multEE

facilitating multi-level governance
for Energy Efficiency

Document with general formulae of bottom-up methods to assess the impact of energy efficiency measures

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List of abbreviations

a	annum
BMB	Biomass Boiler
CHP	Combined Heat and Power
d	day
EED	Energy Efficiency Directive
ESD	Energy Services Directive
ESL	Energy Saving Lamp
EUR	Euro
FFB	Fossil Fuel Boiler
h	Hour(s)
Kd	Calvin days
kh	kilo hours
kWh	Kilowatt-hours
PV	Photovoltaic
SME	Small and Medium Enterprise
VSD	Variable Speed Drives
WP	Work Package

I Introduction

The monitoring of energy efficiency targets be it on local, regional or national level, requires assessing the impacts of energy efficiency policies and measures in terms of energy savings and consequently their contribution to the energy efficiency target. Possible impacts of such policies and measures can, on the one hand, be assessed top down, i.e. by means of specific indicators such as energy consumption in households for heating per m^2. On the other hand, so called bottom-up methods can be used to assess the impact of single energy efficiency measures. However, they allow evaluating single measures not only in terms of energy savings but also in terms of their cost-effectiveness expressed as cost in relation to energy saving impact (e.g. EUR/kWh). The energy savings obtained through the implementation of a single energy efficiency measure can be summed up to assess total energy savings in a specific area (e.g. heating).

The aim of the underlying report is to provide guidance on assessing the impacts of energy efficiency measures bottom-up. It comprises a multitude of energy efficiency measures for which bottom-up savings calculation methods, i.e. specific calculation formulae have been developed. In order to apply these calculation methods, country-specific calculation values, so called default values, have to be defined (e.g. as baseline for calculating energy savings from the retrofit of existing buildings, the average space heating demand of the building stock in a given period in a particular country may be applied). However, one has to note that savings calculated with bottom-up methods are foremost theoretical, especially when default values instead of project specific values, i.e. values specific to the building that has been retrofitted for the savings calculation are used. Such calculated savings are called deemed savings as opposed to metered savings where the savings from a particular measure are "(…) determined by recording the actual reduction in energy use, taking due account of factors such as additionality, occupancy, production levels and the weather which may affect consumption"[1]. Other forms of calculating the impact of energy efficiency measures bottom-up are scaled savings and surveyed savings.

The majority of the formulae presented hereinafter have been developed by the Austrian Energy Agency and the partners of the multEE project for the monitoring of the implementation of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services (ESD) and the Directive 2012/27/EU on Energy Efficiency (EED). Some formulae were taken from the European Commission's publication "Recommendations on Measurement and Verification Methods in the Framework

[1] Energy Efficiency Directive, Annex V, page 35.

of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services[2]". In addition, some bottom-up calculation formulae were newly developed by the Austrian Energy Agency.

Hence, this document comprises bottom-up calculation formulae for measures relating to the following areas:

- Behavioural change and awareness raising
- Building envelope and building components
- Air-conditioning systems
- Circulating Pumps
- Cogeneration
- District heating
- Energy audits of technical processes
- Heat pumps
- Heating system improvement
- Industrial motors
- Introduction of energy management systems
- Lighting
- Mobility
- Office equipment
- Photovoltaic plants
- Replacement of boilers
- Smart district heating grids
- Solar thermal panels
- Stand-by killer in households
- Systems for heat recovery in buildings
- White goods

The bottom-up calculation methods suggested in this document are to be considered as guiding principles, not claiming to be the universal method to calculate energy savings from single energy efficiency measures bottom-up.

[2] https://www.energy-community.org/pls/portal/docs/906182.PDF, 30 June 2015

II Behavioural measures

Target sector: households

Behavioural measures and their savings calculation methods described hereunder focus solely on the sector households and comprise the measures (1) Awareness Raising, (2) Energy audits and (3) Smart Meters and informative billing.

II.I Awareness Raising

Sector(s): specific target groups

A full implementation of the Energy Efficiency Directive requirements presupposes that consumers will change behaviour and this will lead to persistent and long-term energy-savings benefits.[3] According to Article 12 of the Energy Efficiency Directive, Member States shall take appropriate measures to promote suitable information and awareness-raising to inform citizens of the benefits of taking on energy efficiency improvement measures.[4]

The method described hereunder applies to awareness raising and information campaigns that spread information and messages on energy efficiency and energy saving targeted to specific stakeholder groups. The objective of awareness raising and information campaigns are to induce behaviour change by influencing individual and organizational perceptions, preferences and abilities (e.g.: consumer choice, building occupant behaviour, purchase or renovation preferences of architects, owners, tenants, choice of transport mode, etc.). In fact it is very difficult to verify possible savings through awareness raising and information campaigns. The following method is an approximation.

[3] EEA Technical report (2013): Achieving energy efficiency through behaviour change: what does it take? No 5/2013, p. 8, Copenhagen.
[4] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32012L0027&from=EN, Article 12, p. 20

II.I.I Awareness Raising campaigns

Campaigns may vary a lot from each other. They differ in content, target groups, scale, media use, etc. Such campaigns may be information and motivation campaigns; awareness raising programs or the provision of non-individualized energy efficiency "tips" or counselling. Furthermore the message may be spread via different channels (news, TV, brochures, etc.).

Awareness-raising and information campaigns should be supported by social marketing. Social marketing seeks to develop and integrate marketing concepts with other approaches to influence behaviours that benefit individuals and communities for the greater social good. It seeks to integrate research, best practice, theory, audience and partnership insight, to inform the delivery of competition sensitive and segmented social change programs that are effective, efficient, equitable and sustainable.[5]

In order to achieve any effects, it is imperative that the campaign is tailor-made for the target group that should be reached. To address them, the most suitable communication instruments should be used.

At this point it should be mentioned that the potential savings might be increased when combined with so called enabling factors such as financial resources or new skills for example and reinforcing factors such as feedback.[6] Nevertheless when it comes to individual behaviour social interaction, lifestyles, norms and values as well as technologies and policies should be kept in mind as they are all enabling or constraining behavioural change as well.[7]

[5] International Social Marketing Association, European Social Marketing Association & Australian Association of Social Marketing (2013). *Consensus Definition of Social Marketing* (4 October 2013).
[6] http://ec.europa.eu/energy/intelligent/projects/sites/iee-projects/files/projects/documents/behave_guidelines_for_behavioural_change_programmes_en.pdf
[7] European Environment Agency (EEA): Achieving energy efficiency through behaviour change: what does it take?, 2013 Copenhagen.

The following formula is an approach to quantify potential savings through awareness raising campaigns:

Bottom-up formula	
$TFES = FEC_{TG} * S_Q$ $FEC_{TG} = n * FEC_{person}$	
Definition	
TFES	Total Final Energy Savings [kWh/a]
FEC_{TG}	Final energy consumption of specific target group (either for electricity or for electricity and heat) [kWh/a]
FEC_{person}	Final energy consumption of a person (either for electricity or for electricity and heat) [kWh/a]
S_Q	Savings factor of the awareness raising campaign [%]
n	Number of persons of a specific target group
Baseline	
No awareness raising campaign has been launched.	

Values:

Lifetime of the measure in years (default or project specific)

(Average) Final Energy Consumption of specific target group (either for electricity or for electricity and heat) (default or project specific)

Final energy consumption of a person (either for electricity or for electricity and heat) (default or project specific)

Savings factor of an awareness raising campaign (default or project specific)

Number of persons of a specific target group (project specific)

II.I.II Guidance for identification of default values

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", behavioural measures or programmes, page 86[8]. A project specific value may be used if results from empirical studies are available.

Average final energy consumption of specific target groups or a person: the final energy consumption of the specific target group or a person for electricity and heat can be calculated based on the national energy balance. Alternatively, this information may also be sought from energy suppliers or regulators, the national statistical office or from empirical studies.

Savings factor of information campaigns: If no empirical values are at hand from recent studies or national surveys on the impacts of awareness raising campaigns, findings from the following study may be considered: http://ec.europa.eu/energy/intelligent/projects/sites/iee-projects/files/projects/documents/behave_guidelines_for_behavioural_change_programmes_en.pdf, page 20. The maximum savings reported amount up to 1-2%. This is an approximation which is quite high. It needs to be noted that the savings achieved very much depend on the quality of the information campaign and can therefore not be generalized.[9]

[8] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF
[9] http://ec.europa.eu/energy/intelligent/projects/sites/iee-projects/files/projects/documents/behave_guidelines_for_behavioural_change_programmes_en.pdf, p. 20

II.II Energy audits for households

According to the Energy Efficiency Directive Article 8(3) „Member States shall also develop programmes to raise awareness among households about the benefits of such audits through appropriate advice services."

Energy audits for households lead to awareness raising and may result in more rational energy consumption behaviour patterns. In some cases, energy audits may also induce investments in energy efficient technologies in households. In this chapter, only the impacts of energy savings resulting from behavioural change are analysed.

Energy audits for households may take different forms:

- On-site audits in households: an energy auditor visiting the respective household can directly identify energy saving potentials and discuss possible interventions, be it behavioural or investment-driven with the household.
- On-site audits at information centres: provided at dedicated information and advisory centres for individuals who seek information on how to reduce their energy consumption, decrease energy cost etc. In contrast to on-site audits in households, mostly information material is provided to the individuals; an on-site inspection of the household does not take place.
- Telephone consulting: individuals seek information about specific issues related to energy consumption and saving energy over the phone when calling information centres, specific hotlines of regulators, energy suppliers etc.
- Internet-based consulting: specified internet masks developed by e.g. energy suppliers or regulators allow to analyse a household's energy consumption patterns once specific information about the household's energy situation is provided (e.g. number and age of electrical appliances in place, thermal quality of the building). Based on the information provided, tailored advice on how to improve the household's energy efficiency can be generated through the internet mask.

Energy savings resulting from energy audits for households may be assessed by looking at the quality level of the energy audit. The quality level is determined as follows[10]:

- Quality level 1: the final consumer receives personal advice either through an energy auditor or through internet-based consulting (internet mask). The consumer's energy consuming patterns are analysed individually and tailor-made suggestions for improving the energy efficiency of the household are given. The audit takes no longer than 15 minutes.
- Quality level 2: the final consumer receives personal advice through an energy auditor. The consumers energy consuming patterns are analysed individually and tailor-made suggestions for improving the energy efficiency of the household are given. The audit takes no longer than 30 minutes.
- Quality level 3: the final consumer receives advice through an energy auditor either at an information centre or at home. In addition, an individual energy concept for his/her household is developed (report). The audit takes more than 60 minutes (e.g. thermography). The energy audit has to be carried out by a qualified auditor who does not represent any sort of specific technology or energy carrier.

The following formula applies to audits targeting either electricity consumption only or heat and electricity consumption altogether.

Bottom-up formula	
$TFES = n_{Q1} * FEC_{HH} * S_{Q1} + n_{Q2} * FEC_{HH} * S_{Q2} + n_{Q3} * FEC_{HH} * S_{Q3}$	
Definition	
TFES	Total Final Energy Savings [kWh/a]
n_Q	Number of energy audits at a specific quality level
FEC_{HH}	(Average) Final Energy Consumption of household(s) (either for electricity or for electricity and heat) [kWh/a]
$S_{Q1,2,3}$	Savings factor of an energy audit at a specific quality level [%]
Baseline	
Household not having received an energy audit.	

[10] The quality levels were defined by the Austrian monitoring body for the specific case of Austria and may be adapted by the partner countries.

Values:

Lifetime of the measure in years (default or project specific)

Number of energy audits at a specific quality level (project specific)

(Average) Final Energy Consumption of household(s) (either for electricity or for electricity and heat) (default or project specific)

Savings factor of an energy audit at a specific quality level (default or project specific)

II.II.I Guidance for identification of default values

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", behavioural measures or programmes, page 86[11]. A project specific value may be used if results from empirical studies are available.

(Average) Final Energy Consumption of household(s): the final energy consumption of households for electricity and heat can be calculated based on the national energy balance. Alternatively, this information may be sought from energy suppliers or regulators, the national statistical office or from empirical studies. Also project specific values may be used if the household's energy consumption for electricity and heat is known.

Savings factor of an energy audit at a specific quality level: if no empirical values are at hand from recent studies on the impacts of energy audits in households, findings from different studies may be considered:

- Achieving energy efficiency through behaviour change, page 43: http://www.eea.europa.eu/publications/achieving-energy-efficiency-through-behaviour.
- A review of intervention studies aimed at household energy conservation, chapter 3.3.3: http://www.rug.nl/staff/e.m.steg/abrahamsestegvlekrothengatterreview.pdf.

The maximum savings reported in literature amount up to 20%. However, it needs to be noted that the savings achieved very much depend on how the intervention in the households was designed and they can therefore not be generalized.

[11] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

II.III Smart Meters and informative billing

The EU aims to replace at least 80% of electricity meters with smart meters by 2020 wherever it is cost-effective to do so. In EU Member States, many pilot studies have been conducted in order to identify the energy savings potential of smart meters. While the short-term effects have shown reductions in energy consumption in households, the long-term effects of smart meters are still to be examined. Smart meters have proven the most efficient when the installation of the digital meter is combined with feedback systems (e.g. displays in the households showing real-time consumption, billing at short intervals).

The formula below applies to smart meters installed for measuring the consumption of electricity, gas or district heating in households. In order to maximise the benefits of smart meters, the household shall receive real-time feedback about its daily or monthly energy consumption e.g. through home displays showing the actual consumption or short billing cycles.

Bottom-up formula	
$TFES = n * FEC_{HH} * s_{Smart}$	
Definition	
TFES	Total Final Energy Savings [kWh/a]
n	Number of smart meters installed in households
FEC_{HH}	(Average) Final Energy Consumption of household(s) (either for electricity or for electricity and heat) [kWh/a]
S_{Smart}	Savings factor resulting from the installation of a smart meter incl. feedback mechanisms in households [%]
Baseline	
Household not having received a smart meter with real-time feedback.	

Values:

Lifetime of the measure in years (default or project specific)

Number of smart meters installed in households (project specific)

(Average) Final Energy Consumption for electricity and for electricity and heat respectively of household(s) (default or project specific)

Savings factor resulting from the installation of a smart meter incl. feedback mechanisms in households (default or project specific)

II.III.I Guidance for identification of default values

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 86[12]. A project specific value may be used if results from empirical studies are available.

(Average) Final Energy Consumption of household(s) (either for electricity or for electricity and heat): the final energy consumption of households for electricity and heat can be calculated based on the national energy balance. Alternatively, this information may be sought from energy suppliers or regulators, the national statistical office or from empirical studies. Also project specific values may be used if the household's energy consumption for electricity and heat is known.

Savings factor:

- Data may be available from empirical (pilot) studies carried out in the different EU Member States.
- Results from the cost-benefit analyses of EU Member States on smart meters: Commission Staff Working Document publishing savings factors for the different EU Member States: Cost-benefit analyses & state of play of smart metering deployment in the EU-27: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014SC0189&from=EN
- Report from the Commission (COM2014) 356 final: Benchmarking smart metering deployment in the EU-27 with a focus on electricity: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014DC0356&from=EN

[12] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

III Building envelope and building components

Target sectors: households (residential buildings), public and private services (tertiary buildings)

Bottom-up methods for buildings comprise the introduction of building codes for new residential and tertiary buildings and the thermal improvement of the building envelope for (1) newly constructed residential buildings, (2) refurbished residential buildings and (3) non-residential buildings (service buildings). In addition, a method is provided for the thermal improvement of a single building component.

It needs to be noted that measures related to improving the thermal quality of building envelops not only reduce the heating demand but also the cooling demand of the buildings.

III.I Introduction of building codes for new residential and tertiary buildings

The method introduction of building codes for new residential and tertiary buildings provides for the evaluation of annual energy savings derived from the introduction of new building codes with stricter requirements in relation to the buildings space heating demand and from the implementation of measures that promote buildings that go beyond existing building codes.[13]

[13] Recommendations on Measurement and Verification Methods in the Framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services, page 66; Download: https://www.energy-community.org/pls/portal/docs/906182.PDF, 30 June 2015

Bottom-up formula[14]

Option 1:

$$TFES = A * \left(SHD_{inicode} * EF_{Ref} - SHD_{newcode} * EF_{Eff}\right)$$

Option 2:

$$TFES = A * \left(\frac{SHD_{inocode}}{\eta_{inicode}} - \frac{SHD_{newcode}}{\eta_{new}}\right)$$

Definition

TFES:	Total Final Energy Savings [kWh/a]
A	Conditioned gross floor area of the newly constructed building [m^2]
$SHD_{inicode}$	Specific Space Heating Demand of building constructed according to the initial building code introduced after YYYY or of the building code in force in YYYY [$kWh/m^2/a$]
$SHD_{newcode}$	Specific Space Heating Demand of building constructed according to the new building code implemented in YYYY [$kWh/m^2/a$]
EF_{Ref}	Expenditure Factor of the heating system in the building constructed according to the old building code
EF_{Eff}	Expenditure Factor of the heating system in the building constructed according to the new building code
$\eta_{inicode}$	Annual use efficiency of the heating system in the building constructed according to the old (inicode) building code
η_{new}	Annual use efficiency of the heating system in the building constructed according to the new (newcode) building code

Baseline[15]

Specific space heating demand of the initial building code in place in year YYYY or introduced after YYYY. In case, no building code was in place in YYYY, the baseline is the average space heating demand of buildings constructed in YYYY.

In case where measures promote buildings that go beyond the building code, the yearly final energy savings are calculated based on the difference in the ratio between specific space heating demand and energy efficiency of the heating systems between the initial building code in place or introduced after YYYY and the ratio in the buildings promoted.

If the building code also imposes efficiency requirements for heating systems, these should be included too.

The specific space heating demand values should be corrected with the relevant heating degree days.

[14] Ibidem, page 67.
[15] Ibidem, page 66.

Values:

Lifetime of the measure in years (default or project specific)

Conditioned gross floor area (default or project specific)

Specific Space Heating Demand of building constructed according to the initial building code (default)

Specific Space Heating Demand of building constructed according to the new building code (default)

Expenditure Factor of the heating system in the building constructed according to the old building code (default or project specific)

Expenditure Factor of the heating system in the building constructed according to the new building code (default or project specific)

Annual use efficiency of the heating system in the building constructed according to the old building code (default or project specific)

Annual use efficiency of the heating system in the building constructed according to the new building code (default or project specific)

III.I.I Guidance for identification of default values

When applying the methods for calculating energy savings from energy efficiency measures related to buildings and heating systems, a model building needs to be defined, specifying the conditioned floor area of different building types, an average space heating demand per building type (reference and energy efficient building), an average hot water demand per building unit and the efficiency of the heating system based on assumptions made related to the heating structure of the country.

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 85-86[16] for the lifetime of measures relating to the building shell incl. windows and heating systems, if considered in the national building code. Alternatively, the lifetime may be determined based on national empirical values.

Conditioned gross floor area: values for determining the conditioned gross floor area are to be defined in the model building. The average gross floor area may be calculated based on national statistics or may be available from analyses of energy certificates, buildings databases etc.

[16] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

Specific Space Heating Demand of building (old and new building code): For the reference building, the specific space heating demand for different building types (single- and multi-family houses, apartment blocks, non-residential buildings) can be applied as stipulated in the initial building code.

For the energy efficient building, the specific space heating demand for different building types (single- and multi-family houses, apartment blocks, non-residential buildings) can be applied as stipulated in the new building code.

Efficiency of the heating system:

- **Expenditure Factor of the heating system:** It is determined by the ratio of heating energy demand (fuel consumption of the heating system) to space heating demand plus domestic hot water demand (ratio of final energy demand to useful energy demand). Input parameters for the calculation are:
    - Space heating demand (plus domestic hot water demand) and
    - Heating energy (fuel) demand determined by the boiler's efficiency, distribution losses and energy demand of auxiliary systems.
- **Annual use efficiency of the heating system:** It is determined by the ratio of space heating demand plus domestic hot water demand to heating energy demand (ratio of useful energy demand to final energy demand). Input parameters for the calculation are:
    - Space heating demand (plus domestic hot water demand) and
    - Heating energy (fuel) demand determined by the boiler's efficiency, distribution losses and energy demand of auxiliary systems.

The efficiency of the heating system shall be determined in the model building for the reference and/or efficient heating system. EU Member States may have set default values for the efficiency of the heating system when implementing the Energy Performance Building Directive and consequently the energy performance certificate.

Heating Degree Days: figures may be available either at the national meteorological institute or at the national statistical office.

III.II Thermally improved building envelope of newly constructed residential buildings

Newly constructed buildings are considered energy efficient if they meet a higher efficiency standard than stipulated in the national building code of new constructions.

The following formula applies to single- and multi-family homes as well as to big housing blocks.

Bottom-up formula	
Option 1: $TFES = A * (SHD_{Ref} - SHD_{Eff}) * EF_{Eff}$ **Option 2:** $TFES = A * (SHD_{Ref} - SHD_{Eff}) * \frac{1}{\eta_{Eff}}$	
Definition	
TFES:	Total Final Energy Savings [kWh/a]
A	Conditioned gross floor area of the newly constructed building [m^2]
SHD_{Ref}	Specific Space Heating Demand of the reference building [$kWh/m^2/a$]
SHD_{Eff}	Specific Space Heating Demand of the energy efficient building [$kWh/m^2/a$]
EF_{Eff}	Expenditure Factor of the heating system in the newly constructed building
η_{Eff}	Annual use efficiency of the heating system in the newly constructed building
Baseline	
Maximum space heating demand allowed as stipulated in the national building code [$kWh/m^2/a$]. The space heating demand values should be corrected with the relevant heating degree days.	

Values:

Lifetime of the measure in years (default or project specific)

Conditioned gross floor area of the newly constructed building (default or project specific)

Specific Space Heating Demand of the reference building (default or project specific)

Specific Space Heating Demand of the energy efficient building (default or project specific)

Expenditure Factor of the efficient heating system in the newly constructed building (default or project specific)

Annual use efficiency of the heating system in the newly constructed building (default or project specific)

III.II.I Guidance for identification of default values

When applying the methods for calculating energy savings from energy efficiency measures related to buildings and heating systems, a model building needs to be defined, specifying an average value of the conditioned floor area per building type, an average space heating demand per building type (reference and energy efficient building), an average hot water demand per building unit and the efficiency of the heating system based on assumptions made related to the heating structure of the country.

However, if available, project specific values may also be used for the savings calculation, but attention needs to be paid to the fact that project specific values and default values may not mixed in one and the same savings calculation.

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 85[17]. Alternatively, the lifetime may be determined based on national empirical values.

Conditioned gross floor area of the newly constructed residential building: values for determining the conditioned gross floor area are to be defined in the model building. The average gross floor area may be calculated based on national statistics on newly constructed residential buildings or may be available from analyses of energy certificates, buildings databases etc.

[17] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

Specific Space Heating Demand (reference and energy efficient building): values for determining the specific space heating demand are to be defined in the model building.

For newly constructed buildings, the average specific space heating demand of the reference building may be taken from the national building code.

The average specific space heating demand of the energy efficient building may be determined by considering more ambitious regulations on the heating demand of new buildings for example as set in subsidy guidelines.

Efficiency of the heating system:

- **Expenditure Factor of the heating system:** It is determined by the ratio of heating energy demand (fuel consumption of the heating system) to space heating demand plus domestic hot water demand (ratio of final energy demand to useful energy demand). Input parameters for the calculation are:
    - Space heating demand (plus domestic hot water demand) and
    - Heating energy (fuel) demand determined by the boiler's efficiency, distribution losses and energy demand of auxiliary systems.
- **Annual use efficiency of the heating system:** It is determined by the ratio of space heating demand plus domestic hot water demand to heating energy demand (ratio of useful energy demand to final energy demand). Input parameters for the calculation are:
    - Space heating demand (plus domestic hot water demand) and
    - Heating energy (fuel) demand determined by the boiler's efficiency, distribution losses and energy demand of auxiliary systems.

The efficiency of the heating system shall be determined in the model building for the reference and/or efficient heating system. EU Member States may have set default values for the efficiency of the heating system when implementing the Energy Performance Building Directive and consequently the energy performance certificate.

Heating Degree Days: figures may be available either at the national meteorological institute or at the national statistical office.

III.III Thermally improved building envelope of refurbished residential buildings

This method provides for evaluating the energy savings of measures related to the thermal refurbishment of existing residential buildings. It should be noted that the method does not provide for the replacement of the existing heating system.

The following formula applies to single- and multi-family homes as well as to big housing blocks.

Bottom-up formula	
Option 1: $TFES = A * \left((SHD_{Ref} + HWD) * EF_{Ref} - (SHD_{Eff} + HWD) * EF_{Eff}\right)$ **Option 2:** $TFES = A * \left(\frac{SHD_{Ref}+HWD}{\eta_{REf}} - \frac{SHD_{Eff}+HWD}{\eta_{Eff}}\right)$	
Definition	
TFES:	Total Final Energy Savings [kWh/a]
A	Conditioned gross floor area of the refurbished building [m^2]
SHD_{Ref}	Specific Space Heating Demand of the reference building [$kWh/m^2/a$]
SHD_{Eff}	Specific Space Heating Demand of the energy efficient building [$kWh/m^2/a$]
HWD	Specific Domestic Hot Water Demand [$kWh/m^2/a$]
EE_{Ref}	Expenditure Factor of the heating system in the reference building
EF_{Eff}	Expenditure Factor of the heating system in the efficient building
η_{Ref}	Annual use efficiency of the heating system in the reference building
η_{Eff}	Annual use efficiency of the heating system in the efficient building
Baseline	
Area-related space heating demand prior to the thermal refurbishment of the building [$kWh/m^2/a$]. The space heating demand values should be corrected with the relevant heating degree days.	

Values:

Lifetime of the measure in years (default or project specific)

Conditioned gross floor area of the refurbished building (default or project specific)

Specific Space Heating Demand of the reference building (default or project specific)

Specific Space Heating Demand of the energy efficient building (default or project specific)

Specific Domestic Hot Water Demand (default or project specific)

Expenditure Factor of the heating system in the reference building (default or project specific)

Expenditure Factor of the heating system in the efficient building (default or project specific)

Annual use efficiency of the heating system in the reference building (default or project specific)

Annual use efficiency of the heating system in the efficient building (default or project specific)

III.III.I Guidance for identification of default values

When applying the methods for calculating energy savings from energy efficiency measures related to buildings and heating systems, a model building needs to be defined, specifying an average value of the conditioned floor area per building type, an average space heating demand per building type (reference and energy efficient building), an average hot water demand per building unit and the efficiency of the heating system based on assumptions made related to the heating structure of the country.

However, if available, project specific values may also be used for the savings calculation, but attention needs to be paid to the fact that project specific values and default values may not mixed in one and the same savings calculation.

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 85[18]. Alternatively, the lifetime may be determined based on national empirical values.

Conditioned gross floor area of the refurbished building: values for determining the conditioned gross floor area are to be defined in the model building. The average gross floor area may be calculated based on national

[18] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

statistics on buildings for buildings in stock or may be available from analyses of energy certificates, buildings databases etc.

Specific Space Heating Demand (reference and energy efficient building): values for determining the specific space heating demand are to be defined in the model building.

The average specific space heating demand of the reference building may be calculated based on national statistics such as energy balance, useful energy balance and statistics on buildings.

Alternatively, average values for a specific space heating demand for different building types – whether they are thermally refurbished or not – may be available from national empirical studies, analyses of energy certificates, buildings databases etc. For selected European countries (mostly EU Member States), reference can also be made to the EU-funded projects TABULA and EPISCOPE (http://episcope.eu/welcome/) where national building typologies representing the residential building stock have been developed.

For thermally refurbished buildings, the space heating demand may also be determined by subsidy guidelines, specifying a certain thermal quality to be reached when applying for subsidies for thermal refurbishment.

Specific Domestic Hot Water Demand (average value): values for determining the area-related domestic hot water demand are to be defined in the model building. It is calculated based on the building's gross floor area and the efficiency of the heating system providing not only space heating but also hot water. The efficiency of the heating system is determined by the efficiency of the heating system, the distribution losses and energy demand of auxiliary systems.

Efficiency of the heating system:

- **Expenditure Factor of the heating system:** It is determined by the ratio of heating energy demand (fuel consumption of the heating system) to space heating demand plus domestic hot water demand (ratio of final energy demand to useful energy demand). Input parameters for the calculation are:
    - Space heating demand (plus domestic hot water demand) and
    - Heating energy (fuel) demand determined by the boiler's efficiency, distribution losses and energy demand of auxiliary systems.
- **Annual use efficiency of the heating system:** It is determined by the ratio of space heating demand plus domestic hot water demand to heating energy demand (ratio of useful energy demand to final energy demand). Input parameters for the calculation are:

- Space heating demand (plus domestic hot water demand) and
- Heating energy (fuel) demand determined by the boiler's efficiency, distribution losses and energy demand of auxiliary systems.

The efficiency of the heating system shall be determined in the model building for the reference and/or efficient heating system. EU Member States may have set default values for the efficiency of the heating system when implementing the Energy Performance Building Directive and consequently the energy performance certificate.

Heating Degree Days: figures may be available either at the national meteorological institute or at the national statistical office.

III.IV Thermally improved building envelope of newly constructed non-residential buildings

This method applies to newly constructed service buildings which meet a higher energy efficiency standard than stipulated in the national building code. Such service buildings comprise offices, educational buildings, hospitals, nursing homes, hotels and restaurants, sports facilities, wholesale and retail trade service buildings and other types of energy-consuming buildings.

Bottom-up formula	
Option 1: $TFES = A * (SHD_{Ref} - SHD_{Eff}) * EF_{Eff}$ **Option 2:** $TFES = A * (SHD_{Ref} - SHD_{Eff}) * \frac{1}{\eta_{Eff}}$	
Definition	
TFES:	Total Final Energy Savings [kWh/a]
A	Conditioned gross floor area relating to the average space heating demand of the reference building [m^2]
SHD_{Ref}	Specific Space Heating Demand of the reference building [$kWh/m^2/a$]
SHD_{Eff}	Specific Space Heating Demand of the energy efficient building [$kWh/m^2/a$]
EF_{Eff}	Expenditure Factor of the heating system in the efficient building
η_{Eff}	Annual use efficiency of the heating system in the efficient building
Baseline	
Maximum allowed space heating demand as stipulated in the national building code for newly constructed non-residential buildings [$kWh/m^2/a$]. The space heating demand values should be corrected with the relevant Heating Degree Days.	

Values:

Lifetime of the measure in years (default or project specific)

Conditioned gross floor area relating to the average space heating demand of the reference building (project specific)

Specific Space Heating Demand of the reference building (default or project specific)

Specific Space Heating Demand of the energy efficient building (default or project specific)

Expenditure Factor of the heating system in the efficient building (default or project specific)

Annual use efficiency of the heating system in the efficient building (default or project specific)

III.IV.I Guidance for identification of default values

When applying the methods for calculating energy savings from energy efficiency measures related to buildings and heating systems, a model building needs to be defined, specifying an average value of the conditioned floor area per building type, an average space heating demand per building type (reference and energy efficient building), an average hot water demand per building unit and the efficiency of the heating system based on assumptions made related to the heating structure of the country.

However, if available, project specific values may also be used for the savings calculation, but attention needs to be paid to the fact that project specific values and default values may not mixed in one and the same savings calculation.

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 86[19]. Alternatively, the lifetime may be determined based on national empirical values.

Specific Space Heating Demand (reference and energy efficient non-residential building): values for determining the specific space heating demand are to be defined in the model building.

For newly constructed non-residential buildings, the average specific space heating demand of the reference building may be taken from the national building code as minimum energy efficiency requirement.

[19] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

The average specific space heating demand of the energy efficient non-residential building may be determined by more ambitious regulations on the heating demand of new non-residential buildings for example as set in subsidy guidelines. Also project-specific values can be used for the savings calculation if a representative default value is difficult to be determined.

Efficiency of the heating system:

- **Expenditure Factor of the heating system:** It is determined by the ratio of heating energy demand (fuel consumption of the heating system) to space heating demand plus domestic hot water demand (ratio of final energy demand to useful energy demand). Input parameters for the calculation are:
    - Space heating demand (plus domestic hot water demand) and
    - Heating energy (fuel) demand determined by the boiler's efficiency, distribution losses and energy demand of auxiliary systems.
- **Annual use efficiency of the heating system:** It is determined by the ratio of space heating demand plus domestic hot water demand to heating energy demand (ratio of useful energy demand to final energy demand). Input parameters for the calculation are:
    - Space heating demand (plus domestic hot water demand) and
    - Heating energy (fuel) demand determined by the boiler's efficiency, distribution losses and energy demand of auxiliary systems.

The efficiency of the heating system shall be determined in the model building for the reference and/or efficient heating system. EU Member States may have set default values for the efficiency of the heating system when implementing the Energy Performance Building Directive and consequently the energy performance certificate.

Heating Degree Days: figures may be available either at the national meteorological institute or at the national statistical office.

III.V Thermally improved building envelope of existing non-residential buildings

This method applies to existing service buildings which meet a higher energy efficiency standard after thermal refurbishment than stipulated in the national building code. The method does not foresee the replacement of the existing heating system. Service buildings comprise offices, educational buildings, hospitals, nursing homes, hotels and restaurants, sports facilities, wholesale and retail trade service buildings and other types of energy-consuming buildings.

Bottom-up formula	
Option 1: $TFES = A * \left((SHD_{Ref} + HWD) * EF_{Ref} - (SHD_{Eff} + HWD) * EF_{Eff}\right)$ **Option 2:** $TFES = A * \left(\frac{SHD_{Ref}+HWD}{\eta_{Ref}} - \frac{SHD_{Eff}+HWD}{\eta_{Eff}}\right)$	
Definition	
TFES:	Total Final Energy Savings [kWh/a]
A	Conditioned gross floor area relating to the average space heating demand of the reference building [m^2]
SHD_{Ref}	Specific Space Heating Demand of the reference building [$kWh/m^2/a$]
SHD_{Eff}	Specific Space Heating Demand of the energy efficient building [$kWh/m^2/a$]
HWD	Specific Hot Water Demand [$kWh/m^2/a$]
EF_{Ref}	Expenditure Factor of the heating system in the reference building
EF_{Eff}	Expenditure Factor of the heating system in the efficient building
η_{Ref}	Annual use efficiency of the heating system in the reference building
η_{Eff}	Annual use efficiency of the heating system in the efficient building
Baseline	
Specific space heating demand prior to the thermal refurbishment of the building [$kWh/m^2/a$]. The space heating demand values should be corrected with the relevant heating degree days.	

Values:

Lifetime of the measure in years (default or project specific)

Conditioned gross floor area relating to the average space heating demand of the reference building (project specific)

Specific Space Heating Demand of the reference building (default or project specific)

Specific Space Heating Demand of the energy efficient building (default or project specific)

Specific Hot Water Demand (default or project specific)

Expenditure Factor of the heating system in the reference building (default or project specific)

Expenditure Factor of the heating system in the efficient building (default or project specific)

Annual use efficiency of the heating system in the reference building (default or project specific)

Annual use efficiency of the heating system in the efficient building (default or project specific)

III.V.I Guidance for identification of default values

When applying the methods for calculating energy savings from energy efficiency measures related to buildings and heating systems, a model building needs to be defined, specifying an average value of the conditioned floor area per building type, an average space heating demand per building type (reference and energy efficient building), an average hot water demand per building unit and the efficiency of the heating system based on assumptions made related to the heating structure of the country.

However, if available, project specific values may also be used for the savings calculation, but attention needs to be paid to the fact that project specific values and default values may not mixed in one and the same savings calculation.

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 86[20]. Alternatively, the lifetime may be determined based on national empirical values.

Specific Space Heating Demand (reference and energy efficient non-residential building): values for determining the area-related space heating demand are to be defined in the model building.

[20] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

The average specific space heating demand of the reference building may be calculated based on national statistics such as the energy balance and useful energy balance, if available for different types of non-residential buildings.

Alternatively, average values for specific space heating demand may be available from national empirical studies, analyses of energy certificates, buildings databases or the national building code in place at the time when the building was constructed. For selected EU Member States, reference can also be made to the EU-funded projects TABULA and EPISCOPE (http://episcope.eu/welcome/) where national building typologies representing the residential and non-residential building stock have been developed.

For thermally refurbished buildings, the space heating demand may be determined by subsidy guidelines, specifying a certain thermal quality to be reached when applying for subsidies. Also project-specific values can be used for the savings calculation if a representative default value is difficult to be determined.

Specific Domestic Hot Water Demand (average value): values for determining the area-related domestic hot water demand are to be defined in the model building. It is calculated based on the building's gross floor area and the efficiency of the heating system providing not only space heating but also hot water. The efficiency of the heating system is determined by the efficiency of the heating system, the distribution losses and energy demand of auxiliary systems.

Efficiency of the heating system:

- **Expenditure Factor of the heating system:** It is determined by the ratio of heating energy demand (fuel consumption of the heating system) to space heating demand plus domestic hot water demand (ratio of final energy demand to useful energy demand). Input parameters for the calculation are:
    - Space heating demand (plus domestic hot water demand) and
    - Heating energy (fuel) demand determined by the boiler's efficiency, distribution losses and energy demand of auxiliary systems.
- **Annual use efficiency of the heating system:** It is determined by the ratio of space heating demand plus domestic hot water demand to heating energy demand (ratio of useful energy demand to final energy demand). Input parameters for the calculation are:
    - Space heating demand (plus domestic hot water demand) and
    - Heating energy (fuel) demand determined by the boiler's efficiency, distribution losses and energy demand of auxiliary systems.

The efficiency of the heating system shall be determined in the model building for the reference and/or efficient heating system. EU Member States may have set default values for the efficiency of the heating system when implementing the Energy Performance Building Directive and consequently the energy performance certificate.

Heating Degree Days: figures may be available either at the national meteorological institute or at the national statistical office.

III.VI Thermal improvement of single building elements (windows, roof etc.)

The method provides for evaluating the energy savings derived from the thermal improvement of single building elements (e.g. windows, building shell). The heating system will not be replaced while improving single building elements.

Bottom-up formula

Wall insulation:

Option 1:

$$TFES_{wall} = (U_{Ref\_wall} - U_{Eff\_wall}) * A * HDD * f * EF_{Ref}$$

Option 2:

$$TFES_{wall} = (U_{Ref\_wall} - U_{Eff\_wall}) * A * HDD * f * \frac{1}{\eta_{Ref}}$$

Window replacement:

Option 1:

$$TFES_{windows} = (U_{Ref\_window} - U_{Eff\_window}) * A * HDD * f * EF_{Ref}$$

Option 2:

$$TFES_{windows} = (U_{Ref\_window} - U_{Eff\_window}) * A * HDD * f * \frac{1}{\eta_{Ref}}$$

Roof insulation:

Option 1:

$$TFES_{roof} = (U_{Ref\_roof} - U_{Eff\_roof}) * A * HDD * f * EF_{Ref}$$

Option 2:

$$TFES_{windows} = (U_{Ref\_window} - U_{Eff\_window}) * A * HDD * f * \frac{1}{\eta_{Ref}}$$

Definition	
TFES:	Total Final Energy Savings [kWh/a]
U_{Ref_wall} $U_{Ref\_windows}$ U_{Ref_roof}	U-value of the reference building element: overall heat transfer coefficient [W/m^{2}K]
U_{Eff_wall} $U_{Eff\_windows}$ U_{Eff_roof}	U-value of the efficient building element: overall heat transfer coefficient [W/m^{2}K]
A	Area of the building element refurbished [m^2]
HDD_{AC}	Heating degree days at average climatic conditions [Kd/a]
f	Conversion factor to kWh [kh/d]
EF_{Ref}	Expenditure Factor of the heating system in the reference building
η_{Ref}	Annual use efficiency of the heating system in the reference building
Baseline	
U-value of each refurbished element or average U-value of each element in the period of construction of the building undergoing refurbishment or in the year of last refurbishment.	

Values:

Lifetime of the measure in years (default or project specific)

U-value of the reference building element (default or project specific)

U-value of the efficient building element (default or project specific)

Area of the building element refurbished (project specific)

Heating Degree Days (default)

Conversion factor (default)

Expenditure Factor of the heating system in the reference building (default or project specific)

Annual use efficiency of the heating system in the reference building (default or project specific)

III.VI.I Guidance for identification of default values

When applying the methods for calculating energy savings from energy efficiency measures related to buildings and heating systems, a model building needs to be defined, specifying an average value of the conditioned floor area per building type, an average space heating demand per building type (reference and energy efficient building), an average hot water demand per building unit and the efficiency of the heating system based on assumptions made related to the heating structure of the country.

However, if available, project specific values may also be used for the savings calculation, but attention needs to be paid to the fact that project specific values and default values may not mixed in one and the same savings calculation.

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 85-86[21]. Alternatively, the lifetime may be determined based on national empirical values.

U-values for the reference and energy efficient building element: for the reference building element, the u-values valid in the year or period of construction of the building may be used. Those can usually be found in the national building regulations, i.e. building codes.

For the energy efficient building element, more ambitious u-values than stipulated in the latest national building code may be determined by subsidy guidelines, specifying a certain thermal quality to be reached when applying for subsidies. Also project-specific values can be used for the savings calculation if a representative default value is difficult to be determined.

Heating Degree Days: figures may be available either at the national meteorological institute or at the national statistical office.

Conversion factor: the factor is 0,024 kilo hours per day if the heating system is running 24 hours. This factor may be reduced as it is subject to the average daily operating time of the heating system (e.g. heating system running from 06h00 to 22h00 => 0,024*0,67).

Efficiency of the heating system:

- **Expenditure Factor of the heating system:** It is determined by the ratio of heating energy demand (fuel consumption of the heating system) to space heating demand plus domestic hot water demand (ratio of final energy demand to useful energy demand). Input parameters for the calculation are:
    - Space heating demand (plus domestic hot water demand) and
    - Heating energy (fuel) demand determined by the boiler's efficiency, distribution losses and energy demand of auxiliary systems.

[21] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

- **Annual use efficiency of the heating system:** It is determined by the ratio of space heating demand plus domestic hot water demand to heating energy demand (ratio of useful energy demand to final energy demand). Input parameters for the calculation are:
    - Space heating demand (plus domestic hot water demand) and
    - Heating energy (fuel) demand determined by the boiler's efficiency, distribution losses and energy demand of auxiliary systems.

The efficiency of the heating system shall be determined in the model building for the reference and/or efficient heating system. EU Member States may have set default values for the efficiency of the heating system when implementing the Energy Performance Building Directive and consequently the energy performance certificate.

IV Air-conditioning Systems

Sectors: households and services (residential and non-residential buildings)

The section "Air-conditioning systems" provides methods to calculate energy savings resulting from the replacement of conventional air conditioning systems with more energy efficient ones. Further on, a method is provided to calculate energy savings from cooling buildings with a centralized district cooling system instead of single decentralized ones.

IV.I Air conditioning

The methods provided under air conditioning apply to the new installation and replacement of central compression cooling systems (before the end of their lifetime) as well as to room air conditioners with a cooling power output below 12 kW. Whereas one calculating option relates to the installed cooling power of the cooling system, another one relates to the cooling demand of the building.

IV.I.I Central compression cooling system

When applying the method "central compression refrigeration system", the following requirements have to be fulfilled:

- The compressors must be powered by electrical energy.
- Cooling systems with free cooling or heat recovery are not covered.

The method is valid for new installation and replacement of central compression cooling systems. It can be used for residential and non-residential buildings.

Below, two calculation formulae are provided. The first option applies to cases where the cooling demand of the building stays constant, only a more efficient cooling system is put in place. The second option applies to cases where not only the efficiency of the cooling system, but also the cooling demand of the building improves.

Bottom-up formula
Option 1 (for non-refurbished buildings): $TFES = (P_C * h_{FL}) * \left(\frac{1}{ESEER_{Ref}} - \frac{1}{ESEER_{Eff}}\right) * n$ **Option 2 (for refurbished buildings lowering the cooling demand):** $TFES = A * (SCD_{Ref} * \frac{1}{ESEER_{Ref}} - SCD_{Eff} * \frac{1}{ESEER_{Eff}})$

Definition	
TFES:	Total Final Energy Savings [kWh/a]
P_C	Installed cooling power of the cooling system [kW]
h_{FL}	Full-load hours related to the maximum installed cooling power [h]
$ESEER^{22}_{Ref}$	European Seasonal Energy Efficiency Ratio of the reference compression cooling system
$ESEER_{Eff}$	European Seasonal Energy Efficiency Ratio of the more efficient compression cooling system
n	Number of cooling systems installed at a specific cooling power
A	Conditioned floor area of the building [m^2]
SCD_{Ref}	Specific Cooling Demand of the reference building [kWh/m^2/a]
SCD_{Eff}	Specific Cooling Demand of the energy efficient building [kWh/m^2/a]

Baseline
New installation and replacement after the end of its lifetime: the ESEER value of the efficient compression cooling system is compared to the ESEER value of an average compression cooling system available on the market. **Replacement before the end of its lifetime:** the ESEER value of the efficient compression cooling system is compared to the ESEER value of the existing compression cooling system. If savings are calculated based on the cooled floor area, the baseline is determined by the efficiency of the cooling system installed before replacement (in case of new installation, an average cooling system available on the market may serve as baseline) as well as by the cooling demand of the reference building.

[22] The European Seasonal Energy Efficiency Ratio (ESEER) is a weighed formula enabling to take into account the variation of EER (Energy Efficiency Ratio) with the load rate and the variation of air or water inlet condenser temperature.

Source: http://www.eurovent-certification.com/en/Certification_Programmes/Programme_Descriptions.php?lg=en&rub=03&srub=01&select_prog=LCP-HP, 13 July 2015.

Values:

Lifetime of the measure in years (default or project specific)

Installed cooling power of the cooling system (project specific)

Full-load hours (project specific)

ESEER values for the central compression cooling system (reference system and energy efficient system) – for air-cooled and water-cooled systems (default)

Number of cooling systems installed at a specific cooling power (project specific)

Cooled floor area of the building (default or project specific)

Specific Cooling Demand of the reference building (default or project specific)

Specific Cooling Demand of the energy efficient building (default or project specific)

IV.I.II Room air conditioner < 12 kW cooling capacity

For applying the method "room air conditioner < 12 kW cooling capacity", the following requirements have to be fulfilled:

- The room air conditioner must be powered by electrical energy.
- The air conditioner must be stationary.

The method is valid for the new installation and replacement of room air conditioners. It can be used for residential and non-residential buildings.

Stationary air conditioning systems with a cooling power output below 12 kW have to be categorized according to Regulation 626/2011. The regulation stipulates that split appliances are to be classified according to the SEER[23] value, single and double duct air conditioners are to be classified according to the EER[24] value. The values can be found on the EU energy efficiency label.

Below, two calculation formulae are provided. The first option applies to cases where the cooling demand of the building stays constant, only a more efficient cooling system is put in place. The second option applies to cases where not only the efficiency of the cooling system, but also the cooling demand of the building improves.

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[23] Seasonal energy efficiency ratio (SEER) is the overall energy efficiency ratio of the unit, representative for the whole cooling season, calculated as the reference annual cooling demand divided by the annual electricity consumption for cooling.

Source: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32011R0626&from=EN, Annex I. Download: 1 July 2015.

[24] Energy efficiency ratio (EER) means the declared capacity for cooling [kW] divided by the power input for Cooling [kW] of a unit when providing cooling at standard conditions.

Source: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32011R0626&from=EN, Annex I. Download: 1 July 2015.

Bottom-up formula

Option 1 (for non-refurbished buildings):

$$TFES = (P_C * h_{FL}) * \left(\frac{1}{SEER_{Ref}} - \frac{1}{SEER_{Eff}}\right) * n$$

$$TFES = (P_C * h_{FL}) * \left(\frac{1}{EER_{Ref}} - \frac{1}{EER_{Eff}}\right) * n$$

Option 2 (for refurbished buildings lowering the cooling demand)::

$$TFES = A * (SCD_{Ref} * \frac{1}{SEER_{REF}} - SCD_{Eff} * \frac{1}{SEER_{EFF}})$$

$$TFES = A * (SCD_{Ref} * \frac{1}{EER_{Ref}} - SCD_{Eff} * \frac{1}{EER_{Eff}})$$

Definition

TFES:	Total Final Energy Savings [kWh/a]
P_C	Installed cooling power of the cooling system [kW]
h_{FL}	Full-load hours related to the maximum installed cooling power [h]
$SEER_{Ref}$	Seasonal Energy Efficiency Ratio of the reference air conditioning system
$SEER_{Eff}$	Seasonal Energy Efficiency Ratio of the more efficient air conditioning system
EER_{Ref}	Energy Efficiency Ratio of the reference air conditioning system
EER_{Eff}	Energy Efficiency Ratio of the more efficient air conditioning system
n	Number of room air conditioners < 12 kW installed
A	Conditioned floor area of the building [m^2]
SCD_{Ref}	Specific Cooling Demand of the reference building [$kWh/m^2/a$]
SCD_{Eff}	Specific Cooling Demand of the energy efficient building [$kWh/m^2/a$]

Baseline

New installation and replacement after the end of its lifetime: the (S)EER value of the efficient air conditioning system is compared to the (S)EER value of an average air conditioning system available on the market.

Replacement before the end of its lifetime: the (S)EER value of the efficient air conditioning system is compared to the (S)EER value of the existing air conditioning system.

If savings are calculated based on the cooled floor area, the baseline is determined by the efficiency of the cooling system installed before replacement (in case of new installation, an average cooling system available on the market may serve as baseline) as well as by the cooling demand of the reference building.

Values:

Lifetime of the measure in years (default or project specific)

Full-load hours [h/a] (project specific)

SEER values for the room air conditioner < 12 kW cooling capacity (reference system and energy efficient system) (default)

EER values for the room air conditioner < 12 kW cooling capacity (reference system and energy efficient system) (default)
Number of cooling systems installed at a specific cooling power (project specific)
Cooled floor area of the building (default or project specific)
Specific Cooling Demand of the reference building (default or project specific)
Specific Cooling Demand of the energy efficient building (default or project specific)

IV.I.III Guidance for identification of default values

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 85-87[25]. Alternatively, the lifetime of air conditioning devices may be defined in national standards or project specific values may be available.

ESEER values: represent the average efficiency of the air conditioning system at different operation levels. For determining default ESEER values, average values of Eurovent certified air conditioning systems of different energy efficiency standards may be calculated based on the Eurovent database: http://www.eurovent-certification.com/en/Certified_products/Search_Engine.php?rub=04&srub=04&ssrub=&lg=en

SEER values and EER values: requirements for the minimum energy efficiency of air conditioning systems are stipulated in Regulation (EU) No 206/2012 implementing Directive 2009/125/EC with regard to eco-design requirements for air conditioners and comfort fans: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:072:0007:0027:en:PDF

SEER and EER values: Regulation (EU) No 626/2011 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of air conditioners: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32011R0626&from=EN

An overview of the Eco-design regulations of the EU can be found under: https://ec.europa.eu/energy/sites/ener/files/documents/list_of_ecodesign_measures.pdf

[25] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

An overview of the Eco-labelling regulations of the EU can be found under: https://ec.europa.eu/energy/sites/ener/files/documents/list_of_enegy_labelling_measures.pdf

Conditioned floor area of the building: values for determining the cooled floor area are to be defined in the model building. The average floor area may be calculated based on national statistics or may be available from analyses of energy certificates, buildings databases etc.

Specific Cooling Demand (reference and energy efficient building): values for determining the area-related space cooling demand are to be defined in the model building.

For newly constructed buildings, the average specific space cooling demand of the reference building may be taken from the national building code.

The average specific space cooling demand of the energy efficient building may be determined by considering more ambitious regulations on the cooling demand of new buildings for example as set in subsidy guidelines.

IV.II District cooling

District cooling represents an alternative to conventional air conditioning systems, delivering chilled water to buildings needing cooling. District cooling systems are more efficient, as larger systems are considerably more energy-efficient than small, individual units.

The method provides to replace several existing decentralized cooling systems with a central cooling system (district cooling system).

Bottom-up formula	
$TFES = \left(\frac{Q_b}{COPS_d} * t_d\right) * nb - \left[\left(\frac{Q_b * nb * f_{sf} + q_l * l}{COPS_c}\right) * t_c\right] - P_P * t_c$	
Definition	
TFES	Total Final Energy Savings [kWh/a]
Q_b	Average cooling load per building [kW]
$COPS_d$	Average System Coefficient of Performance (decentralized systems)
t_d	Average yearly operating hours (decentralized systems) [h/a]
nb	Number of buildings
f_{sf}	Simultaneity Factor
q_l	Specific distribution losses [kW/m]
l	Length of distribution grid [m]
$COPS_c$	System Coefficient of Performance (centralized system)
t_c	Average yearly operating hours (centralized system) [h/a]
P_P	Power of distribution pump [kW]
Baseline	
Decentralized cooling systems	

Values:

Lifetime of the measure in years (default)
Average cooling load per building (default or project specific)
Average System Coefficient of Performance (project specific)
Average yearly operating hours (project specific)
Number of buildings (project specific)
Simultaneity Factor (default or project specific)
Specific distribution losses (default or project specific)
Length of distribution grid (project specific)
Power of distribution pump (project specific)

IV.II.I Guidance for identification of default values

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 85[26].

Average cooling load per building: values for determining the cooling load per building are to be defined in the model building or can be project specific. The value can be calculated based on national standards (e.g. Austria: ÖNORM H 6040 or VDI 2078).

Average System Coefficient of Performance: a system specific value. The value can be found in national guidelines (e.g. Austria: VDMA-24247-5) or studies. The following international database may also be recommended for determining this coefficient: http://www.eurovent-certification.com/

Average yearly operating hours: project specific value dependent on the climatic conditions in the different countries. Default values may be found in relevant national publications.

Simultaneity Factor: Simultaneity is a concept which is used to describe that separate customer's peak load doesn't occur at the same time due to (1) demand occurring at different times of the day, (2) a variation of demand that occurs randomly over time and is influenced by individual temperature regulation in both district cooling and district heating systems, (3) different buildings are not exposed to the maximum temperature at the same time due to shading etc. and (4) different ways of operating the technical installations.[27]
It is suggested to use a project specific value as simultaneity factor. It depends on the number of buildings supplied with district cooling. Default values may be found in national publications.

Specific distribution losses: project specific values. Default values can be found in datasheets of distribution pipe manufacturers or national publications.

Length of distribution grid: project specific value. The value can be determined from plans.

Power of distribution pump: project specific value. The value can be calculated based on the mass flow and pressure losses.

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[26] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

[27] ECOHEATCOOL, Work Package 5, Possibilities with more district cooling in Europe: http://www.euroheat.org/files/filer/ecoheatcool/documents/Ecoheatcool_WP5_Web.pdf, p. 12

V Circulating pump

Target sector: households (residential buildings), public and private services (tertiary buildings)

The methods hereunder provide for the calculation of energy savings derived from the installation of new energy efficient circulating pumps and from the replacement of existing circulating pumps. A circulating pump is considered efficient if it has an energy efficiency index of ≤ 0.23 and therefore corresponds to the minimum requirements as set in the Ecodesign-Directive 2009/125/EG which specifies an energy efficiency index of ≤ 0.23 for heating circulating pumps as of 1st August 2015.

V.I Installation of a new heating circulating pump

For the method "installation of a new heating circulating pump", an energy efficient circulating pump is compared to an average circulating pump available on the market.

Bottom-up formula	
$TFES = n * \left(\frac{P_{Ref} * t_a - P_{eff} * t_a * fLPr}{1000}\right)$ Calculation load profile: $f_{LPr} = t_{Q100\%} * Q_{100\%} + t_{Q75\%} * Q_{75\%} + t_{Q50\%} * Q_{50\%} + t_{Q25\%} * Q_{25\%}$	
Definition	
TFES:	Total Final Energy Savings [kWh/a]
n	Number of installed circulating pumps
P_{Ref}	Electrical power of an average circulating pump available on the market [W]
P_{eff}	Electrical power of an efficient circulating pump [W]
t_a	Average yearly operating hours of circulating pumps [h/a]
f_{LPr}	Factor load profile
Q	Delivery rating of the pump
t_Q	Relative load time
Baseline	
Electrical power of an average circulating pump available on the market	

Values:

Lifetime of the measure in years (default or project specific)

Number of installed circulating pumps (project specific)

Electrical power of an average circulating pump (project specific)

Electrical power of an efficient circulating pump (project specific)

Average yearly operating hours of circulating pumps (default or project specific)

Delivery rating of the pump (default)

Relative load time (default)

V.II Replacement of an existing heating circulating pump

For the method "replacement of an existing heating circulating pump", an energy efficient circulating pump is compared to an average circulating pump installed in a building.

Bottom-up formula

$$TFES = n * \left(\frac{P_{Ref} * t_a - P_{eff} * t_a * fLPr}{1000}\right)$$

Calculation load profile:

$$f_{LPr} = t_{Q100\%} * Q_{100\%} + t_{Q75\%} * Q_{75\%} + t_{Q50\%} * Q_{50\%} + t_{Q25\%} * Q_{25\%}$$

Definition	
TFES:	Total Final Energy Savings [kWh/a]
n	Number of installed circulating pumps
P_{Ref}	Electrical power of the installed energy inefficient circulating pump (reference system) [W]
P_{eff}	Electrical power of an efficient circulating pump [W]
t_a	Average yearly operating hours of circulating pumps [h/a]
f_{LPr}	Factor load profile
Q	Delivery rating of the pump
t_Q	Relative load time
Baseline	
Electrical power of the installed energy inefficient circulating pump (reference system)	

Values:

Lifetime of the measure in years (default or project specific)
Number of installed circulating pumps (project specific)
Electrical power of the installed energy inefficient circulating pump (project specific)
Electrical power of an efficient circulating pump (project specific)
Average yearly operating hours of circulating pumps (default or project specific)
Delivery rating of the pump (default)
Relative load time (default)

V.II.I Guidance for identification of default values

Lifetime of the measure: information about the lifetime of circulating pumps may be enquired from producers of circulating pumps. The information received from producers in Austria is 15 years on average.

Average yearly full load hours: as a possible source, the publication "EU SAVE II Project Promotion of Energy Efficiency in Circulation Pumps, especially in Domestic Heating Systems" can be referred to: http://www.eci.ox.ac.uk/research/energy/downloads/eusave-pump-t2.pdf
Alternatively, values from (national) empirical studies – if available – can be applied or information can be sought directly from manufacturers of circulating pumps (e.g. Grundfos).

Factor load profile: a commonly known load profile is the so called "Blauer Engel[28]", applicable for speed controlled circulating pumps. The (electrical) energy consumption of the particular circulator is calculated using the "energy weighted" method that takes account of the energy consumption of the circulator at the 25%, 50%, 75% and 100% flow points, as determined by a standard time-flow profile curve.[29] The EU regulation No 622/2012 with regard to eco-design requirements for glandless standalone circulators and glandless circulators integrated in products also refers to this load profile:
http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32012R0622&from=EN

The load profile is as follows:

Delivery rate of the pump [Q]	***Relative load time [t_Q]*** **25% - 100%**
%	*%*
100	*6*
75	*15*
50	*35*
25	*44*

[28] English translation: Blue Angel
[29] http://www.ebpg.bam.de/de/ebpg_medien/011_studyf_08-04_circulators_updated.pdf, page 27. Download 6 August 2015

VI Cogeneration

Target sector: industry

The method targets industrial plants which install a CHP plant for electricity and heat generation. Examples for CHP technologies are: gas turbines with heat recovery system, back pressure steam turbines, condensation steam turbines and block heat and power plants.

VI.I Combined Heat and Power plants (CHP) in industry

Applying this method requires that the thermal and electric capacity as well as the efficiency of the installed CHP plant are known.

Bottom-up formula

$$TFES = \left(\frac{P_{el,CHP}}{\eta_{el,Ref}} + \frac{Q_{th,CHP}}{\eta_{th,Ref}} - \frac{P_{el,CHP}}{\eta_{el,CHP}}\right) \cdot t_{100} \cdot (1 - f_{PG})$$

Factor for feeding electricity and heat into the public grid

$$f_{PG} = \frac{Q_{th,PG} + W_{el,PG}}{Q_{th,CHP} + W_{el,CHP}}$$

Definition	
TFES	Total Final Energy Savings [kWh/a]
$P_{el,CHP}$	Electrical power of the CHP plant [kW_{el}]
$\eta_{el,Ref}$	Electrical efficiency of the reference electricity generation plant [%]
$Q_{th,CHP}$	Thermal power of the CHP plant [kW_{th}]
$\eta_{th,Ref}$	Thermal efficiency of the reference heat generation plant [%]
$\eta_{el,CHP}$	Electrical efficiency of the CHP plant [%]
t_{100}	Average yearly full load hours of the CHP plant [h/a]
f_{PG}	Factor for feeding electricity and heat into the public grid
$Q_{th,PG}$	Heat fed into the public grid (e.g. district heat)
$W_{el,PG}$	Electricity fed into the public grid
$Q_{th,CHP}$	Heat generated in CHP plant
$W_{el,CHP}$	Electricity generated in CHP plant

Baseline
Generation of heat and power through a separate system, i.e. not a combined one

Values:
Lifetime of the measure in years (default or project specific)
Electrical power of the CHP plant (project specific)
Electrical efficiency of the reference electricity generation plant (default)
Thermal power of the CHP plant (project specific)
Thermal efficiency of the reference heat generation plant (default)
Electrical efficiency of the CHP plant (project specific)
Average yearly full load hours of the CHP plant (project specific)
Factor for feeding electricity and heat into the public grid (project specific)

VI.I.I Guidance for identification of default values

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 85-87[30].

Electrical efficiency of the CHP plant (reference system): Decision 2011/877/EU establishing harmonised efficiency reference values for separate production of electricity and heat: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:343:0091:0096:EN:PDF (Annex I and Annex II)

Thermal efficiency of the CHP plant (reference system): Decision 2011/877/EU: establishing harmonised efficiency reference values for separate production of electricity and heat: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:343:0091:0096:EN:PDF (Annex I and Annex II)

[30] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

VII District heating

Target sector: households (residential buildings)

Bottom-up methods for district heating comprise the connection of new and existing residential buildings, both refurbished and non-refurbished, to the district heating grid. Residential buildings cover single- and multi-family homes as well as big housing blocks.

Attention has to be paid to the fact that the methods described below target exclusively the connection of buildings to the district heating grid. The improvement of the building shell, be it through applying higher energy efficiency standards than requested to newly constructed buildings or refurbishing existing buildings thermally, at the same time as connecting buildings to the district heating grid is not covered by the methods in this section.

VII.I Connection to the district heating grid (non-refurbished existing residential buildings)

The method aims at connecting a building to the district heating grid and therefore replacing an existing heating system. Both heating systems, i.e. the existing and the new one, provide heat and hot water.

The method targets single-family and multi-family homes as well as apartment blocks that have not been thermally refurbished (e.g. retrofit of the building shell, exchange of windows).

Bottom-up formula for single-family homes

Option 1:

$$TFES = A * ((SHD + HWD) * EF_{Ref} - (SHD + HWD) * EF_{Eff})$$

Option 2:

$$TFES = A * \left(\frac{SHD + HWD}{\eta_{Ref}} - \frac{SHD + HWD}{\eta_{Eff}}\right)$$

Definition

TFES	Total Final Energy Savings [kWh/a]
A	Conditioned gross floor area of the non-refurbished residential building connected to the district heating grid [m²]
SHD	Specific Space Heating Demand [kWh/m^2/a]
HWD	Specific Domestic Hot Water Demand [kWh/m^2/a]
EF_{Ref}	Expenditure Factor of the reference heating system
EF_{Eff}	Expenditure Factor of the efficient heating system
η_{Ref}	Annual use efficiency of the reference heating system
η_{Eff}	Annual use efficiency of the efficient heating system

Baseline

Average heating system producing heat and hot water.

The space heating demand values should be corrected with the relevant heating degree days.

Values:

Lifetime of the measure in years (default or project specific)

Conditioned gross floor area of the non-refurbished residential building connected to the district heating grid (default or project specific)

Specific Space Heating Demand (default or project specific)

Specific Domestic Hot Water Demand (default or project specific)

Expenditure Factor of the reference heating system (default or project specific)

Expenditure Factor of the efficient heating system (default or project specific)

Annual use efficiency of the reference heating system (default or project specific)

Annual use efficiency of the efficient heating system (default or project specific)

Bottom-up formula for multi-family homes and apartment blocks	
Option 1: $TFES = n * A_{DU} * ((SHD + HWD) * EF_{Ref} - (SHD + HWD) * EF_{Eff})$ **Option 2:** $TFES = n * A_{DU} * \left(\frac{SHD + HWD}{\eta_{Ref}} - \frac{SHD + HWD}{\eta_{Eff}}\right)$	
Definition	
TFES	Total Final Energy Savings [kWh/a]
n	Number of building units connected to the district heating grid
A_{DU}	Conditioned gross floor area of the building unit located in the non-refurbished residential building connected to the district heating grid [m^2]
SHD	Specific Space Heating Demand [kWh/m^2/a]
HWD	Specific Domestic Hot Water Demand [kWh/m^2/a]
EF_{Ref}	Expenditure Factor of the reference heating system
EF_{Eff}	Expenditure Factor of the efficient heating system
η_{Ref}	Annual use efficiency of the reference heating system
η_{Eff}	Annual use efficiency of the efficient heating system
Baseline	
Average heating system producing heat and hot water. The space heating demand values should be corrected with the relevant heating degree days.	

Values:

Lifetime of the measure in years (default or project specific)

Number of building units connected to the district heating grid (project specific)

Conditioned gross floor area of the building unit located in the non-refurbished residential building connected to the district heating grid (default or project specific)

Specific Space Heating Demand of the building unit (default or project specific)

Specific Domestic Hot Water Demand (default or project specific)

Expenditure Factor of the reference heating system (default or project specific)

Expenditure Factor of the efficient heating system (default or project specific)

Annual use efficiency of the reference heating system (default or project specific)

Annual use efficiency of the efficient heating system (default or project specific)

VII.I.I Guidance for identification of default values

When applying the methods for calculating energy savings from energy efficiency measures related to buildings and heating systems, a model building needs to be defined, specifying an average value of the conditioned floor area per building type, an average space heating demand per building type (reference and energy efficient building), an average hot water demand per building unit and the efficiency of the heating system based on assumptions made related to the heating structure of the country.

However, if available, project specific values may also be used for the savings calculation, but attention needs to be paid to the fact that project specific values and default values may not mixed in one and the same savings calculation.

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 85[31]. Alternatively, the lifetime may be determined based on national empirical values.

Conditioned gross floor area of the non-refurbished residential building (average value) connected to the district heating grid: values for determining the conditioned gross floor area are to be defined in the model building. The average gross floor area may be calculated based on national statistics on buildings for buildings in stock or may be available from analyses of energy certificates, buildings databases etc.

Specific Space Heating Demand (average value): values for determining the Specific space heating demand are to be defined in the model building.

The average specific space heating demand of the reference building may be calculated based on national statistics such as energy balance, useful energy balance and statistics on buildings.

Alternatively, average values for a specific space heating demand for different building types may be available from national empirical studies, analyses of energy certificates, buildings databases etc. For selected European countries (mostly EU Member States), reference can also be made to the EU-funded projects TABULA and EPISCOPE (http://episcope.eu/welcome/) where national building typologies representing the residential building stock have been developed.

[31] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

Specific Domestic Hot Water Demand (average value): values for determining the area-related domestic hot water demand are to be defined in the model building. It is calculated based on the building's gross floor area and the efficiency of the heating system providing not only space heating but also hot water. The efficiency of the heating system is determined by the efficiency of the heating system, the distribution losses and energy demand of auxiliary systems.

Efficiency of the heating system:

- **Expenditure Factor of the heating system:** It is determined by the ratio of heating energy demand (fuel consumption of the heating system) to space heating demand plus domestic hot water demand (ratio of final energy demand to useful energy demand). Input parameters for the calculation are:
    - Space heating demand (plus domestic hot water demand) and
    - Heating energy (fuel) demand determined by the boiler's efficiency, distribution losses and energy demand of auxiliary systems.
- **Annual use efficiency of the heating system:** It is determined by the ratio of space heating demand plus domestic hot water demand to heating energy demand (ratio of useful energy demand to final energy demand). Input parameters for the calculation are:
    - Space heating demand (plus domestic hot water demand) and
    - Heating energy (fuel) demand determined by the boiler's efficiency, distribution losses and energy demand of auxiliary systems.

The efficiency of the heating system shall be determined in the model building for the reference and/or efficient heating system. EU Member States may have set default values for the efficiency of the heating system when implementing the Energy Performance Building Directive and consequently the energy performance certificate.

Heating Degree Days: figures may be available either at the national meteorological institute or at the national statistical office.

VII.II Connection to the district heating grid (thermally refurbished residential buildings)

The method aims at connecting a building to the district heating grid and therefore replacing an existing heating system. Both heating systems, i.e. the existing and the new one, provide heat and hot water.

The method targets single-family and multi-family homes as well as apartment blocks that have been thermally refurbished (e.g. retrofit of the building shell, exchange of windows), however already before the building has been connected to the district heating grid.

Bottom-up formula for single family homes	
Option 1: $TFES = A * ((SHD + HWD) * EF_{Ref} - (SHD + HWD) * EF_{Eff})$ **Option 2:** $TFES = A * \left(\frac{SHD + HWD}{\eta_{Ref}} - \frac{SHD + HWD}{\eta_{Eff}}\right)$	
Definition	
TFES	Total Final Energy Savings [kWh/a]
A	Conditioned gross floor area of the refurbished residential building(s) connected to the district heating grid [m^2]
SHD	Specific Space Heating Demand [$kWh/m^2/a$]
HWD	Specific Domestic Hot Water Demand [$kWh/m^2/a$]
EF_{Ref}	Expenditure Factor of the reference heating system
EF_{Eff}	Expenditure Factor of the efficient heating system
η_{Ref}	Annual use efficiency of the reference heating system
η_{Eff}	Annual use efficiency of the efficient heating system
Baseline	
Average heating system producing heat and hot water. The space heating demand values should be corrected with the relevant heating degree days.	

Values:

Lifetime of the measure in years (default or project specific)

Conditioned gross floor area of the refurbished residential building connected to the district heating grid (default or project specific)

Specific Space Heating Demand (default or project specific)

Specific Domestic Hot Water Demand (average value) (default or project specific)

Expenditure Factor of the reference heating system (default or project specific)

Expenditure Factor of the efficient heating system (default or project specific)

Annual use efficiency of the reference heating system (default or project specific)

Annual use efficiency of the efficient heating system (default or project specific)

Bottom-up formula for multi-family homes and apartment blocks

Option 1:

$$TFES = n * A_{DU} * ((SHD + HWD) * EF_{Ref} - (SHD + HWD) * EF_{Eff})$$

Option 2:

$$TFES = n * A_{DU} * \left(\frac{SHD + HWD}{\eta_{Ref}} - \frac{SHD + HWD}{\eta_{Eff}}\right)$$

Definition

TFES	Total Final Energy Savings [kWh/a]
n	Number of building units connected to the district heating grid
A_{DU}	Conditioned gross floor area of the building unit located in the refurbished residential building connected to the district heating grid [m^2]
SHD	Specific Space Heating Demand [kWh/m^2/a]
HWD	Specific Domestic Hot Water Demand [kWh/m^2/a]
EF_{Ref}	Expenditure Factor of the reference heating system
EF_{Eff}	Expenditure Factor of the efficient heating system
η_{Ref}	Annual use efficiency of the reference heating system
η_{Eff}	Annual use efficiency of the efficient heating system

Baseline

Average heating system producing heat and hot water.

The space heating demand values should be corrected with the relevant heating degree days.

Values:

Lifetime of the measure in years (default or project specific)

Number of building units connected to the district heating grid (project specific)

Conditioned gross floor area of the building unit located in the refurbished residential building connected to the district heating grid (default or project specific)

Specific Space Heating Demand of the building unit (default or project specific)

Specific Domestic Hot Water Demand (default or project specific)

Expenditure Factor of the reference heating system (default or project specific)

Expenditure Factor of the efficient heating system (default or project specific)

Annual use efficiency of the reference heating system (default or project specific)

Annual use efficiency of the efficient heating system (default or project specific)

VII.II.I Guidance for identification of default values

When applying the methods for calculating energy savings from energy efficiency measures related to buildings and heating systems, a model building needs to be defined, specifying an average value of the conditioned floor area per building type, an average space heating demand per building type (reference and energy efficient building), an average hot water demand per building unit and the efficiency of the heating system based on assumptions made related to the heating structure of the country.

However, if available, project specific values may also be used for the savings calculation, but attention needs to be paid to the fact that project specific values and default values may not mixed in one and the same savings calculation.

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 85[32]. Alternatively, the lifetime may be determined based on national empirical values.

Conditioned gross floor area of the thermally refurbished residential building (average value) connected to the district heating grid: values for determining the conditioned gross floor area to be defined in the model building. The average gross floor area may be calculated based on national statistics on buildings for buildings in stock or may be available from analyses of energy certificates, buildings databases etc.

[32] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

Specific Space Heating Demand (average value): values for determining the area-related space heating demand are to be defined in the model building.

Average values for the specific space heating demand of thermally refurbished buildings may be available from national empirical studies, analyses of energy certificates, buildings databases etc.

The space heating demand may also be determined by subsidy guidelines, specifying a certain thermal quality to be reached when applying for subsidies for thermal refurbishment.

Specific Domestic Hot Water Demand (average value): values for determining the specific domestic hot water demand are to be defined in the model building. It is calculated based on the building's gross floor area and the efficiency of the heating system providing not only space heating but also hot water. The efficiency of the heating system is determined by the efficiency of the heating system, the distribution losses and energy demand of auxiliary systems.

Efficiency of the heating system:

- **Expenditure Factor of the heating system:** It is determined by the ratio of heating energy demand (fuel consumption of the heating system) to space heating demand plus domestic hot water demand (ratio of final energy demand to useful energy demand). Input parameters for the calculation are:
    - Space heating demand (plus domestic hot water demand) and
    - Heating energy (fuel) demand determined by the boiler's efficiency, distribution losses and energy demand of auxiliary systems.
- **Annual use efficiency of the heating system:** It is determined by the ratio of space heating demand plus domestic hot water demand to heating energy demand (ratio of useful energy demand to final energy demand). Input parameters for the calculation are:
    - Space heating demand (plus domestic hot water demand) and
    - Heating energy (fuel) demand determined by the boiler's efficiency, distribution losses and energy demand of auxiliary systems.

The efficiency of the heating system shall be determined in the model building for the reference and/or efficient heating system. EU Member States may have set default values for the efficiency of the heating system when implementing the Energy Performance Building Directive and consequently the energy performance certificate.

Heating Degree Days: figures may be available either at the national meteorological institute or at the national statistical office.

VII.III Connection to the district heating grid (newly constructed residential buildings)

The method aims at connecting a newly constructed residential building to the district heating grid instead of equipping the building with an average heating system (e.g. central heating system). Both heating systems, i.e. the average and the new one, provide heat and hot water.

The method targets single-family and multi-family homes as well as apartment blocks.

Bottom-up formula for single-family homes

Option 1:

$$TFES = A * ((SHD + HWD) * EF_{Ref} - (SHD + HWD) * EF_{Eff})$$

Option 2:

$$TFES = A * \left(\frac{SHD + HWD}{\eta_{Ref}} - \frac{SHD + HWD}{\eta_{Eff}}\right)$$

Definition	
TFES	Total Final Energy Savings [kWh/a]
A	Conditioned gross floor area of the newly built residential building(s) connected to the district heating grid [m^2]
SHD	Specific Space Heating Demand [$kWh/m^2/a$]
HWD	Specific Domestic Hot Water Demand [$kWh/m^2/a$]
EF_{Ref}	Expenditure Factor of the reference heating system
EF_{Eff}	Expenditure Factor of the efficient heating system
η_{Ref}	Annual use efficiency of the reference heating system
η_{Eff}	Annual use efficiency of the efficient heating system

Baseline

Average heating system producing heat and hot water.

The space heating demand values should be corrected with the relevant heating degree days.

Values:

Lifetime of the measure in years (default or project specific)

Conditioned gross floor area of the newly built residential building connected to the district heating grid (default or project specific)

Specific Space Heating Demand (default or project specific)

Specific Domestic Hot Water Demand (default or project specific)

Expenditure Factor of the reference heating system (default or project specific)

Expenditure Factor of the efficient heating system (default or project specific)

Annual use efficiency of the reference heating system (default or project specific)

Annual use efficiency of the efficient heating system (default or project specific)

Bottom-up formula for multi-family homes and apartment blocks

Option 1:

$$TFES = n * A_{DU} * ((SHD + HWD) * EF_{Ref} - (SHD + HWD) * EF_{Eff})$$

Option 2:

$$TFES = n * A_{DU} * \left(\frac{SHD + HWD}{\eta_{Ref}} - \frac{SHD + HWD}{\eta_{Eff}}\right)$$

Definition

TFES	Total Final Energy Savings [kWh/a]
n	Number of building units connected to the district heating grid
A_{DU}	Conditioned gross floor area of the building unit located in the newly built residential building connected to the district heating grid [m^2]
SHD	Specific Space Heating Demand [kWh/m^2/a]
HWD	Specific Domestic Hot Water Demand [kWh/m^2/a]
EF_{Ref}	Expenditure Factor of the reference heating system
EF_{Eff}	Expenditure Factor of the efficient heating system
η_{Ref}	Annual use efficiency of the reference heating system
η_{Eff}	Annual use efficiency of the efficient heating system

Baseline

Average heating system producing heat and hot water.

The space heating demand values should be corrected with the relevant heating degree days.

Values:
Lifetime of the measure in years (default or project specific)
Number of building units connected to the district heating grid (project specific)
Conditioned gross floor area of the building unit located in the newly built residential building connected to the district heating grid (default or project specific)
Specific Space Heating Demand of the building unit (default or project specific)
Specific Domestic Hot Water Demand (default or project specific)
Expenditure Factor of the reference heating system (default or project specific)
Expenditure Factor of the efficient heating system (default or project specific)
Annual use efficiency of the reference heating system (default or project specific)
Annual use efficiency of the efficient heating system (default or project specific)

VII.III.I Guidance for identification of default values

When applying the methods for calculating energy savings from energy efficiency measures related to buildings and heating systems, a model building needs to be defined, specifying an average value of the conditioned floor area per building type, an average space heating demand per building type (reference and energy efficient building), an average hot water demand per building unit and the efficiency of the heating system based on assumptions made related to the heating structure of the country.

However, if available, project specific values may also be used for the savings calculation, but attention needs to be paid to the fact that project specific values and default values may not mixed in one and the same savings calculation.

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 85[33]. Alternatively, the lifetime may be determined based on national empirical values.

Conditioned gross floor area of newly constructed residential building (average value) connected to the district heating grid: values for determining the conditioned gross floor area are to be defined in the model building. The average gross floor area may be calculated based on national statistics on newly constructed residential buildings or may be available from analyses of energy certificates, buildings databases etc.

[33] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

Specific Space Heating Demand (average value): values for determining the specific space heating demand are to be defined in the model building.

The average specific space heating demand may be taken from the national building code or may be determined by considering more ambitious regulations on the heating demand of new buildings for example as set in subsidy guidelines.

Average values for the specific space heating demand may also be available from national empirical studies, analyses of energy certificates, buildings databases etc.

Specific Domestic Hot Water Demand (average value): values for determining the specific domestic hot water demand are to be defined in the model building. It is calculated based on the building's gross floor area and the efficiency of the heating system providing not only space heating but also hot water. The efficiency of the heating system is determined by the efficiency of the heating system, the distribution losses and energy demand of auxiliary systems.

Efficiency of the heating system:

- **Expenditure Factor of the heating system:** It is determined by the ratio of heating energy demand (fuel consumption of the heating system) to space heating demand plus domestic hot water demand (ratio of final energy demand to useful energy demand). Input parameters for the calculation are:
    - Space heating demand (plus domestic hot water demand) and
    - Heating energy (fuel) demand determined by the boiler's efficiency, distribution losses and energy demand of auxiliary systems.
- **Annual use efficiency of the heating system:** It is determined by the ratio of space heating demand plus domestic hot water demand to heating energy demand (ratio of useful energy demand to final energy demand). Input parameters for the calculation are:
    - Space heating demand (plus domestic hot water demand) and
    - Heating energy (fuel) demand determined by the boiler's efficiency, distribution losses and energy demand of auxiliary systems.

The efficiency of the heating system shall be determined in the model building for the reference and/or efficient heating system. EU Member States may have set default values for the efficiency of the heating system when implementing the Energy Performance Building Directive and consequently the energy performance certificate.

Heating Degree Days: figures may be available either at the national meteorological institute or at the national statistical office.

VIII Smart district heating grids

Target Sectors: energy generation and distribution, households and services (residential and non-residential buildings)

Smart district heating and cooling grids manage the supply side through the intelligent use of heat storage and absorption refrigerators, with appropriate control systems. Such systems balance the heating or cooling available – taking into account the availability of stored energy, waste heat from industry, heat from CHP plants (which varies according to electricity demand), and solar heat – with the current demand.[34]

Smart thermal grids distinguish themselves from conventional district heating by, among others, their higher energy efficiency through a wider use of CHP, renewable energy small scale installations and district heating, and by use of industrial waste heat, waste incineration, geothermal, biomass and solar thermal resources. This forms the basis of the energy savings achieved.[35]

The method described hereafter considers different possibilities of measures to generate energy savings through smart district heating grids:

- Interaction with other energy producers (optimisation power plant timetable, optimisation of CHP production)
- Intelligent grid operation (integration and management of storages, adaptive flow temperature control, demand side management, hydraulic optimization)
- Interaction with consumers (feedback, smart metering)
- Optimisation of system temperature level (reduction of return temperature, cascading use, distributed low temperature grids)

The implementation of one measure leads to a change of several other parameters. Therefore, the thermal energy savings can be evaluated only with simulations or experiments.

[34] https://setis.ec.europa.eu/energy-research/smart-district-heating-and-cooling-grids-supply (14 August 2015)
[35] https://eu-smartcities.eu/sites/all/files/Smart%20Thermal%20Grids%20-%20Smart%20Cities%20Stakeholder%20Platform.pdf, page 17 (14 August 2015)

Bottom-up formula	
$TFES_{th} = EC_{th} * f_{SG,th}$	
Definition	
$TFES_{th}$	Total final thermal energy savings [kWh/a]
EC_{th}	Total thermal energy consumption (excl. the pumps own electricity consumption) [kWh/a]
$f_{SG,\ th}$	Energy saving factor due to implementation of a smart measure [%]
Baseline	
Conventional district heating grid.	

Values:
Lifetime of the measure in years (default or project specific)
Thermal energy consumption (project specific)
Energy saving factor (default or project specific)

VIII.I.I Guidance for identification of default values

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 85[36].

Thermal energy consumption: the thermal energy consumption is a project specific value which can be taken from the national energy balance.

Energy saving factor: the energy saving factor is a project specific value. It has to be determined by a simulation of the smart district heating grid. Default values may be found in national publications.

[36] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

IX Energy Audits of technical processes

Sectors: business and industry

Energy audits for companies: The Energy Efficiency Directive Article 1(25) defines an energy audit as „(…) a systematic procedure with the purpose of obtaining adequate knowledge of the existing energy consumption profile of a building or group of buildings, an industrial or commercial operation or installation or a private or public service, identifying and quantifying cost-effective energy savings opportunities, and reporting the findings."

According to Article 8(2) of the Energy Efficiency Directive "Member States shall develop programmes to encourage SMEs to undergo energy audits and the subsequent implementation of the recommendations from these audits." On the other hand, companies employing more than 250 employees are obligated to carry out an energy audit (Article 8(4)) or alternatively, set up an energy or environmental management system, provided that the management system includes an energy audit (Article 8(6)).

The calculation of energy savings resulting from the implementation of energy efficiency measures in companies is hereunder reflected in the method "Energy audits of technical processes". The measure is designed at increasing the energy efficiency in technical processes by providing accurate data about the energy consumption per unit of production before the implementation of energy efficiency measures and calculated/envisaged energy consumption of modernised/replaced industrial processes/equipment.

Bottom-up formula	
$TFES = \left(\frac{E_{before}}{P_{before}} - \frac{E_{after}}{P_{after}}\right) * P_{after}$	
Definition	
TFES	Total Final Energy Savings [kWh/a]
E_{before}	Energy consumption of industrial process before implementation of energy efficiency measure [kWh/a]
E_{after}	Energy consumption of industrial process after implementation of energy efficiency measure [kWh/a]
P_{before}	Industrial production volume in units of production before implementation of energy efficiency measure
P_{after}	Industrial production volume in units of production after implementation of energy efficiency measure
Baseline	
Energy consumption of a process or equipment for one production unit (or combined volume of units)	

Values
Lifetime of the measure in years (default or project specific)
Energy consumption of industrial process before implementation of energy efficiency measure (project specific)
Energy consumption of industrial process after implementation of energy efficiency measure (project specific)
Industrial production volume in units of production before implementation of energy efficiency measure (project specific)
Industrial production volume in units of production after implementation of energy efficiency measure (project specific)

IX.I.I Guidance for identification of default values

Lifetime of the measure: depending on the implemented measure, reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 85-87[37].

Energy consumption before and after implementation of the measure: company specific data (measured data).

Industrial production volume: company specific data (measured data)

[37] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

X Introduction of energy management systems

Energy savings resulting from the introduction of a computerized system for managing energy, from introducing the ISO 50001 standard or other management system standards, are calculated based on the annual final energy consumption (separately for electricity and heating energy) prior to the introduction of the energy management system.

Savings of final energy are calculated according to the equation below. When applying the formula, attention needs to be paid to the following:

- The method may focus on specific usages only and not necessarily on the total final energy consumption of the company, especially when the energy management system only targets specific usages (e.g. lighting, cooling). In such cases, the total final energy consumption only refers to the consumption of the specific usage. The same applies when the energy management only focusses on specific energy carriers (e.g. gas).
- Other factors that influence the final energy consumption of the company need to be taken into consideration before claiming energy savings from this measure (e.g. development of the number of employees compared to the base period, changes in production, heated floor area).
- Attention shall be paid that no double counting occurs when the introduction of the energy management system has led to an investment (e.g. modernization of the lighting system by introducing an energy efficient system). In such case, the savings shall only be claimed from one of the measures.
- The energy management system shall be implemented by a qualified energy manager or similar experts.

Bottom-up formula	
$TFES = FEC_{EL} * r_{EL} + FEC_{H} * r_{H}$	
Definition	
TFES	Total Final Energy Savings [kWh/a]
FEC_{EL}	Final energy consumption for electricity [kWh/a] in a company in the last year before the introduction of the energy management system
r_{EL}	Savings factor for electricity resulting from the introduction of the energy management system
FEC_{H}	Final energy consumption for heating [kWh/a] in a company in the last year before the introduction of the energy management system
r_{H}	Savings factor for heating resulting from the introduction of the energy management system
Baseline	
Energy consumption before the introduction of the energy management system. The final energy consumption should be corrected with the relevant heating degree days / cooling degree days. In addition, the data shall further be normalized if necessary (e.g. if heated floor area expands).	

Values:

Lifetime of the measure in years (default or project specific)

Final energy consumption for electricity in the last year before the introduction of the energy management system (project specific)

Savings factor for electricity resulting from the introduction of the energy management system (default or project specific)

Final energy consumption for heating in the last year before the introduction of the energy management system (project specific)

Savings factor for heating resulting from the introduction of the energy management system (default or project specific)

X.I.I Guidance for identification of default values

Lifetime of the measure: depending on the implemented measure, reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 86[38].

Final energy consumption for electricity or heating in the last year before the introduction of the energy management system: it is recommended to use a project specific value.

Savings factor for electricity and heating: if national empirical values are available, these shall be used. Studies carried out in Austria and Germany show savings of approximately 2,8% per year resulting from the introduction of energy management systems.

- IREES & Fraunhofer ISI (2010): Evaluation des Förderprogramms „Energieeffizienzberatung" als eine Komponente des Sonderfonds' Energieeffizienz in kleinen und mittleren Unternehmen (KMU)[39], page 70. http://www.isi.fraunhofer.de/isi-wAssets/docs/e/de/publikationen/evaluation-foerderprogramm-energieeffizienzberatung.pdf
- AEA, KEC, ÖEKV (2010): Energiemanagement für Österreich - Bericht zur Auswertung der Ergebnisse der Pilotstudie – Potenzialabschätzung[40]. Page 24: http://www.energyagency.at/fileadmin/dam/pdf/projekte/industrie/EM2010_Bericht_zur_Potenzialanalyse.pdf

[38] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF
[39] English: Evaluation of the funding programme „Energy efficiency advice" as a component of the special fund „energy efficiency in small and medium enterprises".
[40] Energy management in Austria – evaluation report of the pilot study – assessment of the energy saving potential.

XI Heat pumps

Target sector: households (residential buildings)

The methods described hereunder refer to the installation of soil-, water and air-source heat pumps in new as well as existing residential buildings. They apply to single-family homes, multi-family homes and apartment blocks.

Attention has to be paid to the fact that the methods described below target exclusively the installation of heat pumps in buildings. The improvement of the building shell, be it through applying higher energy efficiency standards than requested to newly constructed buildings or refurbishing existing buildings thermally, at the same time as installing heat pumps is not covered by the methods in this section.

XI.I Installation of a soil-, water or air-source heat pump in new buildings

The method provides for evaluating the energy savings derived from the installation of soil, water- or air-source heat pumps in newly constructed residential buildings. An average heating system for producing heat and hot water serves as reference system.

When applying the formula, the following conditions have to be met:

- The criteria for the minimum Seasonal Performance Factor (SPF) according to Annex VII of the Renewable Energy Directive 2009/28/EC must be taken into account.
- When installing the heat pump, all technical prerequisites for the optimal functioning of the heat pump have to be met.

Bottom-up formula for single-family homes

Option 1:

$$TFES = A * \left((SHD + HWD) * EF_{Ref} - (SHD + HWD) * EF_{Eff}\right)$$

Option 2:

$$TFES = A * \left(\frac{SHD + HWD}{\eta_{Ref}} - \frac{SHD + HWD}{\eta_{Eff}}\right)$$

Definition	
TFES	Total Final Energy Savings [kWh/a]
A	Conditioned gross floor area of the newly constructed building [m^2]
SHD	Specific Space Heating Demand [kWh/m²/a]
HWD	Specific Domestic Hot Water Demand [kWh/m²/a]
EF_{Ref}	Expenditure Factor of the reference heating system
EF_{Eff}	Expenditure Factor of the efficient heating system
η_{Ref}	Annual use efficiency of the reference heating system
η_{Efff}	Annual use efficiency of the efficient heating system

Baseline

Average heating system producing heat and hot water.

The space heating demand values should be corrected with the relevant heating degree days.

Values:

Lifetime of the measure in years (default or project specific)

Conditioned gross floor area of the newly constructed building (default or project specific)

Specific Space Heating Demand (default or project specific)

Specific Domestic Hot Water Demand (default or project specific)

Expenditure Factor of the reference heating system (default or project specific)

Expenditure Factor of the efficient heating system (default or project specific)

Annual use efficiency of the reference heating system (default or project specific)

Annual use efficiency of the efficient heating system (default or project specific)

Bottom-up formula for multi-family homes and apartment blocks

Option 1:

$$TFES = n * A_{DU} * \left((SHD + HWD) * EF_{Ref} - (SHD + HWD) * EF_{Eff}\right)$$

Option 2:

$$TFES = n * A_{DU} * \left(\frac{SHD + HWD}{\eta_{Ref}} - \frac{SHD + HWD}{\eta_{Eff}}\right)$$

Definition	
TFES	Total Final Energy Savings [kWh/a]
n	Number of building units concerned
A_{DU}	Conditioned gross floor area of the building unit located in the newly constructed building and supplied by the heat pump
SHD	Specific Space Heating Demand [kWh/m²/a]
HWD	Specific Domestic Hot Water Demand [kWh/m²/a]
EF_{Ref}	Expenditure Factor of the reference heating system
EF_{Eff}	Expenditure Factor of the efficient heating system
η_{Ref}	Annual use efficiency of the reference heating system
η_{Efff}	Annual use efficiency of the efficient heating system

Baseline

Average heating system producing heat and hot water.

The space heating demand values should be corrected with the relevant heating degree days.

Values:

Lifetime of the measure in years (default or project specific)

Number of building units concerned (project specific)

Conditioned gross floor area of the building unit located in the newly constructed building (default or project specific)

Specific Space Heating Demand of the building unit (default or project specific)

Specific Domestic Hot Water Demand (default or project specific)

Expenditure Factor of the reference heating system (default or project specific)

Expenditure Factor of the efficient heating system (default or project specific)

Annual use efficiency of the reference heating system (default or project specific)

Annual use efficiency of the efficient heating system (default or project specific)

XI.I.I Guidance for identification of default values

When applying the methods for calculating energy savings from energy efficiency measures related to buildings and heating systems, a model building needs to be defined, specifying an average value of the conditioned floor area per building type, an average space heating demand per building type (reference and energy efficient building), an average hot water demand per building unit and the efficiency of the heating system based on assumptions made related to the heating structure of the country.

However, if available, project specific values may also be used for the savings calculation, but attention needs to be paid to the fact that project specific values and default values may not mixed in one and the same savings calculation.

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 85[41]. Alternatively, the lifetime may be determined based on national empirical values.

Conditioned gross floor area of newly constructed residential building (average value) connected to the district heating grid: values for determining the conditioned gross floor area are to be defined in the model building. The average gross floor area may be calculated based on national statistics on newly constructed residential buildings or may be available from analyses of energy certificates, buildings databases etc.

Specific Space Heating Demand (average value): values for determining the specific space heating demand are to be defined in the model building.

The average specific space heating demand may be taken from the national building code or may be determined by considering more ambitious regulations on the heating demand of new buildings for example as set in subsidy guidelines.

Average values for the specific space heating demand may also be available from national empirical studies, analyses of energy certificates, buildings databases etc.

Specific Domestic Hot Water Demand (average value): values for determining the specific domestic hot water demand are to be defined in the model building. It is calculated based on the building's gross floor area and the

[41] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

efficiency of the heating system providing not only space heating but also hot water. The efficiency of the heating system is determined by the efficiency of the heating system, the distribution losses and energy demand of auxiliary systems.

Efficiency of the heating system:

- **Expenditure Factor of the heating system:** It is determined by the ratio of heating energy demand (fuel consumption of the heating system) to space heating demand plus domestic hot water demand (ratio of final energy demand to useful energy demand). Input parameters for the calculation are:
    - Space heating demand (plus domestic hot water demand) and
    - Heating energy (fuel) demand determined by the boiler's efficiency, distribution losses and energy demand of auxiliary systems.
- **Annual use efficiency of the heating system:** It is determined by the ratio of space heating demand plus domestic hot water demand to heating energy demand (ratio of useful energy demand to final energy demand). Input parameters for the calculation are:
    - Space heating demand (plus domestic hot water demand) and
    - Heating energy (fuel) demand determined by the boiler's efficiency, distribution losses and energy demand of auxiliary systems.

The efficiency of the heating system shall be determined in the model building for the reference and/or efficient heating system. EU Member States may have set default values for the efficiency of the heating system when implementing the Energy Performance Building Directive and consequently the energy performance certificate.

Heating Degree Days: figures may be available either at the national meteorological institute or at the national statistical office.

XI.II Installation of a soil-, water or air-source heat pump in existing buildings

The method provides for evaluating the energy savings derived from the installation of soil, water- or air-source heat pumps in existing refurbished residential buildings. An average heating system for producing heat and hot water serves as reference system.

When applying the formula, the following conditions have to be met:

- The criteria for the minimum Seasonal Performance Factor (SPF) according to Annex VII of the Renewable Energy Directive 2009/28/EC must be taken into account.
- When installing the heat pump, all technical prerequisites for the optimal functioning of the heat pump have to be met.

Bottom-up formula for single-family homes

Option 1:

$$TFES = A * \left((SHD + HWD) * EF_{Ref} - (SHD + HWD) * EF_{Eff}\right)$$

Option 2:

$$TFES = A * \left(\frac{SHD + HWD}{\eta_{Ref}} - \frac{SHD + HWD}{\eta_{Eff}}\right)$$

Definition	
TFES	Total Final Energy Savings [kWh/a]
A	Conditioned gross floor area of the existing building [m^2]
SHD	Specific Space Heating Demand [kWh/m^2/a]
HWD	Specific Domestic Hot Water Demand [kWh/m^2/a]
EF_{Ref}	Expenditure Factor of the reference heating system
EF_{Eff}	Expenditure Factor of the efficient heating system
η_{Ref}	Annual use efficiency of the reference heating system
η_{Efff}	Annual use efficiency of the efficient heating system

Baseline

Average heating system producing heat and hot water.

The space heating demand values should be corrected with the relevant heating degree days.

Values:

Lifetime of the measure in years (default or project specific)

Conditioned gross floor area of the newly constructed building (default or project specific)

Specific Space Heating Demand (default or project specific)

Specific Domestic Hot Water Demand (default or project specific)

Expenditure Factor of the reference heating system (default or project specific)

Expenditure Factor of the efficient heating system (default or project specific)

Annual use efficiency of the reference heating system (default or project specific)

Annual use efficiency of the efficient heating system (default or project specific)

Bottom-up formula for multi-family homes and apartment blocks

Option 1:

$$TFES = n * A_{DU} * \left((SHD + HWD) * EF_{Ref} - (SHD + HWD) * EF_{Eff}\right)$$

Option 2:

$$TFES = n * A_{DU} * \left(\frac{SHD + HWD}{\eta_{Ref}} - \frac{SHD + HWD}{\eta_{Eff}}\right)$$

Definition

TFES	Total Final Energy Savings [kWh/a]
n	Number of building units concerned
A_{DU}	Conditioned gross floor area of the building unit located in the existing building and supplied by the heat pump
SHD	Specific Space Heating Demand [kWh/m²/a]
HWD	Specific Domestic Hot Water Demand [kWh/m^2/a]
EF_{Ref}	Expenditure Factor of the reference heating system
EF_{Eff}	Expenditure Factor of the new heating system
η_{Ref}	Annual use efficiency of the reference heating system
η_{Efff}	Annual use efficiency of the efficient heating system

Baseline

Average heating system producing heat and hot water.

The space heating demand values should be corrected with the relevant heating degree days.

Values:
Lifetime of the measure in years (default or project specific)
Number of building units concerned (project specific)
Conditioned gross floor area of the building unit located in the newly constructed building (default or project specific)
Specific Space Heating Demand of the building unit (default or project specific)
Specific Domestic Hot Water Demand (default or project specific)
Expenditure Factor of the reference heating system (default or project specific)
Expenditure Factor of the efficient heating system (default or project specific)
Annual use efficiency of the reference heating system (default or project specific)
Annual use efficiency of the efficient heating system (default or project specific)

XI.II.I Guidance for identification of default values

When applying the methods for calculating energy savings from energy efficiency measures related to buildings and heating systems, a model building needs to be defined, specifying an average value of the conditioned floor area per building type, an average space heating demand per building type (reference and energy efficient building), an average hot water demand per building unit and the efficiency of the heating system based on assumptions made related to the heating structure of the country.

However, if available, project specific values may also be used for the savings calculation, but attention needs to be paid to the fact that project specific values and default values may not mixed in one and the same savings calculation.

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 85[42]. Alternatively, the lifetime may be determined based on national empirical values.

Conditioned gross floor area of the thermally refurbished residential building (average value): values for determining the conditioned gross floor area are to be defined in the model building. The average gross floor area may be calculated based on national statistics on buildings for buildings in stock or may be available from analyses of energy certificates, buildings databases etc.

[42] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

Specific Space Heating Demand (average value): values for determining the specific space heating demand are to be defined in the model building.

Average values for the specific space heating demand of thermally refurbished buildings may be available from national empirical studies, analyses of energy certificates, buildings databases etc.

The space heating demand may also be determined by subsidy guidelines, specifying a certain thermal quality to be reached when applying for subsidies for thermal refurbishment.

Specific Domestic Hot Water Demand (average value): values for determining the specific domestic hot water demand are to be defined in the model building. It is calculated based on the building's gross floor area and the efficiency of the heating system providing not only space heating but also hot water. The efficiency of the heating system is determined by the efficiency of the heating system, the distribution losses and energy demand of auxiliary systems.

Efficiency of the heating system:

- **Expenditure Factor of the heating system:** It is determined by the ratio of heating energy demand (fuel consumption of the heating system) to space heating demand plus domestic hot water demand (ratio of final energy demand to useful energy demand). Input parameters for the calculation are:
    - Space heating demand (plus domestic hot water demand) and
    - Heating energy (fuel) demand determined by the boiler's efficiency, distribution losses and energy demand of auxiliary systems.
- **Annual use efficiency of the heating system:** It is determined by the ratio of space heating demand plus domestic hot water demand to heating energy demand (ratio of useful energy demand to final energy demand). Input parameters for the calculation are:
    - Space heating demand (plus domestic hot water demand) and
    - Heating energy (fuel) demand determined by the boiler's efficiency, distribution losses and energy demand of auxiliary systems.

The efficiency of the heating system shall be determined in the model building for the reference and/or efficient heating system. EU Member States may have set default values for the efficiency of the heating system when implementing the Energy Performance Building Directive and consequently the energy performance certificate.

Heating Degree Days: figures may be available either at the national meteorological institute or at the national statistical office.

XII Heating system improvement

Target sector: households (residential buildings) and services (non-residential buildings)

This section provides a method for the calculation of energy savings resulting from the partial or complete improvement of the heating system. In addition, it provides methods for calculating savings related to:

- Improved thermal insulation of hot water tanks
- Thermal insulation of pipes in the heating system
- Installation of thermostatic valves on radiators

XII.I Improvement of heat generation, distribution and emission

The formula for heating system improvements may be applied to residential and non-residential buildings. The savings calculation may consider the following options:

1. New installation and replacement of boilers:
    - Regular replacement of existing boilers after the end of their lifetime with new boilers being more energy efficient than the old ones;
    - Early replacement of defect old boilers (instead of repair) and installation of new boilers being more energy efficient;
    - Early replacement of existing boilers and installation of new boilers being more energy efficient;
    - New buildings: installation of boilers being more efficient than the standard one.
2. Partial or complete replacement of the heaters
3. Partial or complete replacement or improvement of distribution network
4. New installation or improvement of control system

The method also allows for calculating the energy savings of the different heat subsystems (generation, distribution, and emission, each including its controls) by comparing the system losses and defining system performance factors.

The annual energy savings should be referred to end-use actions related to the installation of condensing boilers with modulated burners operating with a return-water temperature not exceeding 60°C which can be associated or not with an improvement in heat distribution.

Bottom-up formula	
Option 1: $TFES = A * SHD * (EF_{Ref} - EF_{Eff})$ **Option 2:** $TFES = A * SHD * \left(\frac{1}{\eta_{rp}} - \frac{1}{\eta_{cp}}\right)$ $\eta_{rp} = \eta_{rb}\ \eta_{re}\ \eta_{rd}$ $\eta_{cp} = \eta_{eb}\ \eta_{ee}\ \eta_{ed}$	
Definition	
TFES	Total Final Energy Savings [kWh/a]
A	Conditioned gross floor area of the building [m²]
SHD	Specific Heating Demand [kWh/m^{2}a]
EF_{Ref}	Expenditure Factor of the reference heating system
EF_{Eff}	Expenditure Factor of the new heating system
η_{rp}	Annual use efficiency of replaced heating system
η_{cp}	Annual use efficiency of condensing heating system
η_{rb}	Annual use efficiency of replaced boiler
η_{re}	Annual use efficiency of replaced heaters
η_{rd}	Annual use efficiency of replaced distribution system
η_{eb}	Annual use efficiency of efficient new boiler
η_{ee}	Annual use efficiency of new heaters
η_{ed}	Annual use efficiency of efficient distribution system
Baseline	
Replacement of the boiler at the end of its lifetime: market average of an energy inefficient boiler. Anticipated replacement: market average of an energy inefficient boiler or of boilers in stock. New installation: market average of an energy inefficient boiler or of boilers in stock. The space heating demand values should be corrected with the relevant heating degree days.	

Values:

Lifetime of the measure in years (default or project specific values)

Specific Heating Demand (default or project specific values)

Conditioned gross floor area of the building (default or project specific values)

Expenditure Factor of the reference heating system (default or project specific)

Expenditure Factor of the new heating system (default or project specific)

Annual use efficiency of replaced heating system (with participating parts) (default or project specific values)

Annual use efficiency of condensing heating system (with participating parts) (default or project specific values)

XII.I.I Guidance for identification of default values

When applying the methods for calculating energy savings from energy efficiency measures related buildings and heating systems, a model building needs to be defined, specifying the conditioned floor area of the different building types, an average space heating demand per building type (reference and energy efficient building), an average hot water demand per building unit and the efficiency of the heating system based on assumptions made related to the heating structure of the country.

However, if available, project specific values may also be used for the savings calculation, but attention needs to be paid to the fact that project specific values and default values may not mixed in one and the same savings calculation.

Lifetime of the measure: the document "Saving lifetimes of Energy Efficiency Improvement Measures in bottom-up calculations Final CWA draft (CEN WS 27)" defines the following lifetimes[43]:

Boilers	17 years (default)
Heating control	5 years (default)
Heat reflecting radiator panels	18 years (harmonized)
Insulation of hot water pipes	>25 years (harmonized)
Replacement of hot water storage tank	15 years (harmonized)

Alternatively, the lifetime may be determined based on national empirical values.

Specific Heating Demand: values for determining the specific space heating demand are to be defined in the model building.

[43] http://energie.wallonie.be/servlet/Repository/CWA_27_final_draft_.PDF?IDR=7973

For newly constructed buildings, the average specific space heating demand of the reference building may be taken from the national building code or may be determined by considering more ambitious regulations on the heating demand of new buildings for example as set in subsidy guidelines.

For buildings in stock, the average specific space heating demand may be calculated based on national statistics such as energy balance, useful energy balance and statistics on buildings. Alternatively, average values for a specific space heating demand for different building types – whether they are thermally refurbished or not – may be available from national empirical studies, analyses of energy certificates, buildings databases etc. For selected European countries (mostly EU Member States), reference can also be made to the EU-funded projects TABULA and EPISCOPE (http://episcope.eu/welcome/) where national building typologies representing the residential building stock have been developed. For thermally refurbished buildings, the space heating demand may also be determined by subsidy guidelines, specifying a certain thermal quality to be reached when applying for subsidies for thermal refurbishment.

Efficiency of the heating system:

- **Expenditure Factor of the heating system:** It is determined by the ratio of heating energy demand (fuel consumption of the heating system) to space heating demand plus domestic hot water demand (ratio of final energy demand to useful energy demand). Input parameters for the calculation are:
    - Space heating demand (plus domestic hot water demand) and
    - Heating energy (fuel) demand determined by the boiler's efficiency, distribution losses and energy demand of auxiliary systems.
- **Annual use efficiency of the heating system:** It is determined by the ratio of space heating demand plus domestic hot water demand to heating energy demand (ratio of useful energy demand to final energy demand). Input parameters for the calculation are:
    - Space heating demand (plus domestic hot water demand) and
    - Heating energy (fuel) demand determined by the boiler's efficiency, distribution losses and energy demand of auxiliary systems.

  Reference may be made to the document "EMEEES bottom-up case application 4: Residential condensing boilers in space heating", page 14: http://www.evaluate-energy-savings.eu/emeees/downloads/EMEEES_WP42_Method_4_resboilers_080609.pdf. Alternatively, the national empirical values can be used.

Supplementary information may be sought under:

- Domestic heating and hot water – Choice of fuel and system type, Good Practice Guide, GPG 301: Domestic heating and hot water – Choice of fuel and system type, Good Practice Guide, GPG 301: http://www.perfectheatingandplumbing.com/Docs/gpg301_Dom_Htg_and_HW.pdf
- Domestic Central Heating and Hot Water: Systems with Gas and Oil-fired Boilers, GPG 284: http://regulations.completepicture.co.uk/pdf/Energy%20Conservation/Heating%20Systems%20-%20Boilers/Domestic%20central%20heating%20and%20hot%20water-%20systems%20with%20gas%20and%20oil-fired%20boilers%20-.pdf
- Controls for domestic Central Heating and Hot Water, GPG 302: http://www.draytoncontrols.co.uk/uploadedFiles/Drayton/Industry_Regulation/Good_Practise_Guide_302_ENG.pdf

Heating Degree Days: figures may be available either at the national meteorological institute or at the national statistical office.

XII.II Improved thermal insulation of warm water tanks

When applying the formula, assumptions have to be made with regard to the volume of the tank to be insulated (in litres), the insulation thickness in cm and the location of the tank (heated or non-heated room).

The method can be applied to single- and multi-family homes as well as to apartment blocks.

Bottom-up formula for single-family homes	
Option 1: $TFES = n * (Q_{loss-old} - Q_{loss-new}) * EF$ **Option 2:** $TFES = \frac{Q_{loss-old} - Q_{loss-new}}{\eta}$	
Definition	
TFES	Total Final Energy Savings [kWh/a]
n	Number of insulated tanks
$Q_{loss-old}$	Yearly heat loss of a non-insulated tank [kWh/a]
$Q_{loss-new}$	Yearly heat loss of a well-insulated tank [kWh/a]
EF	Expenditure factor of the heating system in place
η	Annual use efficiency of the existing heating system
Baseline	
Yearly heat loss of a poorly insulated tank	

Values:

Lifetime of the measure in years (default or project specific)

Number of insulated tanks (project specific)

Yearly heat loss of a poorly insulated tank (default or project specific)

Yearly heat loss of an insulated tank (default or project specific)

Expenditure Factor of the heating system in place (default or project specific)

Annual use efficiency of the existing heating system (default or project specific)

XII.II.I Guidance for identification of default values

When applying the methods for calculating energy savings from energy efficiency measures related to buildings and heating systems, a model building needs to be defined, specifying an average value of the conditioned floor area per building type, an average space heating demand per building type (reference and energy efficient building), an average hot water demand per building unit and the efficiency of the heating system based on assumptions made related to the heating structure of the country.

However, if available, project specific values may also be used for the savings calculation, but attention needs to be paid to the fact that project specific values and default values may not mixed in one and the same savings calculation.

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 85[44]. Alternatively, the lifetime may be determined based on national empirical values.

Yearly heat loss of the tank (poorly insulated and well insulated): information about the heat loss of tanks may be sought from producers of warm water tanks.

Efficiency of the heating system:

- **Expenditure Factor of the heating system:** It is determined by the ratio of heating energy demand (fuel consumption of the heating system) to space heating demand plus domestic hot water demand (ratio of final energy demand to useful energy demand). Input parameters for the calculation are:
    - Space heating demand (plus domestic hot water demand) and
    - Heating energy (fuel) demand determined by the boiler's efficiency, distribution losses and energy demand of auxiliary systems.
- **Annual use efficiency of the heating system:** It is determined by the ratio of space heating demand plus domestic hot water demand to heating energy demand (ratio of useful energy demand to final energy demand). Input parameters for the calculation are:
    - Space heating demand (plus domestic hot water demand) and

[44] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

- Heating energy (fuel) demand determined by the boiler's efficiency, distribution losses and energy demand of auxiliary systems.

The efficiency of the heating system shall be determined in the model building for the reference and/or efficient heating system. EU Member States may have set default values for the efficiency of the heating system when implementing the Energy Performance Building Directive and consequently the energy performance certificate.

XII.III Thermal insulation of pipes in the heating system

The method can be applied to residential and non-residential buildings.

Bottom-up formula	
$TFES = \frac{(q_{init} - q_{new}) * L * HD * 24 * c}{1000}$	
Definition	
TFES:	Total Final Energy Savings [kWh/a]
q_{init}	Initial pipe heat loss [W/m]
q_{new}	Pipe heat loss after thermal insulation [W/m]
L	Length of insulated pipes [m]
c	Intermittency coefficient depending on not continuous operation of the heating system
HD	Heating Days
Baseline	
New installation: the q value of the heat loss of pipes with thermal insulation is compared to the existing q value of the heat loss.	

Values:
Lifetime of the measure in years (default or project specific)
Initial pipe heat loss (default or project specific)
Pipe heat loss after thermal insulation (default or project specific)
Length of insulated pipes (project specific)
Intermittency coefficient (default or project specific)
Heating Days (default)

XII.III.I Guidance for identification of default values

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 85[45]. Alternatively, the lifetime may be determined based on national empirical values.

Initial pipe heat loss: National empirical or statistical values may be used. The heat losses are calculated according to EN 15316-2-3.

Pipe heat loss after thermal insulation: National empirical or statistical values may be used. The heat losses are calculated according to EN 15316-2-3.

Intermittency coefficient: National empirical or statistical values may be used. Intermittency coefficient is calculated according to EN ISO 13790.

Heating Days: Heating Days figures may be available either at the national meteorological institute or at the national statistical office.

[45] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

XII.IV Installation of thermostatic valves on radiators

The method is valid for new installation of thermostatic valves on radiators without thermostatic valves. It can be applied to residential and non-residential buildings.

It shall be noted that the same formula as provided for the calculation of energy savings from the installation of thermostatic valves on radiators can be applied for calculating energy savings from making the whole heating system (heat generation, distribution and emission) or only part of it more energy efficient (heat generation or heat distribution or heat emission).

Bottom-up formula	
$TFES = A * SHD * \frac{1}{\eta_{boiler} * \eta_{dis}} * \left(\frac{1}{\eta_{ini}} - \frac{1}{\eta_{new}}\right)$	
Definition	
TFES:	Total Final Energy Savings [kWh/a]
SHD	Specific heating demand of the building [kWh/m^2/a]
A	Conditioned gross floor area [m²]
η_{boiler}	Annual use efficiency of heat generation
η_{dis}	Annual use efficiency of heat distribution
η_{ini}	Annual use efficiency of initial heat emission
η_{new}	Annual use efficiency of new heat emission
Baseline	
New installation: the η value of the heat emission efficiency with thermostatic valves is compared to the η value of the heat emission efficiency without thermostatic valves. The space heating demand values should be corrected with the relevant heating degree days.	

Values:
Lifetime of the measure in years (default or project specific)
Specific Heating Demand of the building (default or project specific)
Conditioned gross floor area (default or project specific)
Annual use efficiency of heat generation (default or project specific)
Annual use efficiency of heat distribution (default or project specific)
Annual use efficiency of initial heat emission (default or project specific)
Annual use efficiency of new heat emission (default or project specific)

XII.IV.I Guidance for identification of default values

When applying the methods for calculating energy savings from energy efficiency measures related buildings and heating systems, a model building needs to be defined, specifying the conditioned floor area of the different building types, an average space heating demand per building type (reference and energy efficient building), an average hot water demand per building unit and the efficiency of the heating system based on assumptions made related to the heating structure of the country.

However, if available, project specific values may also be used for the savings calculation, but attention needs to be paid to the fact that project specific values and default values may not mixed in one and the same savings calculation.

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 85[46]. Alternatively, the lifetime may be determined based on national empirical values.

Specific Heating Demand of the Building: values for determining the specific space heating demand are to be defined in the model building.

For newly constructed buildings, the average specific space heating demand of the reference building may be taken from the national building code or may be determined by considering more ambitious regulations on the heating demand of new buildings for example as set in subsidy guidelines.

For buildings in stock, the average specific space heating demand may be calculated based on national statistics such as energy balance, useful energy balance and statistics on buildings. Alternatively, average values for a specific space heating demand for different building types – whether they are thermally refurbished or not – may be available from national empirical studies, analyses of energy certificates, buildings databases etc. For selected European countries (mostly EU Member States), reference can also be made to the EU-funded projects TABULA and EPISCOPE (http://episcope.eu/welcome/) where national building typologies representing the residential building stock have been developed. For thermally refurbished buildings, the space heating demand may also be determined by subsidy guidelines, specifying a certain thermal quality to be reached when applying for subsidies for thermal refurbishment.

[46] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

Heat generation efficiency / Heat distribution efficiency / Heat emission efficiency: reference can be made to the document "EMEEES bottom-up case application 4: Residential condensing boilers in space heating", page 14: http://www.evaluate-energy-savings.eu/emeees/downloads/EMEEES_WP42_Method_4_resboilers_080609.pdf. Alternatively or complementary, national (empirical) values can be used.

Heating Degree Days: figures may be available either at the national meteorological institute or at the national statistical office.

XIII Industrial Motors

Target sector: industry

Measures related to industrial motors comprise the replacement of electric motor drives, the use of rotational electrical motors and the installation of variable speed drives (VSDs).

XIII.I Replacement of electric motor drives in industry

In order to decrease the energy consumption of electric motor drives in industry, an existing electric motor drive is replaced with a more efficient one. The other system components (control, load) remain the same.

The formula below can only be applied for calculating the savings of exactly identical motor drives and identical use patterns. If the technical data or the field of use varies between the motor drives, the bottom-up formula cannot be applied and the energy savings have to be calculated separately.

Bottom-up formula	
$TFES = P * t * f_l * \left(\frac{1}{\eta_{ref}} - \frac{1}{\eta_{eff}}\right) * n_m$	
Definition	
TFES	Total Final Energy Savings [kWh/a]
P	Electrical power of the installed motor drive [kW]
t	Average yearly operating hours [h/a]
f_l	Average load factor [%]
η_{ref}	Efficiency of the replaced motor drive [%]
η_{eff}	Efficiency of the new motor drive [%]
n_m	Number of identical electric motors replaced
Baseline	
The baseline is an existing electric motor drive (e.g. IE1).	

Values:

Lifetime of the measure (default or project specific)

Electrical power of the installed motor drive (project specific)

Average yearly operating hours (default or project specific)

Average load factor (default or project specific)

Efficiency of the replaced motor drive (project specific)

Efficiency of the new motor drive (project specific)

Number of identical electric motors replaced (project specific)

XIII.I.I Guidance for identification of default values

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 87[47].

Electrical power of the installed motor drive: a project specific value; the value can be found in the datasheet of the motor drive.

Average yearly operating hours: project specific value; the number of operating hours varies between the different areas of application. However, default values can be found in the EUP Lot 11: http://www.eup-network.de/fileadmin/user_upload/Produktgruppen/Lots/Final_Documents/Lot11_Motors_FinalReport.pdf.

Average load factor: a project specific value; default values can be found in the EUP Lot 11: http://www.eup-network.de/fileadmin/user_upload/Produktgruppen/Lots/Final_Documents/Lot11_Motors_FinalReport.pdf.

Efficiency of the replaced motor drive: project specific value; the value can be found in the datasheet of the replaced motor drive.

Efficiency of the new motor drive: project specific value; the value can be found in the datasheet of the new motor drive.

Minimum requirements for the efficiency of motor drives can be found in the EU Regulation 640/2009 with regard to eco-design requirements for electric motors:

[47] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009R0640&from=EN.

Number of identical electric motors replaced: project specific value.

XIII.II Resizing of rotational electrical motors

Motors that run many hours per year at light loading, e.g. below 20%, should be replaced by smaller energy efficient motors. Therefore, savings achieved result from the resizing of the motor. In order to account for energy savings from this measure, a minimum level of energy performance of the motor has to be met: it is suggested that the motor runs above 20% of its rated power most of the time.

Bottom-up formula	
$TFES = \left(\frac{P_{Ref} * f_{Ref}}{\eta_{Ref}} - \frac{P_{eef} * f_{Eef}}{\eta_{Eff}}\right) * t * n_m$	
Definition	
TFES	Total Final Energy Savings [kWh/a]
P_{ref}	Mechanical power of the existing motor [kW]
P_{Eff}	Mechanical power of the resized motor [kW]
t	Average yearly operating hours [h/a]
f_{Ref}	Average load factor of existing motor [%]
f_{Eff}	Average load factor of resized motor [%]
η_{ref}	Efficiency of the standard motor [%]
η_{eff}	Efficiency of the energy efficient, resized motor [%]
n	Number of equal rotational electrical motors replaced by equal energy efficient, resized motors
Baseline	
New sales: IE1 (almost equivalent to EFF2 motors). Replacement of inefficient motors: EEF3. It is recommended to reconsider the original baselines after three years to make them dynamic and reflect autonomous change in market and stock values of energy efficiency.	

Values:
Lifetime of the measure in years (default or project specific)
Mechanical power of the existing motor (project specific)
Mechanical power of the resized motor (project specific)
Average yearly operating hours (default or project specific)
Average load factor of existing motor (default or project specific)
Average load factor of the resized motor (default or project specific)
Efficiency of the standard motor (project specific)
Efficiency of the energy efficient, resized motor (project specific)
Number of equal rotational electrical motors replaced by equal energy efficient, resized motors (project specific)

XIII.II.I Guidance for identification of default values

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 87[48].

Mechanical power of the installed motor: project specific value; the value can be found in the datasheet of the motor.

Average yearly operating hours: project specific value; the number of operating hours varies between the different areas of application. However, default values can be found in the EUP Lot 11: http://www.eup-network.de/fileadmin/user_upload/Produktgruppen/Lots/Final_Documents/Lot11_Motors_FinalReport.pdf.

Average load factor: a project specific value; default values can be found in the EUP Lot 11: http://www.eup-network.de/fileadmin/user_upload/Produktgruppen/Lots/Final_Documents/Lot11_Motors_FinalReport.pdf.

Efficiency of the standard motor: project specific value; the value can be found in the datasheet of the standard motor.

[48] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

Efficiency of the energy efficient motor: project specific value; the value can be found in the datasheet of the new motor.

Minimum requirements for the efficiency of motor drives can be found in the EU Regulation 640/2009 with regard to eco-design requirements for electric motors: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009R0640&from=EN.

Energy efficiency standards are also set in the international standard IEC 60034-30.

Number of identical electric motors replaced: project specific value.

XIII.III Variable Speed Drives

In order to decrease the energy consumption of electric motor drives in industry, existing motor drives are equipped with variable speed drives. The motor drive and the load remain the same. Only the control unit is replaced. The formula is valid for pump and ventilation systems.

The formula below can only be applied for calculating the savings of exactly identical VSDs and identical use patterns. If the technical data or the field of use varies between the VSDs, the bottom-up formula cannot be applied and the energy savings have to be calculated separately.

Bottom-up formula	
$TFES = P * t * f_{VSD} * \frac{1}{\eta} * n_{VSD}$	
Definition	
TFES	Total Final Energy Savings [kWh/a]
P	Electrical power of the installed motor drive [kW]
t	Average yearly operating hours [h/a]
f_{VSD}	Energy saving factor due to installation of a VSD [%]
η	Efficiency of the installed motor drive [%]
n_{VSD}	Number of variable speed drives installed
Baseline	
The baseline system is an existing electric motor drive (e.g. IE1) with a mechanical control.	

Values:
Lifetime of the measure in years (default or project specific)
Electrical power of the installed motor drive (project specific)
Average yearly operating hours (default or project specific)
Energy saving factor due to installation of a VSD (default or project specific)
Efficiency of the installed motor drive (project specific)
Number of VSDs installed (project specific)

XIII.III.I Guidance for identification of default values

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 87[49].

Electrical power of the installed motor drive: project specific value; the value can be found in the datasheet of the motor drive.

Average yearly operating hours: project specific value; the number of operating hours varies between the different areas of application. However, default values can be found in the EUP Lot 11: http://www.eup-network.de/fileadmin/user_upload/Produktgruppen/Lots/Final_Documents/Lot11_Motors_FinalReport.pdf.

Energy saving factor due to installation of a VSD: project specific value; default values can be found in the EUP Lot 11: http://www.eup-network.de/fileadmin/user_upload/Produktgruppen/Lots/Final_Documents/Lot11_Motors_FinalReport.pdf.

Efficiency of the installed motor drive: project specific value; the value can be found in the datasheet of the motor drive.

Number of VSDs installed: project specific value.

[49] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

XIV Lighting

Target sectors: households (residential buildings), public and private services (non-residential buildings incl. hotels and gastronomy), public sector (street lighting), industry.

Bottom-up methods for lighting aim at the replacement of energy inefficient lamps (conventional light bulbs until their total phase-out, halogen lamps) with energy efficient ones (CFL, LED). The measures target the following areas:

- Residential buildings (households),
- Private and public service buildings (offices, hotels & gastronomy),
- Street lighting and
- Lighting in industrial buildings.

XIV.I Energy efficient lighting in residential buildings

The measure aims at the replacement of energy inefficient lamps in households with energy saving lamps or LEDs.

Bottom-up formula	
$TFES = \frac{n * (P_{Stock\_Average} - P_{Best\_Market\_Promoted}) * t}{1000}$	
Definition	
TFES:	Total Final Energy Savings [kWh/a]
n	Number of lamps replaced/sold
$P_{Stock\_Average}$	Power average of existing lamp [W]
$P_{Best\_Market\_Promoted}$	Power of the market promoted efficient lamp [W]
t	Average yearly operating hours [h/a]
Baseline	
Average power input of stock of conventional/inefficient lighting system (halogen lamps as conventional light bulbs have been phased out through the EU Regulation 244/2009).	

Values:

Lifetime of the measure in years (default or project specific)

Number of lamps replaced/sold (project specific)

Power average of the existing lamp (default or project specific)

Power of the market promoted efficient lamp (default or project specific)

Average yearly operating hours (default or project specific)

XIV.I.I Guidance for identification of default values

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 85[50]. Alternatively, the lifetime of energy efficient lamps may be determined based on their average yearly operating hours and/or in consultation with the respective guild.

Power average of the existing light bulb: the reference lamp and its power average have to be determined. To define the lamp's power average, sales data of this type of lamp may be analysed or lamp manufacturers be consulted.

Power average of the market promoted efficient lamp: the market promoted efficient lamp (e.g. LED, Energy Saving Lamp (ESL)) and its power average have to be determined. To define the lamp's power average, sales data of this type of lamp may be analysed or lamp manufacturers be consulted. The energy efficiency minimum requirements as specified in the EU regulations for eco-design have to be considered.

Average yearly operating hours: may be determined based on standard values and/or in consultation with the respective industry.

Supplementary information may be sought under:

- Regulation (EC) No 244/2009: eco-design requirements for non-directional household lamps: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:076:0003:0016:en:PDF

[50] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

- Regulation (EC) No 859/2009: amending Regulation (EC) No 244/2009: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:247:0003:0005:en:PDF
- Regulation (EC) No 245/2009: eco-design requirements for fluorescent lamps without integrated ballast, for high intensity discharge lamps, and for ballasts and luminaires able to operate such lamps: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:076:0017:0044:en:PDF
- Regulation (EC) No 347/2010: amending Regulation (EC) No 245/2009: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32010R0347&from=EN
- Regulation (EU) No 1194/2012: eco-design requirements for directional lamps, light emitting diode lamps and related equipment: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:342:0001:0022:en:PDF

An overview of the Eco-design regulations of the EU can be found under: https://ec.europa.eu/energy/sites/ener/files/documents/list_of_ecodesign_measures.pdf

An overview of the Eco-labelling regulations of the EU can be found under: https://ec.europa.eu/energy/sites/ener/files/documents/list_of_enegy_labelling_measures.pdf

XIV.II Energy efficient lighting in non-residential buildings

The measure mainly applies to office buildings where the existing inefficient lighting system is replaced with a new efficient lighting system.

Bottom-up formula	
$TFES = \frac{A * (P_{Ref} - P_{Eff} * F_{red}) * t}{1000}$	
Definition	
TFES:	Total Final Energy Savings [kWh/a]
A	Floor area of office building where lighting system has been refurbished [m^2]
P_{Ref}	Installed lighting power before replacement per m^2 [W/m^2]
P_{Eff}	Installed lighting power after replacement per m^2 [W/m^2]
F_{red}	Reduction factor for additional measures (e.g. dimming) Partial dimming Interval timer Occupancy sensor Automatic adaption to daylight
t	Average yearly operating hours [h/a]
Baseline	
Average power input of the inefficient lighting system per m^2	

Values:

Lifetime of the measure in years (default or project specific)

Floor area of office building where lighting system has been refurbished (project specific)

Installed lighting power before replacement per m^2 (default or project specific)

Installed lighting power after replacement per m^2 (default or project specific)

Reduction factor for additional measures (e.g. dimming) (default or project specific)

Average yearly operating hours (default or project specific)

XIV.II.I Guidance for identification of default values

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 86[51]. Alternatively, the lifetime of energy efficient lamps may be determined based on their average yearly operating hours and/or in consultation with the respective guild.

Installed lighting power before replacement per m^2: figures for the lighting power per m^2 of the reference building may be defined in national standards, studies or similar. Also, lighting specialists and/or industry representatives may be consulted to determine such value. Alternatively, project-specific values can be applied if a representative default value is difficult to determine.

Installed lighting power after replacement per m^2: lighting specialists and/or industry representatives may be consulted to determine such value. Also project-specific values can be applied if a representative default value is difficult to determine. Information about the most efficient lighting devices in non-residential buildings may also be obtained from www.topten.eu.

Reduction factor for additional measures: the publication "Task 4.2: harmonised bottom-up evaluation methods; Method 9, Improvement of lighting systems (Tertiary Sector) – Final draft for consultation" states dimming values: http://www.evaluate-energy-savings.eu/emeees/en/countries/France/docs/EMEEES_Method_9_Lighting_final.pdf, page 50. Alternatively, project specific values may be used.

Average yearly operating hours: the publication "Task 4.2: harmonised bottom-up evaluation methods; Method 9, Improvement of lighting systems (Tertiary Sector) – Final draft for consultation" states a value of 2.580 hours for office buildings:

http://www.evaluate-energy-savings.eu/emeees/en/countries/France/docs/EMEEES_Method_9_Lighting_final.pdf, page 21. Alternatively, project specific values may be used.

Supplementary information may be sought under:

[51] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

- Regulation (EC) No 347/2010 amending Commission Regulation (EC) No 245/2009: http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:104:0020:0028:EN:PDF
- Regulation (EC) No 245/2009: eco-design requirements for fluorescent lamps without integrated ballast, for high intensity discharge lamps, and for ballasts and luminaires able to operate such lamps: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:076:0017:0044:en:PDF
- Regulation (EU) No 1194/2012: eco-design requirements for directional lamps, light emitting diode lamps and related equipment. Download: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:342:0001:0022:en:PDF
- Regulation (EC) No 859/2009: amending Regulation (EC) No 244/2009: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:247:0003:0005:en:PDF
- Regulation (EC) No 244/2009: eco-design requirements for non-directional household lamps:

  http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:076:0003:0016:en:PDF

An overview of the Eco-design regulations of the EU can be found under: https://ec.europa.eu/energy/sites/ener/files/documents/list_of_ecodesign_measures.pdf

An overview of the Eco-labelling regulations of the EU can be found under: https://ec.europa.eu/energy/sites/ener/files/documents/list_of_enegy_labelling_measures.pdf

XIV.III Energy efficient lighting in gastronomy and hotels

The measure aims at the replacement of energy inefficient lamps with energy saving lamps or LEDs.

Bottom-up formula	
$TFES = \frac{n * (P_{Stock\_Average} - P_{Best\_Market\_Promoted}) * t}{1000}$	
Definition	
TFES:	Total Final Energy Savings [kWh/a]
n	Number of lamps replaced/sold
$P_{Stock\_Average}$	Power average of the existing lamp [W]
$P_{Best\_Market\_Promoted}$	Power of the market promoted efficient lamp [W]
t	Average yearly operating hours [h/a]
Baseline	
Average power input of stock of conventional/inefficient lighting system (halogen lamps as conventional light bulbs have been phased out through the EU Regulation 244/2009).	

Values:

Lifetime of the measure in years (default or project specific)

Number of lamps replaced/sold (project specific)

Power average of the existing lamp (default or project specific)

Power of the market promoted efficient lamp (default or project specific)

Average yearly operating hours (default or project specific)

XIV.III.I Guidance for identification of default values

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 85[52]. Alternatively, the lifetime of energy efficient lamps may be determined based on their average yearly operating hours and/or in consultation with the respective guild.

[52] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

Power average of the existing light bulb: the reference lamp and its power average have to be determined. To define the lamp's power average, sales data of this type of lamp may be analysed or lamp manufacturers be consulted.

Power average of the market promoted efficient lamp: the market promoted efficient lamp (e.g. LED, Energy Saving Lamp (ESL)) and its power average have to be determined. To define the lamp's power average, sales data of this type of lamp may be analysed or lamp manufacturers be consulted. The energy efficiency minimum requirements as specified in the EU regulations for eco-design have to be considered.

Average yearly operating hours: The publication "EMEEES bottom-up case application 9: Improvement of Lighting Systems (Tertiary Sector)" lists on page 27 average yearly operating hours of lighting devices in tertiary buildings: http://www.emeees.eu/emeees/downloads/EMEEES_Method_9_Lighting_final.pdf Alternatively, the value may be determined based on standard values and/or in consultation with the respective industry.

Supplementary information may be sought under:

- Regulation (EC) No 244/2009: eco-design requirements for non-directional household lamps:

  http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:076:0003:0016:en:PDF

- Regulation (EC) No 859/2009: amending Regulation (EC) No 244/2009: http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:247:0003:0005:en:PDF

- Regulation (EC) No 245/2009: eco-design requirements for fluorescent lamps without integrated ballast, for high intensity discharge lamps, and for ballasts and luminaires able to operate such lamps: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:076:0017:0044:en:PDF

- Regulation (EC) No 347/2010: amending Regulation (EC) No 245/2009: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32010R0347&from=EN

- Regulation (EU) No 1194/2012: eco-design requirements for directional lamps, light emitting diode lamps and related equipment: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:342:0001:0022:en:PDF

An overview of the Eco-design regulations of the EU can be found under: https://ec.europa.eu/energy/sites/ener/files/documents/list_of_ecodesign_measures.pdf

An overview of the Eco-labelling regulations of the EU can be found under: https://ec.europa.eu/energy/sites/ener/files/documents/list_of_enegy_labelling_measures.pdf

XIV.IV Energy efficient street lighting

For improving the energy efficiency of street lighting systems, old inefficient technologies are being replaced with efficient ones. In addition, the measure provides for energy consumption for street lighting being further reduced by implementing provisions for night setback of between 50% and 100% of luminance intensity.

Bottom-up formula	
$TFES = \left(\left(L_{Ref} \cdot P_{Ref} \right) - \left(L_{Eff} \cdot P_{Eff} \cdot F_{red} \right) \right) \cdot t$	
Definition	
TFES	Total Final Energy Savings [kWh/a]
L_{Ref}	Number of light points of the energy inefficient street lighting system
L_{Eff}	Number of light points of the energy efficient street lighting system
P_{Ref}	Power output per light point of the energy inefficient system [W]
P_{Eff}	Power output per light point of the energy efficient system [W]
F_{red}	Reduction factor for additional measures (e.g. dimming)
	Without night setback (0% power reduction)
	Partial night setback (e.g. 50% power reduction, e.g. between 11 pm and 6 am)
	Complete Night setback (100% power reduction)
t	Average yearly operating hours [h/a]
Baseline	
Average installed lighting power in year XX	

Values:
Lifetime of the measure in years (default or project specific)
Number of light points of the energy inefficient street lighting system (project specific)
Power output per light point of the energy inefficient system (default or project specific)
Power output per light point of the energy efficient system (default or project specific)
Reduction factor for additional measures (default or project specific)
Average yearly operating hours (default or project specific)

XIV.IV.I Guidance for identification of default values

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 86[53]. Alternatively, the lifetime may be determined based on the lighting system's average yearly operating hours and/or in consultation with the respective guild.

Power output per light point of the lighting system (inefficient and efficient): the respective lighting system and its average power output have to be determined. Either project specific values may be applied or default values for a specific power output per light point are determined (either through desk research or in consultation with the lighting industry).

Reduction factor for additional measures: for determining the reduction factor, the total daily operational time of the street lighting system (average number for the whole year) has to be defined as well as the time period during which the street lights are being dimmed on a daily basis.

Average yearly operating hours: is to be determined based on the total daily operational time of the street lighting system (average number for the whole year).

Supplementary information may be sought under:

- Regulation (EC) No 245/2009: eco-design requirements for fluorescent lamps without integrated ballast, for high intensity discharge lamps, and for ballasts and luminaires able to operate such lamps: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:076:0017:0044:en:PDF

[53] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

An overview of the Eco-design regulations of the EU can be found under: https://ec.europa.eu/energy/sites/ener/files/documents/list_of_ecodesign_measures.pdf

An overview of the Eco-labelling regulations of the EU can be found under: https://ec.europa.eu/energy/sites/ener/files/documents/list_of_enegy_labelling_measures.pdf

XIV.V Lighting in industrial buildings

For the measure energy efficient lighting in industrial buildings, it is assumed that conventional inefficient lighting systems are being replaced with new efficient lighting systems.

Bottom-up formula	
$TFES = \frac{(P_{Ref} - P_{Eff} * F_{red}) * t}{1000} * n$	
Definition	
TFES:	Total Final Energy Savings [kWh/a]
P_{Ref}	Installed lighting power before replacement [W]
P_{Eff}	Installed lighting power after replacement [W]
F_{red}	Reduction factor for additional measures (e.g. dimming) Partial dimming Interval timer Motion sensor Automatic adaption to day-light
t	Average yearly operating hours [h/a]
n	Number of lighting systems modernized
Baseline	
Existing lighting power and operating hours are compared to new power and operating hours.	

Values:
Lifetime of the measure in years (default or project specific)
Power output per light point of the energy inefficient system (default or project specific)
Power output per light point of the energy efficient system (default or project specific)
Reduction factor for additional measures (default or project specific)
Average yearly operating hours (default or project specific)
Number of lighting systems modernized (project specific)

XIV.V.I Guidance for identification of default values

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 85-86[54]. Alternatively, the lifetime may be determined based on national empirical values.

Power output per light point of the lighting system (inefficient and efficient): the respective lighting system and its average power output have to be determined. For that reason, either project specific values are used or default values for a specific power output per light point are determined (either through desk research or in consultation with the lighting industry).

Reduction factor for additional measures: reference can be made to the document "EMEEES bottom-up case application 9: Improvement of Lighting Systems (Tertiary Sector)", page 56: http://www.evaluate-energy-savings.eu/emeees/downloads/EMEEES_Method_9_Lighting_final.pdf.
Alternatively, the lifetime may be determined based on national empirical values.

Average yearly operating hours: they may be determined based on standard values and/or in consultation with the respective industry.

Supplementary information may be sought under:

- Regulation (EC) No 245/2009: eco-design requirements for fluorescent lamps without integrated ballast, for high intensity discharge lamps, and for ballasts and luminaires able to operate such lamps: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:076:0017:0044:en:PDF

[54] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

- Regulation (EU) No 1194/2012: eco-design requirements for directional lamps, light emitting diode lamps and related equipment: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:342:0001:0022:en:PDF

An overview of the Eco-design regulations of the EU is available from: https://ec.europa.eu/energy/sites/ener/files/documents/list_of_ecodesign_measures.pdf

An overview of the Eco-labelling regulations of the EU is available from: https://ec.europa.eu/energy/sites/ener/files/documents/list_of_enegy_labelling_measures.pdf

XV Mobility

Target sectors: households, companies

The methods in the sector mobility comprise of the purchase of new cars without replacing an old one, replacing vehicles with efficient ones (new gas driven cars, CNG, electric cars), eco-driving, efficiency improvement through the use of new lubricants and efficient tyres and modal shifts in passenger transport.

XV.I Alternative vehicle technologies (passenger cars)

The method refers to the purchase of an alternative fuel car, both with and without replacing an old conventionally fuelled car.

When a more efficient car is purchased without an old car being replaced, this leads to additional energy consumption. However, the additional energy consumption is lower if an alternative fuel car is purchased instead of a conventional car.

On the other hand, energy can actually be saved if an old car is replaced by a new car.

Bottom-up formula	
$TFES = n * (sFEC_{Ref} - sFEF_{Eff}) * \frac{Mil}{100}$	
Definition	
TFES	Total Final Energy Savings [kWh/a]
n	Number of efficient cars purchased
FEC_{Ref}	Specific Final energy consumption of the reference passenger car [kWh/100 km]
FEC_{Eff}	Specific Final energy consumption of the efficient passenger car [kWh/100 km]
Mil	Average yearly mileage [km/a]
Baseline	
Purchase of an alternative fuel car without replacement of an old conventional car: average final energy consumption of a new conventional fuel car. Replacement of an old conventional car with an alternative fuel car: average final energy consumption of an old passenger car (stock).	

Values:

Lifetime of the measure in years (default or project specific)

Number of efficient cars purchased (project specific)

Final energy consumption of the reference passenger car (average value) (default)

Final energy consumption of the efficient passenger car (average value) (default)

Average yearly mileage (default or project specific)

XV.I.I Guidance for identification of default values

Lifetime of the measure: Reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 86[55]. Lifetime determined in kilometres. Alternatively, the lifetime may be determined based on national standard values or other national data available.

Specific Final energy consumption of the reference passenger car:

Baseline cars in stock: the average specific final energy consumption of the reference passenger car may be calculated based on the national energy balance or be obtained from the national statistical office, the national Ministry of Transport or other institutions dealing with national transport data (e.g. national environmental office, transport associations).

Baseline new conventional fuel car (no replacement of an old car): figures for the average specific energy consumption of new conventional fuel cars may be available at the national statistical office, the national Ministry of Transport or other institutions dealing with national transport data (e.g. national environmental office, transport associations).

Alternatively, figures are available in the Odyssee database that shows the average specific final energy consumption of cars (in stock and new cars) in litres: http://www.indicators.odyssee-mure.eu/online-indicators.html). In this case, a conversion factor (litre to kWh) needs to be applied. The conversion factor may be available at the national Ministry of Transport or other institutions dealing with national transport data (e.g. national environmental office, transport associations). Alternatively, conversion factors are published in the EU Directive 2009/33/EC "Promotion of clean and energy-efficient road transport vehicles" (http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:120:0005:0012:EN:PDF, Annex Table 1: Energy content of motor fuels, p.8)

[55] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

Specific Final energy consumption of the efficient passenger car:

Electric passenger cars: To calculate the average specific energy consumption for pure electric cars, electric cars with a range extender, as well as plug-in hybrid drives, the standard specific consumption of a selection of available electric vehicles can be used constituting an average over this. Figures for the available electric vehicles may be available at the national statistical office, the national Ministry of Transport or other institutions dealing with national transport data (e.g. national environmental office, transport associations) or it can be sought from the Clean Vehicle Portal that provides an overview of the electric and plug-in hybrid car models available on the market www.cleanvehicle.eu/.

CNG passenger cars: To calculate the average specific energy consumption for compressed natural gas (CNG) powered vehicles the norm consumption of a chosen selection of available CNG-cars can be used constituting an average over this. For the CNG powered vehicles the average specific fuel consumption can be determined by taking the manufacturer's information concerning the norm specific consumption. The manufacturer's information on the vehicle specific fuel consumption is in kg/100km. To generate the specific consumption in kWh/100km, a conversion factor has to be applied:

There might be a recommended conversion factor available at the national Ministry of Transport or other institutions dealing with national transport data (e.g. national environmental office, transport associations). The conversion factors may also be sought from the EU Directive 2009/33/EC "Promotion of clean and energy-efficient road transport vehicles" (http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:120:0005:0012:EN:PDF, Annex Table 1: Energy content of motor fuels, p.8)

Average yearly mileage: this value (km/a) may be obtained from the national statistical office, the national Ministry of Transport or other institutions dealing with national transport data. Furthermore, the average mileage could also be available from household or transport surveys. It should be based on observed annual data and should not be extrapolated, as it can fluctuate a lot from one year to the other depending on the economic situation and fuel prices.

XV.II Eco-driving

Trainings in eco-driving have spread over the past years and form in some countries already a compulsory part of driving lessons. Today eco-driving trainings do not only target private persons, but also professional drivers.

In order to really change driving behaviour and save fuel in the long term, it is not sufficient that drivers just follow some tips listed, but drivers should also attend to an eco-driving training given by a qualified driving instructor. Such trainings must consist of a theoretical part as well as a practical driving part on public roads. Hence, only trainings should be recognized which include a practical part and are led by a certified trainer.

Criteria for the recognition of fuel-saving training

In Austria the criteria of training manuals for cars, commercial vehicles and tractors of the Federal Ministry of Environment (BMLFUW[56]) are used as a basis for the recognition of fuel-saving trainings.

Table 1: Criteria for the recognition of fuel-saving training

Type of training	Duration of training	Max. number of participants per trainer	Practical part of the training
Passenger car group training	8 Training Sessions	6	4 Training Sessions
Passenger car eco-driving hour	1 Training Session	1	1 Training Session
Utility vehicle group training	8 Training Sessions	4	2 Training Sessions
Utility vehicle eco-driving hour	2 Training Sessions	1	2 Training Sessions

One training session equals 50 minutes

Certified trainer:

Trainers have to participate in a certification seminar in order to be listed as a certified trainer.

The following formula can be applied to calculating energy savings from trainings in eco-driving of private and professional persons.

[56] BMLFUW (2011): Spritsparen – Modern Driving, Pkw Trainerhandbuch, Wien./ BMLFUW (2011): Spritsparen – Modern Driving, NFZ Trainerhandbuch, Wien.

Bottom-up formula	
For eco-drive trainings related to private cars of households $TFES = \frac{n_{EP,0}}{n_{TP,0}} * n_{vehicles,0} * FEC_{ave,0} * S_{ee,0}$ For in-house eco-drive trainings related to commercial vehicles of fleet-operating companies $TFES = \sum_{i=1}^{3} \frac{n_{EP,i}}{n_{TP,i}} * n_{vehicles,i} * FEC_{ave,i} * S_{ee,i}$	
Definition	
TFES	Total Final Energy Savings of a single fleet-operating company or of a number of private households [kWh/a]
i	Vehicle category ▪ 0 = private cars ▪ 1 = commercial cars, ▪ 2 = light commercial vehicle (below 3.5 t), ▪ 3 = buses and trucks (above 3.5 t)
$n_{EP,i}$	Number of eco-driving training participants driving a specific vehicle category
$n_{TP,i}$	Total number of persons driving a specific vehicle category (trained + untrained)
$n_{vehicles,i}$	Total number of vehicles of a specific vehicle category existing in a fleet-operating company or a number of private households with participants trained
$FEC_{ave,i}$	Average yearly final energy consumption of vehicle of a specific vehicle category [kWh/a] before training
$S_{ee,i}$	Savings factor related to the final energy consumption of a specific vehicle category [%]
Baseline	
Total final energy consumption of all vehicles of a single fleet-operating company or a number of private households with persons taking part at eco-driving trainings, before the training	

Values:

Lifetime of the measure in years (default or project specific)

Number of eco-driving training participants driving a specific vehicle category (project specific)

Total number of persons driving a specific vehicle category (trained + untrained) (project specific)

Total number of vehicles of a specific vehicle category existing in a fleet-operating company or a number of private households with participants trained (project specific)

Savings factor related to the final energy consumption of a certain vehicle category (default or project specific)

Total final energy consumption for a specific vehicle category (car, truck) before training (default or project specific)

XV.II.I Guidance for identification of default values

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 87[57]. A project specific value may be used if results from empirical studies are available.

Average yearly final energy consumption of vehicles of private persons participating in the training: this value may be obtained from the national statistical office, the national Ministry of Transport or other institutions dealing with national transport data (e.g. national environmental office, transport associations).

Savings factor related to eco-driving trainings: The energy saving factors are as follows (Austrian values, can be redefined by the partner countries):

		Private driver	Professional driver
S_{ee}	Savings after an eco-driving group training for passenger cars (8 lessons)	10 %	10 %
S_{ee}	Savings after an eco-driving individual training for passenger cars (1 lesson)	5 %	5 %
S_{ee}	Savings after an eco-driving group training for commercial vehicles	-	6,5 %

[57] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

The compliance with the criteria mentioned in the description for eco-driving training is a prerequisite for accounting of these savings values. To estimate the effectiveness of eco-driving trainings, national surveys may be used.

(Total) final energy consumption for a specific vehicle category:

Baseline cars in stock: the average final energy consumption of the reference passenger car may be obtained from the national statistical office, the national Ministry of Transport or other institutions dealing with national transport data (e.g. national environmental office, transport associations).

Alternatively, figures are available in the Odyssee database that shows the average final energy consumption of cars (in stock and new cars) in litres: http://www.indicators.odyssee-mure.eu/online-indicators.html). In this case, a conversion factor (litre to kWh) needs to be applied. The conversion factor may be available at the national Ministry of Transport or other institutions dealing with national transport data (e.g. national environmental office, transport associations). Alternatively, conversion factors are published in the EU Directive 2009/33/EC "Promotion of clean and energy-efficient road transport vehicles" (http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:120:0005:0012:EN:PDF, Annex Table 1: Energy content of motor fuels, p.8)

Average yearly mileage: this value may be obtained from the national statistical office, the national Ministry of Transport or other institutions dealing with national transport data. Furthermore the average mileage could be also available from household or transport surveys. It should be based on observed annual data and should not be extrapolated, as it can fluctuate a lot from one year to the other depending on the economic situation and fuel prices.

Total final energy consumption for a specific vehicle category [car, light commercial vehicle (below 3.5 t), buses and trucks (above 3.5 t)]: project specific values may be used.

XV.III Efficiency improvement through use of new lubricants and efficient tyres

This method distinguishes between passenger cars and commercial vehicles. Passenger cars are motor vehicles with at least four wheels, used for the transport of passengers, and comprising no more than eight seats in addition to the driver's seat. Commercial vehicles include light commercial vehicles, heavy trucks, coaches and buses.[58]

Within this method vehicles may be equipped with fuel-saving motor oil and tyres. The following lubricants and tyres are considered fuel-saving:[59]

- Eligible lubricants: 5W-30 or 0W-30[60]
- Eligible tyres: environmental label "blue angel" RAL-UZ 89[61]

This formula must be separately evaluated for different types of passenger cars (e.g., mini, compact, vans). It must not be evaluated across the board of all types of vehicles, since this would grossly overestimate the energy savings.

[58] http://www.evaluate-energy-savings.eu/emeees/downloads/EMEEES_WP42_Method_14_Vehicle_EE_080226.pdf
[59] http://www.evaluate-energy-savings.eu/emeees/downloads/EMEEES_WP42_Method_14_Vehicle_EE_080226.pdf
[60] http://ec.europa.eu/environment/gpp/pdf/tbr/transport_tbr.pdf, p. 15
[61] http://www.eceee.org/policy-areas/EEES/public_sector/GermanyAppendixPROST.pdf

Bottom-up formula	
$TFES = ES_{uga} * n_i$ $ES_{uga} = En_{Ref} * \left(1 - \frac{En_{Eff}}{En_{Ref}} * EV_{lub} * EV_{tyr}\right) * \frac{Mil}{100}$	
Definition	
TFES	Total Final Energy Savings [kWh/year]
n_i	Number of vehicles equipped with fuel saving motor oil and tyres
i	Vehicle type
ES_{uga}	Unitary gross annual final energy savings [kWh/a]
En_{Ref}	Average specific fuel consumption of reference vehicle [kWh/100 km]
En_{Eff}	Average specific fuel consumption of efficient vehicle [kWh/100 km]
EV_{lub}	Efficiency value for fuel-saving lubricants [0;1]
EV_{tyr}	Efficiency value for fuel-saving tyres [0;1]
Mil	Average yearly mileage [km/a]
Baseline	
Passenger cars: The European Commission has proposed to set the emission target for passenger cars to 130 g CO_2/km as of 2012.[62] The EU emissions targets are taken to define the threshold between efficient and inefficient vehicles for this case (En_{Ref}). Commercial cars: The commercial vehicles include light commercial vehicles, heavy trucks, coaches and buses. The baseline assumptions should be the average energy consumption of the current vehicle fleet or the national stock.	

Values:
Life time of the measure in years (default or project specific)
Number of vehicles equipped with fuel saving motor oil and tyres (project specific)
Average specific fuel consumption of reference vehicle (default)
Average specific fuel consumption of efficient vehicle (default)
Efficiency value for fuel-saving lubricants (default or project specific)
Efficiency value for fuel-saving tyres (default or project specific)
Average yearly mileage (default or project specific)

[62] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02009R0443-20140408&from=EN , p. 4

XV.III.I Guidance for identification of default values

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 87[63]. A project specific value may be used if results from empirical studies are available.

Average yearly mileage: this value may be obtained from the national statistical office, the national Ministry of Transport or other institutions dealing with national transport data. Furthermore, the average mileage could also be available from household or transport surveys. It should be based on observed annual data and should not be extrapolated, as it can fluctuate a lot from one year to the other depending on the economic situation and fuel prices.

Average fuel consumption of efficient vehicle (default or project specific): this value may be obtained from the national statistical office, the national Ministry of Transport or other institutions dealing with national transport data (e.g. national environmental office, transport associations).

Fuel consumption in the baseline case (default or project specific): this value may be obtained from the national statistical office, the national Ministry of Transport or other institutions dealing with national transport data (e.g. national environmental office, transport associations). Alternatively, figures are available in the Odyssee database that shows the average final energy consumption of cars (in stock and new cars) in litres: http://www.indicators.odyssee-mure.eu/online-indicators.html). In this case, a conversion factor (litre to kWh) needs to be applied. The conversion factor may be available at the national Ministry of Transport or other institutions dealing with national transport data (e.g. national environmental office, transport associations). Alternatively, conversion factors are published in the EU Directive 2009/33/EC "Promotion of clean and energy-efficient road transport vehicles" (http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:120:0005:0012:EN:PDF, Annex Table 1: Energy content of motor fuels, p.8)

Efficiency value for fuel-saving lubricants: These values may be sought from http://www.evaluate-energy-

[63] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

savings.eu/emeees/downloads/EMEEES_WP42_Method_14_Vehicle_EE_080226.pdf, p. 20.

Efficiency value for fuel-saving tyres: These values may be sought from http://www.evaluate-energy-savings.eu/emeees/downloads/EMEEES_WP42_Method_14_Vehicle_EE_080226.pdf, p. 20.

XV.IV Modal Shifts in Passenger Transport

Modal shift is defined as covering distances that would have been travelled anyway with less energy intensive (more sustainable) transport modes. The distance covered remains the same. With respect to short distance trips, policies aim at strengthening non-motorised transport modes and urban public transport. With respect to long distance trips, rail-bound transport is regarded more sustainable than air transportation and individual motor car traffic.[64]

Instruments facilitating the increase of the share of more sustainable transport modes range from spatial planning, regulatory policies and fiscal incentives to motivation and qualification measures.

The choice of a certain mode of transport is crucially determined by the distance to be covered and other geographic and socio-economic circumstances.

Bottom-up formula	
$TFES = Np_{Region} * \sum_{i=1}^{N} Mil_i * (MC_{Ref\ i} - MC_{Eff\ i}) * En_i$	
Definition	
TFES	Total Final Energy Savings per person [kWh/a]
Np_{Region}	Number of persons on which the evaluated mobility mix is based on
Mil_i	Average yearly mileage travelled in a transport mode [km/a]
i	Mode of transport
$MC_{Ref,\ i}$	Share of mode of transport i used (Modal Choice), baseline [0;1]
$MC_{Eff,\ i}$	Share of mode of transport i used (Modal Choice), new [0;1]
En_i	Specific energy consumption of mode of transport i [kWh/person-km]
N	Number of modes of transports concerned

[64] http://www.emeees.eu/emeees/downloads/EMEEES_WP42_15_Modal_Shifts_Final.pdf

Baseline

The baseline is the average specific energy consumption of the modes of transport concerned and the respective annual distance travelled. This baseline will be valid, both if the objective is to calculate additional energy savings compared to autonomous trends, and all energy savings.

Values:

Lifetime of the measure in years (default or project specific)

Average yearly mileage travelled in a transport mode (default or project specific)

Share of mode of transport used (Modal Choice), baseline (project specific)

Share of mode of transport used (Modal Choice), new (project specific)

Specific energy consumption, distinguished by mode of transport (default or project specific)

Number of modes of transport concerned (project specific)

XV.IV.I Guidance for identification of default values

Lifetime of the measure in years: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 86[65]. Alternatively, the lifetime may be determined based on empirical values.

Average yearly mileage in a transport mode: Figures for the specific annual distance travelled in a mode of transport may be derived from direct measurements, studies or surveys. Alternatively, project specific values may be applied if a representative default value is difficult to determine.

Specific energy consumption, distinguished by mode of transport: Figures for the specific energy consumption distinguished by the mode of transport may be derived from direct measurements, studies or surveys. Alternatively project specific values may be applied if a representative default value is difficult to determine.

Occupancy level: Figures for the occupancy level per vehicle may be sought from the national statistics or derived from direct measurements or surveys.

[65] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

XVI Office equipment

Target sectors: public and private services (tertiary buildings)

The bottom-up formula provides for the evaluation of annual energy savings from the installation of new office equipment in tertiary buildings or the replacement of existing equipment with more efficient one.[66]

The annual total final energy savings should be calculated by type of office appliance (e.g. PCs, monitors, printers, copiers, faxes, and multi-functional devices).[67]

The formulae provided allow for the calculation of energy savings resulting from the replacement of existing or installation of new office equipment for three different modes:[68]

1. Final energy savings for the active mode
2. Final energy savings for the standby mode and
3. Final energy savings for usage mode change, referring to the improvement of the standby/on-mode of the same equipment by programmes or measures (without replacement).

[66] Recommendations on Measurement and Verification Methods in the Framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services, page 82; Download: https://www.energy-community.org/pls/portal/docs/906182.PDF, 30 June 2015

[67] Ibidem

[68] Ibidem

Bottom-up formula[69]
For active mode: $TFES = n * \frac{(PA_{referenceyearstockaverage} - PA_{referenceyearbestperfmarket})}{1000} * h_{active}$ **For standby:** $TFES = n * \frac{(PS_{referenceyearstockaverage} - PS_{referenceyearbestperfmarket})}{1000} * h_{standby}$ **For improvement of the usage mode:** $TFES = n * (\frac{PA_{referenceyearstockaverage} * h_{active} + PS_{referenceyearstockaverage} * h_{standby}}{1000} - \frac{(PA_{new} * h_{active} + PS_{new} * h_{standby}))}{1000})$

Definition	
TFES	Total Final Energy Savings [kWh/a]
n	Number of equal office equipment replaced or newly installed
$PA_{referenceyearstockaverage}$	Electrical power input per appliance in active mode [W]
$PA_{referenceyearbestperfmarket}$	Electrical power input in active mode per the efficient equipment from the market [W]
$PS_{referenceyearstockaverage}$	Electrical power input per appliance in standby mode [W]
$PS_{referenceyearbestperfmarket}$	Electrical power input in standby mode per the efficient equipment from the market [W]
PA_{new}	Electrical power input per appliance in active mode, after modification of existing appliance [W]
PS_{new}	Electrical power input per appliance in standby mode, after modification of existing appliance [W]
h_{active}	Hours in active mode [h/a]
$h_{standby}$	Hours in standby mode [h/a]

Baseline
For active mode: calculated as the difference between electrical power consumption in active mode per appliance of the existing stock in the reference year and the power consumption in active mode of the efficient office equipment sold on the market multiplied by the number of hours in active mode. For standby: calculated as the difference between electrical power consumption in standby mode per equipment of the existing stock in the reference year and the power consumption in standby mode of the efficient equipment sold on the market multiplied

[69] Recommendations on Measurement and Verification Methods in the Framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services, page 83; Download: https://www.energy-community.org/pls/portal/docs/906182.PDF, 30 June 2015

by the number of hours in standby mode.

For improvement of the usage mode: improvement of the standby/on-mode ratio of the same equipment by programmes or measures (without replacement) and calculation as the difference between the number of hours in on-mode operation per equipment of the existing stock before and the number of hours in on-mode after operation.

Values:

Lifetime of the measure in years (default or project specific)

Number of office equipment replaced or newly installed (project specific)

Electrical power input per appliance in active mode (default or project specific)

Electrical power input in active mode per the efficient equipment from the market (default or project specific)

Hours in active mode (default or project specific)

Electrical power input per appliance in standby mode (default or project specific)

Electrical power input in standby mode per the efficient equipment from the market (default or project specific)

Hours in standby mode (default or project specific)

XVI.I.I Guidance for identification of default values

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 86[70].

For the different types of office appliances, their use patterns have to be specified. Consequently, it needs to be decided whether energy savings resulting from this measure will be calculated with default or project specific values.

Electrical power input per appliance in active mode (reference appliance) (average value): for computers, reference can be made to the EU Regulation No 617/2013 with regard to eco-design requirement setting minimum energy efficiency requirements: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:175:0013:0033:EN:PDF. Alternatively, information may be sought from technical documentations of the respective appliances.

[70] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

Electrical power input per appliance in active mode (efficient appliance) (average value): energy efficient office appliances are listed under www.topten.eu where technical specifications of specific types of office appliances can be sought from. Moreover, the EU Energy Star database www.energystar.eu lists the energy consumption of the different modes (on, standby, sleep) of a huge number of appliances.

Hours in active mode and in standby mode (average value): European Default values (desktop PC, monitors, laptop PC): Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 84: https://www.energy-community.org/pls/portal/docs/906182.PDF

Alternatively: LOT 3: Personal Computers (desktops and laptops) and Computer Monitors Final Report (Task 1-8), chapter 3.1.4.2 onwards:

http://www.eup-network.de/fileadmin/user_upload/Produktgruppen/Lots/Final_Documents/EuP_Lot3_PC_FinalReport.pdf

Electrical power input in standby mode (reference appliance) (average value): EU Regulation No 801/2013 amending Regulation (EC) No 1275/2008 with regard to eco-design requirements for standby, off mode electric power consumption of electrical and electronic household and office equipment sets minimum energy efficiency requirements: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013R0801&from=EN

Alternatively:
www.topten.eu/uploads/File/STANDBY%20Topten%20EU%20policy%20recommendations%20Feb%2013.pdf

Electrical power input in standby mode (efficient appliance) (average value): energy efficient office appliances are listed under www.topten.eu where technical specifications of specific types of office appliances can be sought from. Moreover, the EU Energy Star database www.energystar.eu lists the energy consumption of the different modes (on, standby, sleep) of a huge number of appliances.

An overview of the Eco-design regulations of the EU is available from: https://ec.europa.eu/energy/sites/ener/files/documents/list_of_ecodesign_measures.pdf

XVII Photovoltaic plants

Target sectors: households (residential buildings), public and private services (tertiary buildings)

The bottom-up formula provides for the evaluation of annual energy savings from the installation of photovoltaic plants (PV plants) to cover the final consumer's own electricity consumption. Only the amount of electricity used to cover the consumer's final energy consumption (own consumption) may be considered when claiming for energy savings within the monitoring of the implementation of the EED; electricity fed into the public grid may therefore not be considered.

This measure results in reduction of final energy sold to customers of energy utilities (and thereby possible primary energy savings) and not in final energy savings.

Bottom-up formula	
Option 1: $TFES = P_{PV} * t * PR * (1 - ee_{grid})$ **Option 2:** $TFES = P_{PV} * \frac{1}{sP_{PV}} * Hm * \eta_{el} * (1 - P_{Loss}) * (1 - ee_{grid})$	
Definition	
TFES	Total Final Energy reduction of electricity delivered from public grid [kWh/a]
P_{PV}	Installed peak power of the PV system [kW_{peak}]
t	Sunshine duration at 1000 W/m^2 (full-time load) at site [h/a]
PR	Performance ratio of the PV plant: ratio of the actual and theoretical energy output of the PV plant [%]
ee_{grid}	Share of electricity that is fed into the public grid and cannot be counted as reduction of energy sold [%]
sP_{PV}	Specific peak power of the PV system [kW_{peak}/m² module area]
H_m	Average sum of global irradiation per square meter received by the modules of the given system with a certain slope (e.g. 35°) and azimuth (e.g. 0°, i.e. oriented towards south) (kWh/m^2)
η_{el}	Average electric efficiency of the modules
P_{Loss}	Combined PV system losses [% of H_m] - Estimated losses due to temperature and low irradiance: 8.1% (using local ambient temperature)[71] - Estimated loss due to angular reflectance effects: 2.9%[71] - Other losses (cables, inverter etc.)
Baseline	
No PV system installed; all electricity needed by final customer is supplied via public electricity grid.	

[71] Source: PVGIS - Joint Research Centre – Europa: http://re.jrc.ec.europa.eu/pvgis/

Values:

Lifetime of the measure in years (default or project specific)

Installed peak power of the PV system (default or project specific)

Sunshine duration at 1000 W/m^2 (full-time load) at site (default or project specific)

Performance ratio of the PV plant: ratio of the actual and theoretical energy output of the PV plant [%](default or project specific)

Share of electricity that is fed into the public grid and cannot be counted as reduction of energy sold (default or project specific)

Specific peak power of the PV system related to installed module area (default or project specific)

Average sum of global irradiation per square meter received by the modules of the given system (default or project specific)

Average electric efficiency of the modules (default or project specific)

Combined PV system losses (default or project specific)

XVII.I.I Guidance for identification of default values

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 85[72].

Installed peak power of the PV system: this data shall be available in market analysis or plant licenses.

Sunshine duration at 1000 W/m^2 (annual full-time load operating hours) at site: (regional) data shall be available at the national meteorological institute.

Performance ratio of the PV plant: if not surveyed through empirical studies monitoring the performance ratio of PV plants, empirical values for some EU countries (some "old" EU Member States) can be found in:

Monitoring of Photovoltaic Systems: Good Practices and Systematic Analysis: http://www.ise.fraunhofer.de/de/veroeffentlichungen/konferenzbeitraege/konferenzbeitraege-2013/28th-eupvsec/woyte.pdf

International Energy Agency: Analysis of Long-Term Performance of PV Systems: Different Data Resolution for Different Purposes, Report IEA-PVPS T13-05:2014

[72] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

Share of electricity that is fed into the public grid: electricity that is generated and its share that is fed into the public grid depend on the size of the PV plant, its orientation and sloping of the roof as well as on the country-specific situation (irradiation, sunshine duration). If no national analyses are already available defining an average feed-in factor of electricity generated from PV into the public grid, such factor needs to be defined for each country.

Specific peak power of the PV system related to installed module area: This data shall be available in the manufacturer specifications

Average sum of global irradiation per square meter received by the modules of the given system: (regional) data shall be available at PVGIS - Joint Research Centre – Europa: http://re.jrc.ec.europa.eu/pvgis/.

Average electric efficiency of the modules: This data shall be available in the manufacturer specifications or surveyed through empirical studies.

Combined PV system losses: if not surveyed through empirical studies monitoring the performance ratio of PV plants, empirical values for some EU countries (some "old" EU Member States) can be found in:

Monitoring of Photovoltaic Systems: Good Practices and Systematic Analysis: http://www.ise.fraunhofer.de/de/veroeffentlichungen/konferenzbeitraege/konferenzbeitraege-2013/28th-eupvsec/woyte.pdf

International Energy Agency: Analysis of Long-Term Performance of PV Systems: Different Data Resolution for Different Purposes, Report IEA-PVPS T13-05:2014

XVIII Replacement of energy inefficient boilers

Target sectors: households (residential sector), public and private services (non-residential buildings)

The following methods provide for the calculation of energy savings resulting from the replacement of old boilers with efficient oil-, gas or biomass boilers. The methods apply to single- and multi-family homes as well as to apartment blocks and may also be applied to service buildings if suitable data is available to apply the calculation formulae.

Attention has to be paid to the fact that the methods described below target exclusively the replacement of energy inefficient boilers. The improvement of the building shell at the same time as replacing boilers is not covered by the methods in this section.

XVIII.I Replacement of an old gas- or oil boiler with an efficient gas- or oil boiler

The following formula can be applied to single- and multi-family homes as well as to apartment blocks where existing oil or gas boilers for heating and hot water are replaced with efficient oil or gas boilers. The formula may also be applied to service buildings provided that default values for the savings calculation are available.

Bottom-up formula

Option 1:

$$TFES = n * A * \left((SHD + HWD) * EF_{Ref} - (SHD + HWD) * EF_{Eff}\right)$$

Option 2:

$$TFES = n * A * (SHD + HWD) * \left(\frac{1}{\eta_{Ref}} - \frac{1}{\eta_{Eff}}\right)$$

Definition	
TFES	Total Final Energy Savings [kWh/a]
n	Number of boilers replaced
A	Conditioned gross floor area of the building [m^2]
SHD	Specific Space Heating Demand [kWh/m²/a]
HWD	Specific Domestic Hot Water Demand [kWh/m²/a]
EF_{Ref}	Expenditure Factor of the existing heating system
EF_{Eff}	Expenditure Factor of the new heating system
η_{Ref}	Annual use efficiency of the existing heating system
η_{Eff}	Annual use efficiency of the new heating system

Baseline

Replacement at the end of the boiler's lifetime: average oil or gas fired boiler generating heat and hot water available on the market.

Replacement before the end of the boiler's lifetime: average efficiency of oil and gas boilers in stock.

The space heating demand values should be corrected with the relevant heating degree days.

Values:

Lifetime of the measure in years (default or project specific)

Number of boilers replaced (project specific)

Conditioned gross floor area of the building (default or project specific)

Specific Space Heating Demand (default or project specific)

Specific Domestic Hot Water Demand (default or project specific)

Expenditure Factor of the existing heating system (default or project specific)

Expenditure Factor of the efficient heating system (default or project specific)

Annual use efficiency of the existing heating system (default or project specific)

Annual use efficiency of the new heating system (default or project specific)

XVIII.I.I Guidance for identification of default values

When applying the methods for calculating energy savings from energy efficiency measures related to buildings and heating systems, a model building needs to be defined, specifying an average value of the conditioned floor area per building type, an average space heating demand per building type (reference and energy efficient building), an average hot water demand per building unit and the efficiency of the heating system based on assumptions made related to the heating structure of the country.

However, if available, project specific values may also be used for the savings calculation, but attention needs to be paid to the fact that project specific values and default values may not mixed in one and the same savings calculation.

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 85[73]. Alternatively, the lifetime may be determined based on national (empirical) values.

Specific Space Heating Demand (reference and energy efficient building): values for determining the specific space heating demand are to be defined in the model building.

The average specific space heating demand of the reference building may be calculated based on national statistics such as energy balance, useful energy balance and statistics on buildings.

Alternatively, average values for a specific space heating demand for different building types – whether they are thermally refurbished or not – may be available from national empirical studies, analyses of energy certificates, buildings databases etc. For selected European countries (mostly EU Member States), reference can also be made to the EU-funded projects TABULA and EPISCOPE (http://episcope.eu/welcome/) where national building typologies representing the residential building stock have been developed.

For thermally refurbished buildings, the space heating demand may also be determined by subsidy guidelines, specifying a certain thermal quality to be reached when applying for subsidies for thermal refurbishment.

[73] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

Specific Domestic Hot Water Demand (average value): values for determining the specific domestic hot water demand are to be defined in the model building. It is calculated based on the building's gross floor area and the efficiency of the heating system providing not only space heating but also hot water. The efficiency of the heating system is determined by the efficiency of the heating system, the distribution losses and energy demand of auxiliary systems.

Efficiency of the heating system:

- **Expenditure Factor of the heating system:** It is determined by the ratio of heating energy demand (fuel consumption of the heating system) to space heating demand plus domestic hot water demand (ratio of final energy demand to useful energy demand). Input parameters for the calculation are:
    - Space heating demand (plus domestic hot water demand) and
    - Heating energy (fuel) demand determined by the boiler's efficiency, distribution losses and energy demand of auxiliary systems.
- **Annual use efficiency of the heating system:** It is determined by the ratio of space heating demand plus domestic hot water demand to heating energy demand (ratio of useful energy demand to final energy demand). Input parametrs for the calculation are:
    - Space heating demand (plus domestic hot water demand) and
    - Heating energy (fuel) demand determined by the boiler's efficiency, distribution losses and energy demand of auxiliary systems.

  Reference may be made to the document "EMEEES bottom-up case application 4: Residential condensing boilers in space heating", page 14: http://www.evaluate-energy-savings.eu/emeees/downloads/EMEEES_WP42_Method_4_resboilers_080609.pdf. Alternatively, the national empirical values can be used.

  Supplementary information may be sought under:

  - Domestic heating and hot water – Choice of fuel and system type, Good Practice Guide, GPG 301: Domestic heating and hot water – Choice of fuel and system type, Good Practice Guide, GPG 301: http://www.perfectheatingandplumbing.com/Docs/gpg301_Dom_Htg_and_HW.pdf
  - Domestic Central Heating and Hot Water: Systems with Gas and Oil-fired Boilers, GPG 284: http://regulations.completepicture.co.uk/pdf/Energy%20Conservation/Heating%20Systems%20-

%20Boilers/Domestic%20central%20heating%20and%20hot%20water-%20systems%20with%20gas%20and%20oil-fired%20boilers%20-.pdf

- Controls for domestic Central Heating and Hot Water, GPG 302: http://www.draytoncontrols.co.uk/uploadedFiles/Drayton/Industry_Regulation/Good_Practise_Guide_302_ENG.pdf

Heating Degree Days: figures may be available either at the national meteorological institute or at the national statistical office.

XVIII.II Replacement of an old boiler with an efficient biomass boiler

The formula provides for calculating the energy savings resulting from the replacement of old inefficient boilers used for heating and hot water (oil, gas or biomass) with energy efficient biomass boilers. It can be used for single- and multi-family homes as well as for apartment blocks.

Bottom-up formula	
Option 1: $TFES = n * A * \left((SHD + HWD) * EF_{Ref} - (SHD + HWD) * EF_{Eff}\right)$ **Option 2:** $TFES = n * A * (SHD + HWD) * \left(\frac{1}{\eta_{Ref}} - \frac{1}{\eta_{Eff}}\right)$	
Definition	
TFES	Total Final Energy Savings [kWh/a]
n	Number of boilers replaced
A	Conditioned gross floor area of the building [m^2]
SHD	Specific Space Heating Demand [kWh/m²/a]
HWD	Specific Domestic Hot Water Demand [kWh/m²/a]
EF_{Ref}	Expenditure Factor of the existing heating system
EF_{Eff}	Expenditure Factor of the new heating system
η_{Ref}	Annual use efficiency of the existing heating system
η_{Eff}	Annual use efficiency of the new heating system
Baseline	
Replacement at the end of the boiler's lifetime: average oil, gas or biomass fired boiler generating heat and hot water available on the market. Replacement before the end of the boiler's lifetime: average efficiency of oil and gas boilers in stock. The space heating demand values should be corrected with the relevant heating degree days.	

Values:

Lifetime of the measure in years (default or project specific)

Number of boilers replaced (project specific)

Conditioned gross floor area of the building (default or project specific)

Specific Space Heating Demand (default or project specific)

Specific Domestic Hot Water Demand (default or project specific)

Expenditure Factor of the reference heating system (default or project specific)

Expenditure Factor of the efficient heating system (default or project specific)

Annual use efficiency of the reference heating system (default or project specific)

Annual use efficiency of the efficient heating system (default or project specific)

XVIII.II.I Guidance for identification of default values

When applying the methods for calculating energy savings from energy efficiency measures related to buildings and heating systems, a model building needs to be defined, specifying an average value of the conditioned floor area per building type, an average space heating demand per building type (reference and energy efficient building), an average hot water demand per building unit and the efficiency of the heating system based on assumptions made related to the heating structure of the country.

However, if available, project specific values may also be used for the savings calculation, but attention needs to be paid to the fact that project specific values and default values may not mixed in one and the same savings calculation.

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 85[74]. Alternatively, the lifetime may be determined based on national empirical values.

Specific Space Heating Demand (reference and energy efficient building): values for determining the specific space heating demand are to be defined in the model building.

The average specific space heating demand of the reference building may be calculated based on national statistics such as energy balance, useful energy balance and statistics on buildings.

[74] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

Alternatively, average values for a specific space heating demand for different building types – whether they are thermally refurbished or not – may be available from national empirical studies, analyses of energy certificates, buildings databases etc. For selected European countries (mostly EU Member States), reference can also be made to the EU-funded projects TABULA and EPISCOPE (http://episcope.eu/welcome/) where national building typologies representing the residential building stock have been developed.

For thermally refurbished buildings, the space heating demand may also be determined by subsidy guidelines, specifying a certain thermal quality to be reached when applying for subsidies for thermal refurbishment.

Specific Domestic Hot Water Demand (average value): values for determining the specific domestic hot water demand are to be defined in the model building. It is calculated based on the building's gross floor area and the efficiency of the heating system providing not only space heating but also hot water. The efficiency of the heating system is determined by the efficiency of the heating system, the distribution losses and energy demand of auxiliary systems.

Efficiency of the heating system:

- **Expenditure Factor of the heating system:** It is determined by the ratio of heating energy demand (fuel consumption of the heating system) to space heating demand plus domestic hot water demand (ratio of final energy demand to useful energy demand). Input parameters for the calculation are:
    - Space heating demand (plus domestic hot water demand) and
    - Heating energy (fuel) demand determined by the boiler's efficiency, distribution losses and energy demand of auxiliary systems.
- **Annual use efficiency of the heating system:** It is determined by the ratio of space heating demand plus domestic hot water demand to heating energy demand (ratio of useful energy demand to final energy demand). Input parameters for the calculation are:
    - Space heating demand (plus domestic hot water demand) and
    - Heating energy (fuel) demand determined by the boiler's efficiency, distribution losses and energy demand of auxiliary systems.

  Reference may be made to the document "EMEEES bottom-up case application 4: Residential condensing boilers in space heating", page 14: http://www.evaluate-energy-savings.eu/emeees/downloads/EMEEES_WP42_Method_4_resboilers_080609.pdf. Alternatively, the national empirical values can be used.

Supplementary information may be sought under:

- Domestic heating and hot water – Choice of fuel and system type, Good Practice Guide, GPG 301: Domestic heating and hot water – Choice of fuel and system type, Good Practice Guide, GPG 301: http://www.perfectheatingandplumbing.com/Docs/gpg301_Dom_Htg_and_HW.pdf
- Domestic Central Heating and Hot Water: Systems with Gas and Oil-fired Boilers, GPG 284: http://regulations.completepicture.co.uk/pdf/Energy%20Conservation/Heating%20Systems%20-%20Boilers/Domestic%20central%20heating%20and%20hot%20water-%20systems%20with%20gas%20and%20oil-fired%20boilers%20-.pdf
- Controls for domestic Central Heating and Hot Water, GPG 302: http://www.draytoncontrols.co.uk/uploadedFiles/Drayton/Industry_Regulation/Good_Practise_Guide_302_ENG.pdf

Heating Degree Days: figures may be available either at the national meteorological institute or at the national statistical office.

XVIII.III Biomass boilers (escorted with old existing ones as additional energy source)

The measure is about replacing conventional fossil fuel fired boilers with biomass boilers. The biomass boiler can represent:

1. The only heating system in the building (please refer to chapter 0) or
2. An additional heating system in the building.

The **existing** fossil fuel boiler (FFB) is supplemented by a biomass boiler (BMB). The annual heat consumption (*Q)* is divided into two parts, according to the ratio of heat production (usually: BMB = base load; FFB = peak load/backup). The default values refer to the heat demand (useful heat) by biomass ($Q_{Biomass}$, e.g. $Q_{Biomass}$ = 90% of total heat demand) and by fossil fuels (Q_{Fossil}, e.g. Q_{Fossil} = 10% of total heat demand).

Bottom-up formula

Existing fossil fuel boiler escorted with an energy efficient biomass boiler:

Option 1:

$$TFES = n * A * \Big((SHD + HWD) * EF_{Ref} - \big(Q_{Fossil} * (SHD + HWD) * EF_{Ref} + Q_{Biomass} * (SHD + HWD) * EF_{Eff}\big) \Big)$$

Option 2:

$$TFES = n * A * \left(\frac{1 * (SHD + HWD)}{\eta_{Ref}} - \left(\frac{Q_{Fossil} * (SHD + HWD)}{\eta_{Ref}} + \frac{Q_{Biomass} * (SHD + HWD)}{\eta_{Eff}} \right) \right)$$

Or:

$$TFES = n * A * Q_{Biomass} * \left(\frac{(SHD + HWD)}{\eta_{Ref}} - \frac{(SHD + HWD)}{\eta_{Eff}} \right)$$

Definition

TFES	Total gross annual energy savings [kWh/a]
n	Number of biomass boilers installed/replaced
A	Conditioned gross floor area of the building [m^2]
SHD	Specific Space Heating Demand [kWh/m²/a]
HWD	Specific Domestic Hot Water Demand [kWh/m²/a]
EF_{Ref}	Expenditure Factor of the existing heating system (fossil fuel boiler)
EF_{Eff}	Expenditure Factor of the new heating system (biomass boiler)
η_{Ref}	Annual use efficiency of the existing heating system (fossil fuel boiler)
η_{Eff}	Annual use efficiency of the new heating system (biomass boiler)

Baseline

Average efficiency of heating systems substituted by biomass boiler:
Market average of an inefficient biomass boiler.
The space heating demand values should be corrected with the relevant heating degree days.

Values:

Lifetime of the measure in years (default or project specific)
Number of biomass boilers installed/replaced (project specific)
Conditioned gross floor area of the building (default or project specific)
Specific Space Heating Demand (default or project specific)
Specific Domestic Hot Water Demand (default or project specific)
Expenditure Factor of the existing heating system (default or project specific)
Expenditure Factor of the new heating system (default or project specific)
Annual use efficiency of the existing heating system (default or project specific)
Annual use efficiency of the new heating system (default or project specific)

XVIII.III.I Guidance for identification of default values

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 85[75]. Alternatively, the lifetime may be determined based on national empirical values.

Conditioned gross floor area of the building: values for determining the conditioned gross floor area are to be defined in the model building. The average gross floor area may be calculated based on national statistics on buildings for buildings in stock or may be available from analyses of energy certificates, buildings databases etc.

Specific Space Heating Demand (average value): values for determining the specific space heating demand are to be defined in the model building.

The average specific space heating demand of the reference building may be calculated based on national statistics such as energy balance, useful energy balance and statistics on buildings.

Alternatively, average values for a specific space heating demand for different building types may be available from national empirical studies, analyses of energy certificates, buildings databases etc. For selected European countries (mostly EU Member States), reference can also be made to the EU-funded projects TABULA and EPISCOPE (http://episcope.eu/welcome/) where national building typologies representing the residential building stock have been developed.

Specific Domestic Hot Water Demand (average value): values for determining the specific domestic hot water demand are to be defined in the model building. It is calculated based on the building's gross floor area and the efficiency of the heating system providing not only space heating but also hot water. The efficiency of the heating system is determined by the efficiency of the heating system, the distribution losses and energy demand of auxiliary systems.

[75] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

Efficiency of the heating system:

- **Expenditure Factor of the heating system:** It is determined by the ratio of heating energy demand (fuel consumption of the heating system) to space heating demand plus domestic hot water demand (ratio of final energy demand to useful energy demand). Input parameters for the calculation are:
    - Space heating demand (plus domestic hot water demand) and
    - Heating energy (fuel) demand determined by the boiler's efficiency, distribution losses and energy demand of auxiliary systems.
- **Annual use efficiency of the heating system:** It is determined by the ratio of space heating demand plus domestic hot water demand to heating energy demand (ratio of useful energy demand to final energy demand). Input parameters for the calculation are:
    - Space heating demand (plus domestic hot water demand) and
    - Heating energy (fuel) demand determined by the boiler's efficiency, distribution losses and energy demand of auxiliary systems.

  In addition, reference can be made to the European standard EN 303-5:2012. "Heating boilers for solid fuels, manually and automatically stoked, nominal heat output of up to 500 kW. Terminology, requirements, testing and marking".

Heating Degree Days: figures may be available either at the national meteorological institute or at the national statistical office.

XIX Solar thermal panels

Target sectors: households (residential buildings), public and private services (tertiary buildings)

Two methods are provided under the area of solar thermal panels:

1. Solar assisted space heating and
2. Domestic water heating with solar energy.

The measure results in primary energy savings and not in final energy savings.

XIX.I.I Solar assisted space heating

The measure refers to the installation of solar thermal plants for hot water and auxiliary heating purposes in existing and newly constructed buildings. The heat generated with solar panels reduces the amount of heat to be generated with an existing heating system.

The method applies to flat plate collectors and evacuated tube collectors which differ from their heat output.

Bottom-up formula	
Option 1: $TFES = A * Q_{ave_{yield}} * EF_{Ref}$ **Option 2:** $TFES = A * Q_{ave\_yield} * \frac{1}{\eta_{Ref}}$	
Definition	
TFES	Total Final Energy Savings [kWh/a]
A	Installed collector surface [m^2]
Q_{ave_yield}	Average yearly heat output per m^2 installed collector surface [$kWh/m^2/a$]
EF_{Ref}	Expenditure Factor of the existing heating system
η_{Ref}	Annual use efficiency of the existing heating system
Baseline	
Existing heating system fired by oil, gas, biomass etc.	

Values:
Lifetime of the measure in years (default or project specific)
Installed collector surface (project specific)
Average yearly heat output per m^2 installed collector surface for flat plate collectors and evacuated tube collectors (default)
Expenditure Factor of the existing heating system (default or project specific)
Annual use efficiency of the existing heating system (default or project specific)

XIX.I.II Water heating with solar energy

The measure provides for the evaluation of energy savings derived from the installation of solar thermal plants exclusively used for domestic hot water heating in existing and newly constructed buildings. The heat generated reduces the amount of heat to be generated with an existing heating system.

The method applies to flat plate collectors and evacuated tube collectors which differ from their heat output.

Bottom-up formula	
Option 1: $TFES = A * Q_{ave_{yield}} * EF_{Ref}$ **Option 2:** $TFES = A * Q_{ave\_yield} * \frac{1}{\eta_{Ref}}$	
Definition	
TFES	Total Final Energy Savings [kWh/a]
A	Installed collector surface [m^2]
Q_{ave_yield}	Average yearly heat output per m^2 installed collector surface [$kWh/m^2/a$]
EF_{Ref}	Expenditure Factor of the existing heating system
η_{Ref}	Annual use efficiency of the existing heating system
Baseline	
Existing heating system fired by oil, gas, biomass etc.	

Values:

Lifetime of the measure in years (default or project specific)

Installed collector surface (project specific)

Average yearly heat output per m^2 installed collector surface for flat plate collectors and evacuated tube collectors (default)

Expenditure Factor of the existing heating system (default or project specific)

Annual use efficiency of the existing heating system (default or project specific)

XIX.I.III Guidance for identification of default values

When applying the methods for calculating energy savings from energy efficiency measures related to buildings and heating systems, a model building needs to be defined, specifying an average value of the conditioned floor area per building type, an average space heating demand per building type (reference and energy efficient building), an average hot water demand per building unit and the efficiency of the heating system based on assumptions made related to the heating structure of the country.

However, if available, project specific values may also be used for the savings calculation, but attention needs to be paid to the fact that project specific values and default values may not mixed in one and the same savings calculation.

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 85[76]. Alternatively, the lifetime may be determined based on national empirical values.

Average yearly heat output per m^2 installed collector surface for flat plate collectors and evacuated tube collectors: in order to define the average yearly heat output of a solar thermal plant, an average plant has to be defined (size, alignment, angle of inclination, shading, etc.).

In case no national data is available on the average yearly heat output of an average solar thermal plant, reference can be made to the following software: T*Sol: http://valentin.de/calculation/thermal/start/en - an Online Solar Calculation and Simulation of Solar Thermal Systems.

[76] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

Efficiency of the heating system:

- **Expenditure Factor of the heating system:** It is determined by the ratio of heating energy demand (fuel consumption of the heating system) to space heating demand plus domestic hot water demand (ratio of final energy demand to useful energy demand). Input parameters for the calculation are:
    - Space heating demand (plus domestic hot water demand) and
    - Heating energy (fuel) demand determined by the boiler's efficiency, distribution losses and energy demand of auxiliary systems.
- **Annual use efficiency of the heating system:** It is determined by the ratio of space heating demand plus domestic hot water demand to heating energy demand (ratio of useful energy demand to final energy demand). Input parameters for the calculation are:
    - Space heating demand (plus domestic hot water demand) and
    - Heating energy (fuel) demand determined by the boiler's efficiency, distribution losses and energy demand of auxiliary systems.

The efficiency of the heating system shall be determined in the model building for the reference and/or efficient heating system. EU Member States may have set default values for the efficiency of the heating system when implementing the Energy Performance Building Directive and consequently the energy performance certificate.

XX Standby killer in households

Target sector: households

The method provides for the evaluation of annual energy savings from the installation of stand-by killers in households.

Standby consumption refers to the electricity consumption that occurs after an appliance is switched off but not removed from power supply. So called standby killers are automatic switch-off aids that recognize standby power and are cutting off the power supply for the connected appliance once it is switched off.

Standby killers in households lead to a reduction in electricity consumption by eliminating standby consumption of appliances. However, for a thorough savings calculation, the standby killer's own consumption has to be taken into consideration, slightly reducing the total savings potential.

Bottom-up formula	
$TFES = n_{SBK} * \frac{P_G * t_{SB} - P_{SBK} * t_a}{1000}$	
Definition	
TFES	Total Final Energy Savings [kWh/a]
n_{SBK}	Number of standby killers installed
P_G	Standby power of the respective appliance(s) [W]
P_{SBK}	Own electricity consumption standby killer [W]
t_a	Annual hours standby killer is in use [h/a]
t_{SB}	Annual hours appliance is on standby [h/a]
Baseline	
Appliances running on standby without using a standby killer	

Values:

Lifetime of the measure in years (default or project specific)

Number of standby killers installed (project specific)

Standby power of the respective appliance(s) connected to the stand-by killer (default or project specific)

Own electricity consumption standby killer (default or project specific)

Annual hours standby killer is in use (default)

Annual hours appliance is on standby (default)

XX.I.I Guidance for identification of default values

Lifetime of the measure: in Austria, the lifetime of the standby killer is set at 10 years.

Standby power of the respective appliance:

- The EU Energy Star database www.energystar.eu lists the energy consumption of the different modes (on, standby, sleep) of a huge number of appliances where reference can be made to when specifying an average value for the energy consumption of a particular appliance.
- Maximum power consumption in off-mode and standby mode: www.topten.eu/uploads/File/STANDBY%20Topten%20EU%20policy%20recommendations%20Feb%2013.pdf
- Regulation (EU) No 801/2013 amending Regulation (EC) No 1275/2008 with regard to ecodesign requirements for standby, off mode electric power consumption of electrical and electronic household and office equipment, and amending Regulation (EC) No 642/2009 with regard to ecodesign requirements for televisions: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013R0801&from=EN
- Regulation (EC) No 1275/2008 with regard to ecodesign requirements for standby and off mode electric power consumption of electrical and electronic household and office equipment sets requirements for the maximum electricity consumption allowed for electrical and electronic household and office equipment in standby mode: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008R1275&from=en
- Regulation (EC) No 278/2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for no-load condition electric power consumption and average active efficiency of external power supplies: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:093:0003:0010:EN:PDF

Own electricity consumption standby killer: a value of 0.5 Watt can be used if not specified or researched otherwise: http://www.topten.ch/deutsch/buro/standby/elektronische_abschalthilfen.html

Annual hours standby killer is in use: as a maximum, the standby killer may be in use all year long, therefore 8.760 hours.

Annual hours appliance is on standby: if not specified otherwise (e.g. through empirical studies carried out on national level):

- The EuP Preparatory Study Lot 5 (TV) Final Report Task (chapter 3.1.2) lists information about on- and standby-modes of TVs per day for different EU Member States: http://www.eup-network.de/fileadmin/user_upload/Produktgruppen/Lots/Final_Documents/Lot_5_Final_Report_1-8.pdf
- The EuP Preparatory Study LOT 3: Personal Computers (desktops and laptops) and Computer Monitors Final Report (Task 1-8) lists an average standby time of office equipment for households under chapter 3.1.4.2 onwards: http://www.eup-network.de/fileadmin/user_upload/Produktgruppen/Lots/Final_Documents/EuP_Lot3_PC_FinalReport.pdf

An overview of the Eco-design regulations of the EU can be found under: https://ec.europa.eu/energy/sites/ener/files/documents/list_of_ecodesign_measures.pdf

XXI Systems for heat recovery in buildings

The calculation of savings is based on the amount of heat transferred from the exhaust air to the inlet air. The savings are determined in relation to the surface of the building in which the ventilation system operates, with the use of default values for air exchange rate and, depending on the operating time of the heating system during the heating season, space height, the temperature difference between the exhaust air and the inlet air, heat recovery rate and air density.

Energy savings resulting from the installation of a ventilation system with heat recovery are calculated as follows:

Bottom-up formula	
$TFES = A * h * \beta * t * c * \rho * \Delta T * \eta * n$	
Definition	
TFES	Total Final Energy Savings [kWh/a]
A	Conditioned gross floor area of the building [m^2]
h	Height of the ventilated area (floor to ceiling) [m]
β	Air exchange rate [h^{-1}]
t	Yearly operating time of the ventilation system [h/a]
c	Specific heat of air [kWh/kg K]
ρ	Air density [kg/m^3]
ΔT	Temperature difference ambient air vs. outside air (average value) during the heating season (° Celsius)
η	Rate of heat recovery
n	Number of ventilation units installed
Baseline	
Building heated with a conventional heating system	

Values:
Lifetime of the measures in years (default or project specific)
Conditioned gross floor area of the building (default or project specific)
Height of the ventilated area (default or project specific)
Air exchange rate (default)
Yearly operating time of the ventilation system (default)
Specific heat of air (default)
Air density (default)
Temperature difference ambient air vs. outside air (average value) during the heating season (default)
Rate of heat recovery (default)
Number of ventilation units installed (project specific)

XXI.I.I Guidance for identification of default values

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 85[77].

Conditioned gross floor area of the building: values for determining the conditioned gross floor area are to be defined in the model building. The average gross floor area may be calculated based on national statistics or may be available from analyses of energy certificates, buildings databases etc.

Height of the ventilated area: values for determining the height of the ventilated area are to be defined in the model building. Alternatively, project specific values may be used.

Air exchange rate (u-value): values can usually be found in the national building regulations, i.e. building codes. Other sources may be subsidy guidelines, specifying a certain thermal quality to be reached when applying for subsidies. Also project-specific values can be used for the savings calculation if a representative default value is difficult to be determined.

[77] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

Yearly operating time of the ventilation system: the value depends on the length of the heating period in each country. Default or project specific values can be used to determine this value.

Specific air temperature: usually, a value of 1 kJ/kg K is used. (http://www.engineeringtoolbox.com/air-properties-d_156.html)

Air density: under normal conditions, air density is at 1,293 kg/m^3. (http://www.engineeringtoolbox.com/air-properties-d_156.html)

Temperature difference ambient air vs. outside air (average values) during the heating season: a common value for ambient air is 21 ° Celsius. Values for the temperature of the ambient air may also be determined in national standards. Values for the outside air are country specific and depend on the climatic conditions of each country. They may be available at the national meteorological institutes.

Rate of heat recovery: the percentages for heat recovery may go up to 90%. However, country specific values shall be defined, taking into consideration the technological standards in each country. Information may be sought from manufacturers of ventilation systems or from empirical studies.

XXII White goods

Target sector: households

The bottom-up formulae provide for the evaluation of annual energy savings resulting from the new installation and replacement of white goods.

The formulae can be applied to:

- Washing machines
- Laundry dryers
- Dishwashers
- Fridges and
- Freezers

XXII.I Purchase of highly efficient white goods

The formula applies to measures relating to the purchase of white goods such as fridges and freezers, washing machines, laundry dryers and dishwashers with the best available energy efficiency class on the market (e.g. A++ or A+++) compared to goods with a lower energy efficiency class available.

Bottom-up formula	
$TFES = n * (E_{ave} - E_{eff})$	
Definition	
TFES	Total Final Energy Savings [kWh/a]
n	Number of energy efficient goods purchased with the highest available energy efficiency class
E_{ave}	Average yearly energy consumption of the least efficient good available on the market [kWh/a]
E_{eff}	Average yearly energy consumption of the highly efficient white good to be installed (A++ or highest available energy efficiency class) [kWh/a]
Baseline	
Average yearly energy consumption of the least efficient good available on the market	

Values:
Lifetime of the measure in years (default or project specific)
Number of energy efficient goods purchased with the highest available energy efficiency class (project specific)
Average yearly energy consumption of the least efficient white good available on the market (default or project specific)
Average yearly energy consumption of the highly efficient white good to be installed (A++ or highest available energy efficiency class) (default)

XXII.II Early replacement of white goods

This method applies to white goods such as fridges and freezers, washing machines, laundry dryers and dishwashers that are replaced at an early stage, i.e. before the end of their actual lifetime, and that are replaced by goods with the best available energy efficiency class on the market (e.g. A++ or A+++).

Bottom-up formula	
$TFES = n * (E_{stock} - E_{eff})$	
Definition	
TFES	Total Final Energy Savings [kWh/a]
n	Number of energy efficient goods purchased with the highest available energy efficiency class
E_{stock}	Average yearly energy consumption of existing white good in stock [kWh/a]
E_{eff}	Average yearly energy consumption of the highly efficient white good to be installed (A++ or highest available energy efficiency class) [kWh/a]
Baseline	
Average yearly energy consumption of existing white good in stock	

Values:
Lifetime of the measure in years (default or project specific)
Number of energy efficient goods purchased with the highest available energy efficiency class (project specific)
Average yearly energy consumption of existing white good in stock (default of project specific)
Average yearly energy consumption of the highly efficient white good to be installed (A++ or highest available energy efficiency class) (default)

XXII.II.I Guidance for identification of default values

Lifetime of the measure: reference can be made to the document "Recommendations on Measurement and Verification Methods in the framework of Directive 2006/32/EC on Energy End-Use Efficiency and Energy Services", page 85[78].

Average yearly energy consumption of existing white good in stock: as a first step, the specifications of the white goods to be considered must be defined (e.g. size, capacity volume).

Further on, sales data of the goods specified indicating their energy efficiency class may be used to identify their average yearly energy consumption. With sales data available from the past ten years or from a similar time range, the energy efficiency of the goods in stock can be determined. The average yearly energy consumption can be defined based on the different EU regulations:

- Washing machines: Regulation (EU) No 1061/2010: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:314:0047:0063:EN:PDF
- Tumble driers: Regulation (EU) No 392/2012: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:123:0001:0026:EN:PDF
- Dish washers: Regulation (EU) No 1059/2010: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:314:0001:0016:en:PDF
- Refrigeration appliances: Regulation (EU) 1060/2010: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32010R1060&from=EN

On overview of the energy labelling legislation of household appliances can be found under: https://ec.europa.eu/energy/sites/ener/files/documents/list_of_enegy_labelling_measures.pdf

Average yearly energy consumption of the highly efficient white good to be installed: the same specifications as defined for the goods in stock need to be applied (e.g. size, capacity volume).

[78] Download: https://www.energy-community.org/pls/portal/docs/906182.PDF

Again, sales data of the goods specified may be used to identify the most energy efficient white goods purchased. For their identification, it is recommended to only consider the sales of the most frequently purchased energy efficient goods in the past one to two years. The minimum energy efficiency requirements are defined in the following EU regulations:

- Washing machines: Regulation (EU) No. 1015/2010: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:293:0021:0030:EN:PDF
- Tumble driers: Regulation (EU) No. 932/2012: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32012R0932&from=EN
- Dish washers: Regulation (EU) No. 1016/2010: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:293:0031:0040:en:PDF
- Refrigeration appliances: Regulation (EU) 643/2009: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009R0643&from=EN

On overview of the eco-design legislation of household appliances can be found under:
https://ec.europa.eu/energy/sites/ener/files/documents/list_of_ecodesign_measures.pdf

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