_i_cr2}$ [-] are calculated

Space heating: in case $Q_{req_STD_H_tot2}=0$; $S_{req_STD_H_cr2}=0$

Otherwise: $S_{req_STD_H_cr2} = Q_{req_STD_H_cr2} / Q_{req_STD_H_tot2}$

In which: $Q_{req_STD_H_tot2} = \text{Sum}_i(Q_{req_STD_H_cr2})$

Domestic hot water: ...

...

Space cooling: ...

...

Other: ...

...

4.4 Step 3: Calculation of the standard energy available by energy carriers of type 1

In the second step the total energy available by energy carriers of type 1 per application i for standard climate $Q_{ava_STD_i_cr1}$ and the relative shares of energy available by energy carriers of type 1 in the total energy available by energy carriers of type 1 per application i for standard climate $S_{ava_STD_i_cr1}$ [-] are calculated. This is done for applications space heating, domestic hot water, space cooling, other and exportation.

For energy carriers PV energy delivered from on-site and solar thermal energy delivered from on-site, the available energy by energy carriers of type 1 per application i for standard climate $Q_{ava_STD_i_cr1}$ [kWh/year] are calculated per application:

Space heating: $Q_{ava_STD_H_cr1} = Q_{act_H_cr1} \times f_{I_sol1_year} \times f_{I_solSTD}$

Domestic hot water: $Q_{ava_STD_DHW_cr1} = Q_{act_DHW_cr1} \times f_{I_sol1_year} \times f_{I_solSTD}$

Space cooling: $Q_{ava_STD_C_cr1} = Q_{act_C_cr1} \times f_{I_sol1_year} \times f_{I_solSTD}$

Other: $Q_{ava_STD_OTH_cr1} = Q_{act_OTH_cr1} \times f_{I_sol1_year} \times f_{I_solSTD}$

Exportation: $Q_{ava_STD_EXP_cr1} = Q_{act_EXP_cr1} \times f_{I_sol1_year} \times f_{I_solSTD}$

The application exportation is not taken into account for Solar thermal energy delivered from on-site.

For energy carrier Wind electrical energy delivered from on-site and Environment energy delivered from on-site, the available energy by energy carriers of type 1 per application i for standard climate $Q_{ava_STD_i_cr1}$ [kWh/year] is calculated per application:

Space heating: $Q_{\text{ava_STD_H_cr1}} = Q_{\text{act_H_cr1}} \times f_{\text{t}}$

Domestic hot water: $Q_{\text{ava_STD_DHW_cr1}} = Q_{\text{act_DHW_cr1}} \times f_{\text{t}}$

Space cooling: $Q_{\text{ava_STD_C_cr1}} = Q_{\text{act_C_cr1}} \times f_{\text{t}}$

Other: $Q_{\text{ava_STD_OTH_cr1}} = Q_{\text{act_OTH_cr1}} \times f_{\text{t}}$

Exportation: $Q_{\text{ava_STD_EXP_cr1}} = Q_{\text{act_EXP_cr1}} \times f_{\text{t}}$

The application exportation is not taken into account for Environment energy delivered from on-site.

The total energy available by energy carriers of type 1 per application for standard climate $Q_{\text{ava_STD_i_tot1}}$ is equal to the sum of the energy available to application i by all energy carriers of type 1 for standard climate:

Space heating: $Q_{\text{ava_STD_H_tot1}} = \text{Sum}_{\text{cr1}}(Q_{\text{ava_STD_H_cr1}})$

Domestic hot water: ...

Space cooling: ...

Other: ...

Exportation: ...

Then, the relative shares of the available energy by energy carriers of type 1 per application i for standard climate $S_{\text{ava_STD_i_cr1}}$ [-] are calculated per application:

Space heating: in case $Q_{\text{ava_STD_H_tot1}}=0$; $S_{\text{ava_STD_H_cr1}}=0$

Otherwise: $S_{\text{ava_STD_H_cr1}} = Q_{\text{ava_STD_H_cr1}} / Q_{\text{ava_STD_H_tot1}}$

Domestic hot water: ...

Space cooling: ...

Other: ...

Exportation: ...

4.5 Step 4: Calculation of the standard energy delivered and exported

The calculation of the standard energy delivered per application consists of distributing the total energy required to be delivered per application (result of step 1) over the energy carriers associated with the respective application, respecting the fixed amount of energy available by energy carriers of type 1 (result of step 3). The calculation of the standard energy exported per energy carrier consists of allocating any remainder of the standard energy delivered to the standard energy exported of the energy carrier. These calculations

are executed separately for energy carriers of type 1 and for energy carriers of type 2 for each of the applications in the following steps:

- ④ 4a. Calculation of the standard energy delivered and exported by energy carriers of type 2 per application;
- ④ 4b. Calculation of the standard energy delivered and exported by energy carriers of type 1 per application;
- ④ 4c. Calculation of the total standard energy delivered and exported.

There is no redistribution of corrected energy over the applications except a possible addition to energy delivered for exportation if this is present in the system configuration. This is only possible (in the current Excel tool) for the following energy carriers:

- ④ Fuel for CHP;
- ④ Electrical energy produced by CHP;
- ④ Electrical energy from on-site (PV or Other).

For these energy carriers, exportation of energy associated with these energy carriers is considered as present in the system configuration in case the input value of application i $Q_{act_i_cr} \neq 0$ for application i =exportation.

4a. Calculation of the standard energy delivered and exported by energy carriers of type 2 per application

The standard energy (delivered and exported) by energy carriers of type 2 per application and per energy carrier is calculated in four steps:

- ④ Calculation of the total standard energy delivered by energy carriers of type 2 per application;
- ④ Calculation of the standard energy delivered by energy carriers of type 2 per application and per energy carrier;
- ④ Calculation of standard energy delivered for electrical energy production of energy carrier Fuel for CHP;
- ④ Calculation of the standard electrical energy produced by CHP.

First the total standard energy delivered by energy carriers of type 2 is calculated by subtracting the standard available energy by energy carriers of type 1 from the total standard required energy per application.

Then this result is distributed over the energy carriers of type 2 associated with the respective application according to the shares obtained in step 1 (relative shares of the required energy by energy carriers of type 2).

The last two steps are only executed if CHP is present (non-zero input values for energy delivered by energy carrier Fuel for CHP). In that case the energy delivered for electrical energy production is rescaled to match the original ratio of thermal energy output to electrical energy output of the CHP. The standard electrical energy produced by CHP is rescaled accordingly by adjusting the standard exported electrical energy.



Calculation of the total standard energy delivered by energy carriers of type 2 per application

The calculation of the total standard energy delivered by type 2 energy carriers per application $Q_{deLSTD_i_tot2}$ [kWh/year] is done separately for each application for applications space heating, domestic hot water, space cooling and other:

Space heating: $Q_{deLSTD_H_tot2} = \text{MAX}(0; Q_{req_STD_H_tot} - Q_{ava_STD_H_tot1})$

Domestic hot water: ...

Space cooling: ...

Other: ...

Calculation of the standard energy delivered by energy carriers of type 2 per application and per energy carrier

The calculation of the standard energy delivered by energy carriers of type 2 per application and per energy carrier is done by distributing the total standard energy delivered by energy carriers of type 2 per application $Q_{deLSTD_i_tot2}$ (result of previous step in 4a) according to the shares equal to the relative shares of the required energy to be delivered for standard use and climate by energy carriers of type 2 per application $S_{req_STD_H_cr2}$ (result of step 2). The calculation is done separately for each application for applications space heating, domestic hot water, space cooling and other and per energy carrier of type 2;

Space heating: $Q_{deLSTD_H_cr2} = S_{deLSTD_H_cr2} \times Q_{deLSTD_H_tot2}$

in which: $S_{deLSTD_H_cr2} = S_{req_STD_H_cr2}$

Domestic hot water: ...

...

Space cooling: ...

...

Other: ...

...

Calculation of standard energy delivered for electrical energy production of energy carrier Fuel for CHP

The standard energy delivered for electrical energy production is rescaled to meet the original ratio of fuel associated with electrical energy output to fuel associated with thermal energy output of the CHP system(s).

$Q_{deLSTD_ELE_FuelCHP} = Q_{deLSTD_TH_FuelCHP} \times R_{ele/th}$

In which: $Q_{deLSTD_TH_FuelCHP} = Q_{deLSTD_H_FuelCHP} + Q_{deLSTD_DHW_FuelCHP} + Q_{deLSTD_C_FuelCHP} + Q_{deLSTD_OTH_FuelCHP}$

$$R_{ele/th} = Q_{act_ELE_FuelCHP} / Q_{act_TH_FuelCHP}$$

In which: $Q_{act_TH_FuelCHP} = Q_{act_H_FuelCHP} + Q_{act_DHW_FuelCHP} + Q_{act_C_FuelCHP} + Q_{act_OTH_FuelCHP}$

With FuelCHP: energy carrier of type fuel for CHP

Calculation of the standard electrical energy produced by CHP

As a consequence of the previous step, also the Electrical energy produced by CHP is rescaled in equal relative share. This is done by adjusting the exported electrical energy accordingly.

The total standard electrical energy produced by CHP $Q_{deLSTD_tot_EleCHP}$ is calculated as follows:

$$Q_{deLSTD_tot_EleCHP} = Q_{deLSTD_ELE_FuelCHP} \times Q_{act_TOT_EleCHP} / Q_{act_ELE_FuelCHP}$$

In which $Q_{act_tot_EleCHP} = Q_{act_H_EleCHP} + Q_{act_DHW_EleCHP} + Q_{act_C_EleCHP} + Q_{act_OTH_EleCHP} + Q_{act_EXP_EleCHP}$

The standard electrical energy produced by CHP and exported is calculated as follows:

$$Q_{deLSTD_EXP_EleCHP} = Q_{deLSTD_TOT_EleCHP} - (Q_{deLSTD_H_EleCHP} + Q_{deLSTD_DHW_EleCHP} + Q_{deLSTD_C_EleCHP} + Q_{deLSTD_OTH_EleCHP})$$

With: EleCHP: energy carrier of type electrical energy produced by CHP.

4b. Calculation of the standard energy delivered and exported by energy carriers of type 1 per application

The total standard energy delivered by energy carriers of type 1 per application is equal to the standard energy available by energy carriers of type 1 of the respective application but limited to the total standard energy required of the respective application. The total is distributed over the energy carriers associated with the respective application according to the relative shares of the standard energy available of the respective application. Any remainder of the standard energy available is added to the standard exported electrical energy of the respective energy carrier. Any remainder in standard energy available of energy carrier solar thermal or environment is considered as unused and is neglected in the calculation method.

Calculation of the total standard energy delivered by energy carriers of type 1 per application

The total standard energy delivered by energy carriers of type 1 of application i $Q_{deLSTD_i_tot1}$ is calculated separately for each application for applications space heating, domestic hot water, space cooling and other and per energy carrier of type 2;

Space heating: $Q_{deLSTD_H_tot1} = \text{MIN}(Q_{req_STD_H_tot} ; Q_{ava_STD_H_tot1})$

Domestic hot water: ...

Space cooling: ...

Other: ...

Calculation of the standard energy delivered by energy carriers of type 1 per application and per energy carrier

Calculation of the standard energy delivered by energy carriers of type 1 per application and per energy carrier:

Space heating: $Q_{deLSTD_H_cr1} = S_{deLSTD_H_cr1} \times Q_{deLSTD_H_tot1}$

in which: $S_{deLSTD_H_cr1} = S_{ava_STD_H_cr1}$

Domestic hot water: ...

...

Space cooling: ...

...

Other: ...

...

Calculation of standard energy exported by energy carriers of type 1

The calculation is executed in two steps:

- ⊙ Calculation of standard energy exported by energy carriers of type 1 per energy carrier;
- ⊙ Calculation of the total standard energy exported (all energy carriers with exportation).

Any remainder of electrical energy delivered by energy carriers of type 1 is added to the exported energy. This may be the case for electrical energy from on-site; produced by PV or other.

Any remainder of thermal energy delivered by energy carriers of type 1 is considered as unused and neglected in the further calculation. This may be the case for Solar thermal energy delivered from on-site or for Environment energy delivered from on-site.

4c. Calculation of the total standard energy delivered and exported

The total standard energy delivered to all applications is calculated per energy carrier and the total standard energy exported is calculated as the sum of the exported electrical energy of the associated energy carriers.



4.6 Step 5: Calculation of the energy performance indicators

The energy performance indicators are calculated based on the weighted energy balance equations in accordance with EN 52000-1: 2017 (equation (2)) [CEN; 2017a].

If not indicated otherwise, the indicators are calculated according to EN 52000-1 (default choices) and taking into account exported on-site produced electrical energy ("Exported on-site produced electrical energy").

For the non-renewable energy performance E_{Pnren} , the output is extended and a distinction is made between the following:

- ⊙ Exported on-site produced electrical energy;
- ⊙ Self-used on-site produced electrical energy only;
- ⊙ No on-site produced electrical energy.

"Exported on-site produced electrical energy" takes into account both self-used on-site produced electrical energy and exported on-site produced electrical energy.

"Self-used on-site produced electrical energy only" is the same as "-Exported on-site produced electrical energy", but whereby:

- ⊙ Exported electrical energy is set to zero.

"No on-site produced electrical energy" is the same as "-Exported on-site produced electrical energy", but whereby:

- ⊙ Exported electrical energy is set to zero;
- ⊙ Electrical energy produced by CHP, PV (or Other) and used on-site for applications S, DHW, C and OTH is added to the electrical energy (delivered from distant) to the respective applications.

The renewable energy ratio RER [-] is calculated according to EN ISO 52000-1: 2017 [CEN; 2017a], equation (17):

$$RER = E_{Pren,RER} / E_{Ptot}$$

The default perimeter choices are implemented; the renewable primary energy $E_{Pren,RER}$ is calculated excluding perimeter distant and the total primary energy E_{Ptot} is calculated including perimeter distant.

5 OUTPUT

5.1 List of output information

The output of the calculation method contains the following information that is reported as output:

- ⊙ Specific annual final standard energy delivered and exported total per application $Q_{STD_i_tot}$ [kWh/(m².year)]
- ⊙ Specific annual final standard energy delivered and exported total per energy carrier $Q_{STD_tot_cr}$ [kWh/(m².year)]
- ⊙ Non-renewable energy performance E_{Pnren} [kWh_{prim,nren}/(m².year)] for the cases
 - No on-site produced electrical energy
 - Self-used on-site produced electrical energy only
 - -Exported electrical energy
- ⊙ Total energy performance E_{Ptot} [kWh_{prim,tot}/(m².year)]
- ⊙ Renewable energy ratio RER [kWh_{prim,ren}/ kWh_{prim,tot}]
- ⊙ CO₂ equivalent emission [kg_{co2,eq}/(m².year)]
- ⊙ Produced electrical energy on-site, self-used E_{pr_self} [kWh_{prim}/(m².year)]
- ⊙ Produced electrical energy on-site, exported E_{pr_export} [kWh_{prim}/(m².year)]
- ⊙ Produced electrical energy on-site, total E_{pr_tot} [kWh_{prim}/(m².year)]

The following input information is repeated in the output:

- ⊙ Default corrections applied to the final measured energy delivered and exported
- ⊙ Optional corrections applied to the final measured energy delivered and exported
- ⊙ Selected input for the options of the optional correction methods

Furthermore, some general information is included in the output:

- ⊙ Default corrections
- ⊙ Building type
- ⊙ Building subtype
- ⊙ Building useful floor area
- ⊙ Location
- ⊙ Year of construction
- ⊙ Year of renovation
- ⊙ Number of units in multifamily house
- ⊙ Building address
- ⊙ Building identifier
- ⊙ EPC Practitioner identifier
- ⊙ ...

5.2 Definitions and information for correct interpretation of the output

To enable correct interpretation of the output, the reader is referred to the previous 2 chapters of this document, in which definitions of the input and calculation are described.

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6 ADDITIONAL INFORMATION FOR MEMBER STATES

6.1 Measurements

Privacy

In the monitoring and accompanying data handling, data protection and security need to be sufficiently ensured and all requirements according to GDPR need to be respected.

In order to minimize costs of the installation of the required monitoring infrastructure, an audit of the existing infrastructure is to be executed to evaluate the use, reuse or renovation of part of the existing monitoring infrastructure prior to the introduction of new components in order to minimize the cost associated with the purchase and installation of the required monitoring infrastructure.

The audit is to be executed on the location of the building unit, prior to installation of the required monitoring infrastructure.

Financial constraints

In the decision making whether or not to include F4 in the EPC assessment in individual MS, a preliminary analysis can be made on the level of the building stock of the infrastructure present in the building stock to estimate following aspects:

- ⦿ the feasibility of the installation of the required monitoring infrastructure;
- ⦿ the potential of the reuse of existing monitoring infrastructure to evaluate the additional cost burden associated with the introduction of feature F4 implementation;
- ⦿ the costs associated with installation of the required infrastructure taken into account the results obtained in execution of the previous bullet.

The outcomes of this preliminary analysis provide input to a broader cost-benefit analysis to supporting a go-no go decision of public authorities on the implementation in the MS.

6.2 Impact of price fluctuation of issuing an EPC including F4 in markets

It is likely that the introduction of F4 in EPC implementation in individual Member States will influence the price of issuing an EPC. The magnitude of this influence on EPC price will depend on the manner of implementation; in addition to existing indicators or replacing them. When implementing in addition, the price is expected to increase, due to additional training, measurement infrastructure and process execution. In case it is replacing existing indicators, the magnitude of the price effect depends on the existing procedures and related costs. In the latter case the increase of price could be (partly) compensated by simplified procedures and corresponding reduction of the related costs.



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⁷ SVEBY stands for the Swedish program for Standardization and verification of the energy performance of buildings.

⁸ BEN stands for the determination of the building's energy use during normal use and a normal year (The National Board of Housing, Building and Planning's regulations amending the agency's regulations and general advice)



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