eXTENDing the energy performance assessment and certification schemes via a mOdular approach

Feature 4

Real energy consumption

Guidelines

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FOREWORD

The Horizon 2020 project X-tendo "eXTENDing the energy performance assessment and certification schemes via a mOdular approach", aims to support public authorities in the transition to next-generation EPC schemes, including improved compliance, reliability, usability and convergence. X-tendo envisions a toolbox as a key output: a freely available online knowledge hub that will contain 10 innovative EPC features that can be implemented in addition to existing EPC practices. One of the 10 features is feature 4 on Real energy consumption.

Currently, EPCs are mostly based on calculation of theoretical energy performance, based on the characteristics of the building's envelope and technical systems, standard outdoor climatic conditions and a standard user behaviour. The latter usually assumes that the building is fully heated or cooled throughout the year to a certain indoor temperature and ventilated at a certain ventilation rate. Despite challenges such as correction for actual occupant behaviour and weather conditions, the inclusion of measured data of building energy use may lead to additional benefits. It is expected to improve the quality, reliability and usability of next-generation EPCs.

On the one hand, an energy performance that is indicated based on actual energy use data relates better with non-experts' understanding of energy consumption and bills, which is important for user acceptance and for creating confidence in view of triggering behaviour change. On the other hand, the actual energy use data may attribute to a more efficient and accurate reflection of the actual energy performance of a building and its use. Increase in automation of data acquisition and processing will simplify procedures and reduce the effort needed for on-site interventions and overall EPC assessor efforts. It will also allow more frequent updating of EPCs that include or are based on an operational rating. Furthermore, energy performance assessment based on actual energy use data is expected to better reflect the actual performance of the building and may improve accuracy. This is important for the quality in general and provides a second basis for tailored renovation advice and improvement of policy instruments in view of achieving the long-term building energy performance objectives.

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 guideline contains a description of the general principles of the method (chapter 1), the formula structure (chapter 4), methodological options (chapter 2) and definitions of input parameters (chapter 3) and output indicators (chapter 5). It also provides guidance on how to obtain the input parameters to be inserted in the calculation tool, gives basic information on the output to facilitate correct interpretation of the results and provides guidance on the introduction and deployment of the methodology in the EU Member States (chapter 6).

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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 (CEN; 2017a) and the Swedish energy performance determination method based on measured energy use data (Boverket; 2017).

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/.

Energy performance values for the building unit are normalized to a reference size unit to enable inter-building comparison of building units with the same function but with different size.

Furthermore, corrections are applied on the metered energy data to exclude the influence of non-standard conditions of climate and use to enable comparison of building units with the same function (in this method referred to as the type and subtype of the building).

The calculation method proposed by X-tendo under Feature 4 – real energy consumption includes the following default or optional corrections of the metered energy data.

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 optional correction methods are not part of the method by default because they require additional inputs (and associated measurement infrastructure or data sources) for which no default values are available. Such optionality gives more flexibility to the implementing bodies of Member States on how to implement the methodology in the local context. The default/advised option is in all optional correction methods to apply the correction method. Especially in case of implementation of the method for certification, it is strongly advised to implement all optional correction methods.

The method developed for Feature 4 can be applied to residential and non-residential buildings (not for industrial or 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) subject 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 (i.e., applying a 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 I_sol_STD 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 I_sol_hor 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 I_sol_hor 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 Eta_sys_DHW described by the following equation; Eta_sys_DHW=a x Q_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 REQUIRED

3.1 Introduction

The input can be divided in two categories;

- Input that is requested on the level of the building unit that is to be assessed;
- 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 its 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;

- Data of the heating degree-days;
- 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 (informative) or Remark" (tab "Summary building input") 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	Text	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 CO_2 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 in the calculation tool. 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.

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 are to be inserted by the Member States. This concerns values for time periods in the past. Multiple sets of these parameter values may be required, one for each climate zone within the Member State with different climatic conditions.

National values of yearly or monthly HDD and CDD are available from Eurostat[1] and preinserted as default values for the countries in the calculation tool. The default values can be overwritten. HDD can also be defined on the level of climate zones within countries or regions. The names and values of the various climate zones can be inserted by overwriting names "Geo (Labels)" and data (one row per climate zone) in the table "HDD: input table" of tab "Tables_&_Assumptions". Make sure to use the exact same names for the climate zones (Columns "GEO (Labels)") in the 3 input tables; for HDD, CDD and I_sol_hor.

Cooling degree-days

Monthly values of the cooling degree-days and monthly values for the standard (reference) year are to be inserted by the Member States. This concerns values for time periods in the past. Multiple sets of these parameter values may be required, one for each climate zone within the Member State with different climatic conditions.

National values of yearly or monthly HDD and CDD are available from Eurostat and preinserted as default values in the calculation tool. These default values can be overwritten and also multiple rows can be overwritten to define multiple climate zones (see Heating degree-days).

Solar Irradiation on a horizontal plane

Monthly values of the solar irradiation on a horizontal plane I_sol_hor and a value for the standard (reference) year I_sol_STD are 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 climate zone 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_sol_STD for all location via PVGIS[2]. One set of data of I_sol_STD (reference period 2005-2016) for each MS is preinserted as default values in the calculation tool. These default values can be overwritten and also multiple rows can be overwritten to define multiple climate zones.

Monthly values of the solar irradiation on a horizontal plane of the standard (reference) year I_sol_STD are required as an input, also in case "No" is selected as an answer to the question "Apply correction for solar irradiation?". The monthly values of I_sol_STD are by default used to

[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.

translate energy data of solar systems of a monitoring period different from a one year period to values to represent a one year period.

Monthly values of I_sol_hor 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_sol_hor (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. This parameter is only required as an input in case "Yes" is selected as an answer to the question "Apply correction for indoor temperature?".

This parameter is used to calculate the correction for indoor temperature..

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;

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**

To complete selection options, building subtype category Other non-residential is added with a value for the internal setpoint temperature in winter of 20°C.

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.

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 Δ_T_gains_H. This parameter is only required as an input in case "Yes" is selected as an answer to the question "Apply correction for indoor temperature?".

This parameter is used to calculate the correction for indoor temperature.

The temperature offset for heat gains during the heating season (standard year) Δ_T_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 represents the local context.

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). This parameter is only required as an input in case "Yes" is selected as an answer to the question "Apply correction for indoor temperature?".

This parameter is used to calculate the correction for indoor temperature.

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 climate zone 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.

Standard area per building user

The standard area per building user A_std_p [m^2/person] is to be specified by the Member States' implementing bodies per subtype of building. This parameter is only required as an input in case "Yes" is selected as an answer to the question "Apply correction for DHW?".

This parameter is used to calculate the correction for DHW energy use.

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.

To complete selection options, building subtype category Other non-residential is added with a value for the standard area per person of 20 m^2/person.

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.

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 [$kWh_{net}/(m^2.year)$] 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. This parameter is only required as an input in case “Yes” is selected as an answer to the question “Apply correction for DHW?”.

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

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.

To complete selection options, building subtype category Other non-residential is added with a value for the heating need for hot water per conditioned floor area of 20 kWh/m^2.

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 het energy use for DHW representative for the local context.

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). This coefficient x is dimensionless, but represents the daily domestic hot water volume per person. The net energy use for DHW is calculated as the lowest result of the net energy use for DHW calculated based on coefficient x and that based on coefficient y (see chapter Coefficient y for calculation of residential reference DHW use).

The coefficient x for calculation of residential reference DHW use [-] 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 het 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). This coefficient y is dimensionless, but represents the daily domestic hot water volume per unit of floor area. The net energy use for DHW is calculated as the lowest result of the net energy use for DHW calculated based on coefficient x (see chapter Coefficient x for calculation of residential reference DHW use) 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 het 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 [°C] is the average tapping temperature level at the draw-off locations. This parameter is only required as an input in case "Yes" is selected as an answer to the question "Apply correction for DHW?".

The parameter is used to calculate the standard net DHW energy use in residential buildings. It is only implemented for building type "Residential".

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 het energy use for DHW or a fixed value better representative for the local context.

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. This parameter is only required as an input in case "Yes" is selected as an answer to the question "Apply correction for DHW?".

The parameter is used to calculate the standard net DHW energy use in residential buildings. It is only implemented for building type "Residential".

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 het energy use for DHW or a fixed value better representative for the local context.

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 or 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.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 het energy use for DHW representative for the local context.
- The explanation in the "default/remarks" column of tab "Summary building input" for row 21 ("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.

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.

The input table allows input for the following energy carriers; Fuel, Fuel for CHP, Electrical energy, District heating, District cooling, Electrical energy produced by CHP, Electrical energy from on-site, Solar thermal and Environment.

For some of these energy carriers, the specification of the energy carrier type and or subtype and or the technology is required. The specification of the energy carrier type is to be specified 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.

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.

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) and is to be inserted as final energy delivered to the building for energy carrier Environment.

In case of a heat pump (for space heating and or domestic hot water production), the aero-, geo- or hydrothermal energy transferred at the evaporator side of the heat pump is to be inserted as final energy delivered to the building for energy carrier Environment. In case there is no submetering to monitor this part of the energy balance of the heat pump, it is allowed to approximate it based on the other energy components of the energy balance of the heat pump with the assumption that the thermal efficiency of the system is 100%. This approximation corresponds with the neglection of the thermal losses of the heat pump, which is reasonable for the purpose of this method. The energy delivered by energy carrier Environment is then equal to (SPF-1) times the electrical or fuel final energy use of the heat pump in which SPF is the Seasonal Performance Factor calculated for the respective monitoring period.

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 energy[3], 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.

Monitoring infrastructure should be present or is to be installed that enables the monitoring of energy delivered for all the EPC-related uses per energy carrier and for the specified applications and for the exported energy. 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,

[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).

the respective input should be omitted (leave blanc or insert zero). Also in case of a common technical system serving more than one type or subtype of building or in case of a multifamily house for which the energy performance is assessed on the level of the individual apartment, submetering is required to divide the final energy use.

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 final energy use 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].

In case of a single unit in a multi-unit building, the procedure to determine the final energy use that can be associated with the single unit for input as the energy delivered to or exported from the unit is described in the Annex of his guideline document. That is the case for instance for an apartment in a multi-family house with a collective technical system for which the energy performance is assessed on the level of an individual apartment.

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.

This parameter is only required as an input in case “Yes” is selected as an answer to the question “Apply correction for DHW?”.

The parameter is used to calculate the standard net DHW energy use in residential buildings. It is only implemented in case “No” is selected for “Total DHW system efficiency is known?”

In case this information is not available, the design value can be inserted as a proxi for the actual number of building users.

Total system efficiency for DHW

The total system efficiency for domestic hot water Eta_DHW [-] is the ratio of the net energy use for DHW to the final energy use for DHW.

This parameter is only required as an input in case “Yes” is selected as an answer to the question “Apply correction for DHW?”.

This parameter is used to calculate the correction factor for DHW energy use. It is only implemented in case “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?”.

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 Eta_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?”.

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_net_STD_DHW and the total system efficiency for domestic hot water Eta_sys_DHW described by the following equation;

Eta_sys_DHW=a x Q_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).

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?".

The average[5] actual indoor air temperature T_i_act_H can be derived from measurements in two steps;

[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.

- A monthly average indoor temperature is calculated from the measurements during the heating season of the indoor air temperature;
- A representative value for the actual indoor temperature for the heating season is calculated as the average weighted[6] 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 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. Also in case inhomogeneous temperatures are expected in the various zones within the heated envelope of the building unit during heating season, it is strongly advised to do measurements of indoor temperature during heating season in multiple zones. The demarcation of zones needs to be done in a way so that it is ensured that the temperature measurement in each zone can be considered to be representative for the respective zone.

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 zone 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.

[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.

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 that will be used to correct the energy data from measurements to represent energy of the actual building under standard conditions of use and climate. For the 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 - in case such optional correction methods are applied - 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 defined as energy carriers of type 1, all energy carriers delivered from distant and energy carriers delivered from nearby are defined as energy carriers of type 2.

In the fourth step the results of steps 2 and 3 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 the application space heating only. It is used to extrapolate or interpolate energy data for a 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). Two factors are used to do such translation; f_HDD_1_year and f_HDD_STD.

The correction factor f_HDD_1_year is calculated by the following equation;

f_HDD_1_year = HDD_1_year / HDD_monper

in which;

HDD_1_year is the sum of HDD of the most recent twelve months comprised in the monitoring period.

HDD_monper is the sum of HDD of all the months comprised in the monitoring period.

The correction factor f_HDD_STD is calculated by the following equation;

f_HDD_STD = HDD_STD / HDD_1_year

in which;

HDD_STD is the value for HDD for the standard year.

Outdoor climatic conditions during cooling season (CDD)

Cooling degree-days method is applied on energy data for the application space cooling only. It is used to extrapolate or interpolate energy data for a 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).

Two factors are used to do such translation; f_CDD_1_year and f_CDD_STD.

The correction factor f_CDD_1_year is calculated by the following equation;

f_CDD_1_year = CDD_1_year / CDD_monper

in which;

CDD_1_year is the sum of CDD of the most recent twelve months comprised in the monitoring period.

CDD_monper is the sum of CDD of all the months comprised in the monitoring period.

The correction factor f_CDD_STD is calculated by the following equation;

f_CDD_STD = CDD_STD / CDD_1_year

in which;

CDD_STD is the value for CDD for the standard year.

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_sol_1_year is calculated by the following equation;

f_I_sol_1_year = I_sol_1_year / I_sol_monper

in which;

I_sol_1_year is the sum of I_sol_hor of the most recent twelve months comprised in the monitoring period.

I_sol_monper is the sum of I_sol_hor of all the months comprised in the monitoring period.

The correction factor f_I_sol_STD is calculated by the following equation;

f_I_sol_STD = I_sol_STD / I_sol_1_year

in which;

I_sol_STD is the value for I_sol_hor for the standard year.

In case "No" is selected for "Apply correction for solar irradiation?" only the factor f_I_sol_1_year_(STD) is calculated by the same equation as above for f_I_sol_1_year but using standard values (reference year). The equation then becomes;

f_I_sol_1_year_(STD) = I_sol_1_year_STD / I_sol_monper_STD

in which;

I_sol_1_year_STD is I_sol_STD of one standard (reference) year.

I_sol_monper_STD is the sum of I_sol_STD of all the months comprised in the monitoring period.

The factor f_I_sol_1_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_sol_STD 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 x ρ x c_p x (T_dhw – T_cw)

In which;

T_dhw is the specified mixed domestic hot water delivery temperature [°C]

T_cw is the specified cold water delivery temperature [°C]

ρ = 994 kg/m^3 (average density of water at conditions representative for water in the DHW system);

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

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. The formulas then become;

V_STD_DHW = MIN[x ; y x (A_use / n_p_eq)]

For which the number of equivalent persons used for calculating the DHW requirements n_p_eq is calculated as function of the maximum number of equivalent persons according to the following formula;

If n_p_eq_max < 1,75, then

n_p_eq = n_p_eq_max

if n_p_eq_max ≥ 1,75 then

n_p_eq = 1,75 + 0,3 x (n_p_eq_max – 1,75)

In which the maximum number of equivalent persons n_p_eq_max is calculated as function of the useful floor area.

For single family houses this is done according to the following formulas;

If A_use < 30m^2 then

n_p_eq_max = 1

If 30m^2 ≤ A_use < 70m^2 then

n_p_eq_max = 1,75 -0,1875 x (70 – A_use)

If A_use ≥ 70m^2 then

n_p_eq_max = 0,025 x A_use

For apartments this is done according to the following formulas;

If A_use < 10m^2 then

n_p_eq_max = 1

If 10m^2 ≤ A_use < 50m^2 then

n_p_eq_max = 1,75 -0,1875 x (50 – A_use)

If A_use ≥ 50m^2 then

n_p_eq_max = 0,035 x A_use

In case of building type "Non-residential";

Q_STD_net_DHW = Q_STD_net_DHW_p x n_std_p

In which;

Q_STD_net_DHW_p = A_std_p x 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

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 – ΔT_gains – T_e_repres_H) / (T_i_act_H – ΔT_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 x f_HDD_1_year x f_HDD_STD (x 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 x f_t

in case Q_req_1_year_DHW_tot=0; S_req_1_year_DHW_cr=0

Otherwise; S_req_1_year_DHW_cr=Q_req_1_year_DHW_cr / Q_req_1_year_DHW_tot

In which: Q_req_1_year_DHW_tot = sum_(Q_req_1_year_DHW_cr)

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

Q_req_STD_DHW_cr = Q_req_1_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_req_STD_DHW_cr = Q_STD_net_DHW_cr / Eta_DHW_tot

In which: Q_STD_net_DHW_cr = S_req_DHW_cr x Q_STD_net_DHW_tot

In which: S_req_DHW_cr = S_req_1_year_DHW_cr

Q_STD_net_DHW_tot is calculated in step 1.

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

Q_req_STD_DHW_cr = Q_req_1_year_DHW_cr x f_DHW

f_DHW is calculated in step 1.

Space cooling: Q_req_STD_C_cr = Q_act_C_cr x f_CDD_1_year x f_CDD_STD

Other: Q_req_STD_OTH_cr = Q_act_OTH_cr x f_t

In which Q_act_i_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_req_STD_ i _tot [kWh/year] is calculated per application;

Space heating: Q_req_STD_H_tot = Sum_(Q_req_STD_H_cr)

Domestic hot water: Q_req_STD_DHW_tot = Sum_(Q_req_STD_DHW_cr)

Space cooling: Q_req_STD_C_tot = Sum_(Q_req_STD_C_cr)

Other: Q_req_STD_OTH_tot = Sum_(Q_req_STD_OTH_cr)

Note that the total energy required to be delivered per application calculated here includes energy carriers of both 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 = Sum_(Q_req_STD_H_cr2)

Domestic hot water: …[7]

[7] The dots '…' indicate the calculation is to be done according to a formula analogue to that of application Space heating. For example for application domestic hot water the formula then becomes:

in case Q_req_STD_DHW_tot2=0; S_req_STD_DHW_cr2=0

Otherwise; S_req_STD_DHW_cr2 = Q_req_STD_DHW_cr2 / Q_req_STD_DHW_tot2

In which: Q_req_STD_DHW_tot2 = Sum_(Q_req_STD_DHW_cr2)

...

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 x f_I_sol_1_year x f_I_sol_STD

Domestic hot water: Q_ava_STD_DHW_cr1 = Q_act_DHW_cr1 x f_I_sol_1_year x f_I_sol_STD

Space cooling: Q_ava_STD_C_cr1 = Q_act_C_cr1 x f_I_sol_1_year x f_I_sol_STD

Other: Q_ava_STD_OTH_cr1 = Q_act_OTH_cr1 x f_I_sol_1_year x f_I_sol_STD

Exportation: Q_ava_STD_EXP_cr1 = Q_act_EXP_cr1 x f_I_sol_1_year x f_I_sol_STD

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_ava_STD_H_cr1 = Q_act_H_cr1 x f_t

Domestic hot water: Q_ava_STD_DHW_cr1 = Q_act_DHW_cr1 x f_t

Space cooling: Q_ava_STD_C_cr1 = Q_act_C_cr1 x f_t

Other: Q_ava_STD_OTH_cr1 = Q_act_OTH_cr1 x f_t

Exportation: Q_ava_STD_EXP_cr1 = Q_act_EXP_cr1 x f_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_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_ava_STD_H_tot1 = Sum_(Q_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_ava_STD_i_cr1 [-] are calculated per application;

Space heating: in case Q_ava_STD_H_tot1=0; S_ava_STD_H_cr1=0

Otherwise; S_ava_STD_H_cr1 = Q_ava_STD_H_cr1 / Q_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 2) 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;

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

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

- Fuel for CHP;
- Electrical energy produced by CHP;
- 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 ≠ 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;

- Calculation of the total standard energy delivered by energy carriers of type 2 per application;
- Calculation of the standard energy delivered by energy carriers of type 2 per application and per energy carrier;
- Calculation of standard energy delivered for electrical energy production of energy carrier Fuel for CHP;
- 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_del_STD_i_tot2 [kWh/year] is done separately for each application for applications space heating, domestic hot water, space cooling and other;

Space heating: Q_del_STD_H_tot2 = 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_del_STD_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 i 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_del_STD_H_cr2 = S_del_STD_H_cr2 x Q_del_STD_H_tot2

in which: S_del_STD_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_del_STD_ELE_FuelCHP = Q_del_STD_TH_FuelCHP * R_ele/th

In which: Q_del_STD_TH_FuelCHP = Q_ del_STD_H_FuelCHP + Q_ del_STD_DHW_FuelCHP Q_ del_STD_C_FuelCHP + Q_ del_STD_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_del_STD_tot_EleCHP is calculated as follows;

Q_del_STD_tot_EleCHP = Q_del_STD_ELE_FuelCHP x 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_del_STD_EXP_EleCHP = Q_del_STD_TOT_EleCHP – (Q_del_STD_H_EleCHP + Q_del_STD_DHW_EleCHP + Q_del_STD_C_EleCHP + Q_del_STD_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_del_STD_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_del_STD_H_tot1 = 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_del_STD_H_cr1 = S_del_STD_H_cr1 x Q_del_STD_H_tot1

in which: S_del_STD_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 ("Minus exported on-site produced electrical energy").

For the non-renewable energy performance E_Pnren, the output is extended and a distinction in relation to the on-site produced electrical energy is made between the following sub-indicators/cases;

- Minus exported on-site produced electrical energy;
- Self-used on-site produced electrical energy only;
- No on-site produced electrical energy.

"Minus 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 determined in the same way as "Minus 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 "Minus 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 space heating, domestic hot water, space cooling and other is set to zero and the same amount 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 total per application or total exported Q_STD_i_tot [kWh/(m^2.year)]
- Specific annual final standard energy delivered and exported total per energy carrier Q_STD_tot_cr [kWh/(m^2.year)]
- Non-renewable primary energy performance E_Pnren [$kWh_{prim,nren}$/(m^2.year)] for the cases
  - No on-site produced electrical energy
  - Self-used on-site produced electrical energy only
  - Minus exported electrical energy
- Total primary energy performance E_Ptot [$kWh_{prim,tot}$/(m^2.year)]
- Renewable energy ratio RER (primary energy) [$kWh_{prim,ren}$/ $kWh_{prim,tot}$]
- CO_2 equivalent emission [$kg_{co2,eq}$/(m^2.year)]
- Produced electrical energy on-site, self-used E_pr_self [kWh_{prim}/(m^2.year)]
- Produced electrical energy on-site, exported E_pr_export [kWh_{prim}/(m^2.year)]
- Produced electrical energy on-site, total E_pr_tot [kWh_{prim}/(m^2.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;

- 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.

6 ADDITIONAL INFORMATION FOR MEMBER STATES

6.1 Guidance on the implementation and on the choice of main output indicators

The list of output information as presented in section 5.1 contains several parameters from which Member States can choose to include in the EPC.

The MEPI methodology is conceptualised in a flexible manner to allow Member States' implementing bodies to implement the methodology in line with the provisions of the Energy Performance of Buildings Directive and in concordance with the local practices already in place in their country or regions. This gives Member States the room to adapt and adjust the method according to national or local EPC calculation methodologies and standards.

The MEPI can be used for certification potentially replacing existing energy performance indicators or it may solely serve informative purposes, for instance for use in addition to existing EPC indicators currently applied in practice.

In case it is chosen to implement MEPI to replace existing indicators for certification – this may be an existing operational rating but also an existing asset rating – it is strongly advised to apply all optional correction methods. Furthermore, it is strongly advised to apply the following methodological choices;

- For correction to indoor temperature during heating season, it is strongly advised to require measurements in multiple zones (see subsection 3.2 on 'Actual indoor temperature during the heating season').
- For correction to domestic hot water, implement the method in which the total system efficiency for DHW is known.

In case it is chosen to implement MEPI in addition to existing indicators, it is strongly advised to add an explanation on the difference between the indicators and choose the output parameters in line with the purpose of the MEPI addition.

It must be noted that for reasons of clarity and continuity, it is disadvantageous to mix the use of asset and operational rating or to switch from one type to the other (for implementation on a specific building type[8]).

Depending on the existing practices of energy performance assessment and certification in a specific Member State and the main objective of the introduction of the MEPI, the way in which the MEPI methodology is implemented as well as the choice of the main foreground indicator(s) may be different.

[8] Both asset and operational rating in the same Member State or region can be perfectly implemented alongside one another but for different building types within scope of each method, as currently is the case in a lot of Member States [Volt J. et al.; 2020].

To provide some guidance on the choice of indicators from the list of output information, the MEPI methodology contains a set of default output indicators, indicated in text style bold in the calculation spreadsheet. These indicators correspond with the default options according to the standard EN ISO 52000-1 [CEN; 2017a]. These parameters are suggested candidates for inclusion in EPC frameworks for the certification of energy performance of buildings. The MEPI tool also includes a broad set of other indicators Member States can choose from in case of implementation of MEPI to enable better aligning with local practice and standards and for continuity.

6.2 Measurements

Privacy

In the monitoring and accompanying data handling, data protection and security needs 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 Member State, a preliminary analysis can be made on the level of the building stock of the infrastructure present in the building stock to estimate the 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 point.

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 Member State.

6.3 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.

7 CONCLUSION

The Measured Energy Performance Indicator methodology is developed within the Horizon 2020 project X-tendo as the result of feature 4 on Real energy consumption. The MEPI tool consists of an Excel spreadsheet and accompanying guidelines. The MEPI methodology 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. The MEPI methodology is conceptualised in a flexible manner - with several methodological options and a broad set of output parameters to select from - to allow Member States implementing bodies to implement it in alignment with the existing local practices.

The MEPI method can be applied to both residential and non-residential buildings and may be implemented for certification under certain conditions (see chapter 6.1) potentially replacing existing energy performance indicators or it may solely serve informative purposes for instance for use in addition to existing EPC indicators.

This document contains the guidelines for the use and introduction of the MEPI methodology in energy performance assessment and certification frameworks of the Member States. It is to be used in combination with the Excel calculation spreadsheet. A full description of the method is included and guidance is provided for executioners of the tool - both public authorities and EPC Practitioners - to deploy and apply it in the local context. The spreadsheet and accompanying guidelines also serve as a basis in the training of the EPC Practitioners.

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SVEBY: Measurement instructions; downloadable from www.sveby.org [in Swedish]

SVEBY: Verification Template; downloadable from www.sveby.org [in Swedish]Extension of the reference list for references related to Feature 4: Real Energy Consumption: see X-Tendo D3.1

Volt J. et al.; 2020; Energy performance certificates - Assessing their status and potential - X-tendo D2.1;Brussels, Belgium; March 2020;

ANNEX: INDIVIDUAL UNIT IN MULTI-UNIT BUILDING

For cases of a multi-unit building with a collective technical system for which the energy performance is to be determined on the level of the individual unit, this annex contains the determination method of the part of the multi-unit final energy use that can be associated with the individual unit. Examples of such cases include a multifamily house (MFH) with collective

[9] SVEBY stands for the Swedish program for Standardization and verification of the energy performance of buildings.

[10] 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)

system for heating for which the energy performance is assessed on the level of an individual apartment or a building with units with different functional categories.

For such cases, only part of the final energy of a specific energy carrier delivered to the entire building for a specific application needs to be inserted in the input table. It concerns only that part of the energy delivered (or exported) that can be associated with the individual unit. The following figures illustrate the principle of determination of final energy use associated with individual units in multi-unit buildings with collective systems.

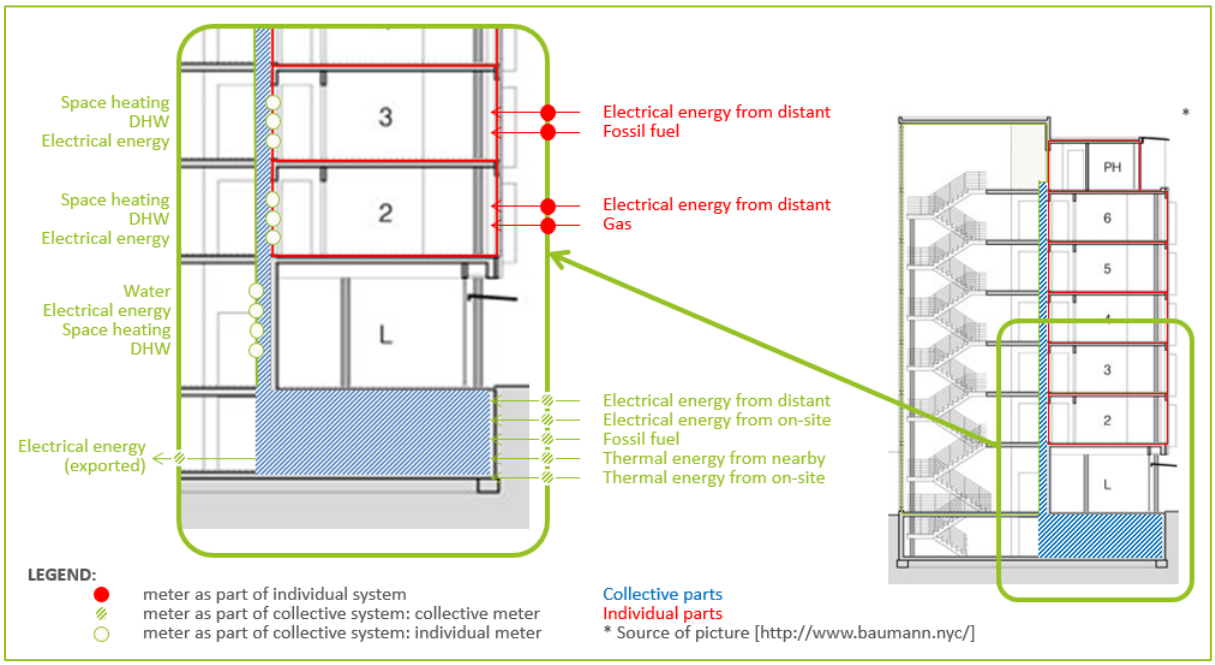

Figure 1: Schematic representation of collective system metering

In addition to the meters illustrated in figure 1, extra submeters may be required to divide the final energy delivered to the building over the various applications.

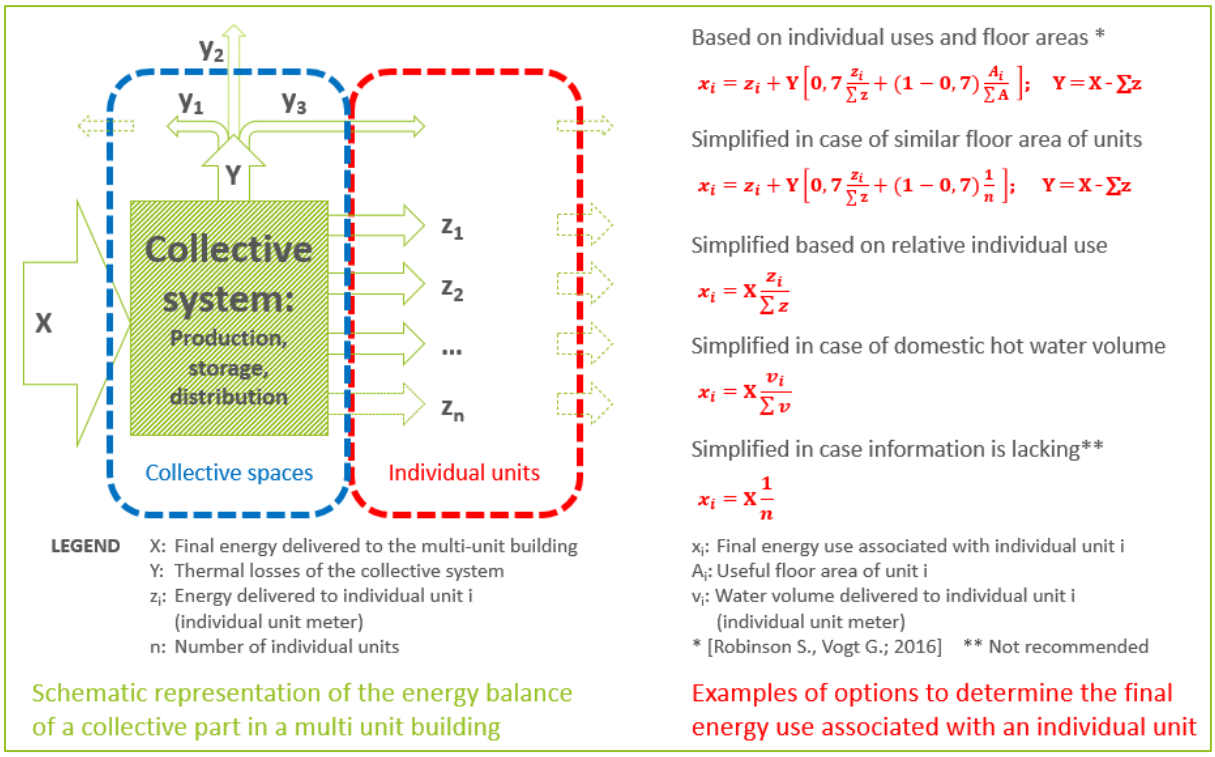

Figure 2: Final energy use associated with individual units in a multi-unit building

On the level of an energy carrier and application, the final energy delivered to the building that can be associated with the individual unit (for instance an apartment in a MFH) is to be inserted in the calculation spreadsheet and is determined according to the following formula;

$$x_i = z_i + Y\left[0,7\frac{z_i}{\sum z} + (1-0,7)\frac{1}{n}\right]$$

In which;

x_i: part of final energy delivered to the building for energy carrier and application that is to be allocated to apartment I [kWh]

z_i: energy delivered to the individual apartment (at the location of the individual apartment) [kWh]

n: number of individual apartments in the MFH [-]

Y: energy associated with inefficiencies of the conversion between final energy level and the location of the individual apartments [kWh]

Y sometimes also is referred to as the system energy losses.

Y is the energy associated with inefficiencies between final energy level and the location of the individual apartments and is calculated as the difference between the final energy delivered to the building and the sum of the energy delivered to all individual apartments z_i according to the following formula;

$$\mathbf{Y}:=X - \sum z$$

In which;

X: final energy delivered to the building for the energy carrier and the application [kWh]

An analogous approach is to be followed in case of different types and or subtypes of buildings that have common technical systems to serve one or more applications, only the losses are (next to the individual uses) weighted according to the floor areas of the different types and or subtypes of buildings according to the following formula;

$$\boldsymbol{x_i} = \boldsymbol{z_i} + \mathbf{Y}\left[\mathbf{0,7}\frac{\boldsymbol{z_i}}{\sum \mathbf{z}} + (\mathbf{1} - \mathbf{0,7})\frac{\boldsymbol{A_i}}{\sum \mathbf{A}}\right]$$

In case for the energy delivered for DHW at the location of the individual units, only water volume submetering is available, it is allowed to divide the final energy use over the individual apartments according to the water volume delivered to the associated apartments, by implementing the following formula;

$$\boldsymbol{x_i} = \mathbf{X}\frac{\boldsymbol{v_i}}{\sum \boldsymbol{v}}$$

In which;

v_i= water volume of DHW delivered to the individual apartment (at the location of the individual apartment) [m^3]

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