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Status of energy savings calculations for priority actions in European countries

Deliverable D2.1 – first PA round

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Abbreviations and acronyms

Acronym	Description
BU	Bottom-Up
DHW	Domestic Hot Water
EED	Energy Efficiency Directive
EEOs	Energy Efficiency Obligation Schemes
ESEER	European Seasonal Energy Efficiency Ratio
EU	European Union
EVs	Electric Vehicles
FEC	Final Energy Consumption
H&C	Heating and Cooling
ICT	Information and Communication Technologies
MS	Member State
NECPs	National Energy and Climate Plans
NEEAPs	National Energy Efficiency Action Plans
PA	Priority Action

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Summary

This report presents an extensive collection of existing Bottom Up (BU) methodologies within the Member States, available from catalogues and from publications of recent projects, providing stakeholders with useful information that is only available at national level, in a structured and user-friendly format. In total, it was possible to identify **16 catalogues with bottom-up calculation methodologies**, from 14 different countries and two research projects (multEE, 2016; EMEEES 2009), and a total of 582 methodologies with application in various activity sectors, covering a wide range of technologies and end-uses. The report further analyses the existing BU methodologies by sector and end-use within each sector, and identifies the areas less addressed by Member States placing the importance (share) of each end-use in total final energy consumption.

The **need for simplified, yet accurate, methodologies to calculate energy savings** from energy efficiency measures being implemented by Member States, to achieve the reduction targets under the Energy Efficiency Directive EED, has been indicated in the consultation performed at the beginning of the streamSAVE project. The consultation was based on online survey and interviews to key stakeholders (Autumn 2020). Among the main challenges Member States face, data collection procedures were stressed as well as the lack of quality data when implementing Article 3 and Article 7 of the Energy Efficiency Directive (EED). Moreover, the revision of the EED brings additional challenges to Member States, in particular regarding Article 7 and several requirements of its Annex V.

The Knowledge Facility of streamSAVE is developing streamlined calculation methodologies for a significant number of savings measures, for which a lack of experience, practices and data is hindering its adoption by several Member States, although its high potential for energy savings – the Priority Actions (PA). This process develops **10 Priority Actions over two cycles** of experience sharing and capacity building. Priority Actions under analysis in the first round are:

- Heat recovery (district heating and excess heat from industry)
- Building Energy Management System (BEMS) and Building Automation and Control Systems (BACS)
- Commercial and Industrial refrigeration system (C&I Refrigeration)
- Electric vehicles (private & public) and related infrastructure (charging stations)
- Lighting systems and public lighting

Based on the catalogues containing bottom-up calculation methodologies within Member States, the main methodologies aligned with the first round of Priority Actions were characterized by their application area, **calculation formula to estimate savings and costs, parameter definition and indicative values (e.g. lifetime) and correction factors for behavioral effects**. The methodologies for heat recovery either compare the final energy consumption before the installation of a heat recovery system to the final energy consumption afterwards, or multiply the installed power and operating time or final energy consumption with a savings factor or percentage of heat recovered. For BEMS/BACS in some cases the so-called BACS factor method is applied; other countries use more technology-specific approaches. For industrial or commercial refrigeration, the methodologies determine the savings of centralized systems based on the efficiency ratio of the before and after situation (ESEER of old and new cooling unit) and the cooling load (based on power and operation hours). Concerning alternative vehicle technologies, the

savings estimation is usually based on the number of purchased vehicles, the difference of energy consumption between a reference and efficient vehicles, and the yearly mileage. Similarly, the number of lighting points/lamps, the difference between the power of both technologies (inefficient and efficient) and the total annual operating hours are factors included in the calculation methodologies of lighting measures. For most Priority Actions, indicative values are available, in contrast to correction factors for behavioral effects and the assessment of their cost effectiveness.

Mapping the current situation in the Member States in terms of **end use and sectoral coverage will help to understand the gaps** that still remain. The next round of streamSAVE's Priority Actions is to be decided based on existing gaps and further stakeholders' consultation. Knowing stakeholders' needs and by cross-comparing the existing methodologies with final energy balances at sectoral and end-use level, the analysis could identify the following end-uses as the main areas where bottom-up methodologies have not been widely developed by Member States: process heat (>200º and <200º) in industry; cross cutting measures in the transport sector; ICT in offices and data centres; space cooling, water heating and cooking in building; public lighting; and also the agricultural sector is not widely addressed with BU methodologies in existing catalogues or guidelines. Space heating in buildings is by far the best represented end-use in the catalogues, by all countries and in all sectors. Nevertheless, even if space heating has been the target of concern by Member States, with a large number of bottom-up methodologies for calculating energy savings from catalogues, it is still an important challenge for decarbonization, as most heating needs are still provided by fossil fuels.

These results from the gap analysis clearly show **priority actions that need to be (further) tackled by Member States** to ensure achievement of the reduction targets required by the Article 3 and Article 7 of the Energy Efficiency Directive.

Note: In this draft deliverable, the first round of Priority Actions is described. In the second part of the project, the assessment of the five, new Priority Actions will be included.

Keywords

Deemed savings; bottom-up methodologies; energy savings calculations; Final Energy Consumption; energy efficiency; gap analysis; end-uses

Introduction

About streamSAVE

Improving energy efficiency in Europe has become key to tackle climate change. The Energy Efficiency Directive establishes a set of measures to promote energy efficiency within the Union. The streamSAVE project will streamline energy savings calculations and provide the support needed to increase Member States' chances of successfully and consistently meeting their energy efficiency targets. The streamSAVE project specifically focuses on Article 3 and 7 of the EED which are devoted to energy efficiency targets and national energy efficiency obligation schemes, respectively.

More broadly, the project aims at fostering transnational knowledge and dialogue between public authorities, technology experts, and market actors. The key stakeholders will improve their energy savings calculation skills and ensure thus the sustainability and replicability of the streamSAVE results towards all European Member States.

Needs for streamlining energy savings estimations

In December 2018, the European Parliament and the Council of the European Union adopted the revised Energy Efficiency Directive 2018/2002/EU which sets the 2030 energy efficiency target to be at least 32,5 %. The EED requires all EU Member States (MS) to set indicative national contributions for 2030 (Article 3) and to report (to be) achieved energy savings on a regular basis (Article 7). Therefore, the requirements for MS in reporting achieved energy savings need to guarantee comparable results of their energy efficiency efforts as well as a decent monitoring and verification process based on a sound data collection process. Even though various projects have focused on harmonization of energy savings calculations (e.g. EMEEES, 2009; multEE, 2016), additional focus must be given on the technical aspects of savings estimations. In frame of the EU "Task Force on mobilizing efforts to achieve the 2020 targets for energy efficiency" (EU TaskForce, 2019; EC COM(2019)224, 2019), Member States pointed out possible reasons, depending on their national context, that explain the difficulties they face in raising energy savings. Member States clearly raised the difficulty to calculate, and thereby report, the energy savings from measures taken or planned, as it is challenging to estimate savings aligned with actual savings achieved, including behavioral impacts.

To achieve their energy saving obligations, Member States are free to opt to establish Energy Efficiency Obligation schemes (EEOs) or to implement alternative energy efficiency measures supported by several mechanisms such as Energy Efficiency Funds, Eco Funds, Voluntary agreements, tax exemptions and reductions. Based on the streamSAVE stakeholder's consultation carried out during autumn 2020, it was possible to learn that in countries having EEOs in place the methodologies to calculate energy savings are well established and catalogues and guidelines for bottom-up (BU) calculation methodologies are generally publicly available in these countries (Rosenow, 2017; streamSAVE D4.1, 2021). Recognizing the need Member States have regarding the complexity of calculating energy savings, the Knowledge Facility of streamSAVE is summarizing and analysing the existing methodologies allowing identification of gaps for improvement. This overview of methodologies supports the development of streamlined methodologies for savings calculations for a significant number of measures, for which a lack of experience, practices and data is hindering its adoption by several MS, although its high potential for energy savings – the Priority Actions (PA).

streamSAVE will target a total of 10 Priority Actions over two cycles of experience sharing and capacity building. Priority Actions under analysis in the first round are:

- Heat recovery (district heating and excess heat from industry)
- Building Energy Management System (BEMS) and Building Automation and Control Systems (BACS)
- Commercial and Industrial Refrigeration System (C&I Refrigeration)
- Electric Vehicles (private & public) and related infrastructure (charging stations)
- Lighting Systems and public lighting

The role of deemed savings methodologies

For the purpose of calculating energy savings, Annex V of EED provides a set of common methods and principles for calculating the impact of energy efficiency obligation schemes or other policy measures under Articles 7, 7a and 7b and Article 20(6). Obligated, participating or entrusted parties, or implementing public authorities may use the deemed savings method, by reference to the results of previous independently monitored energy improvements in similar installations. The generic approach is termed 'ex ante' [1].

Deemed savings means a measurement of energy savings or demand savings for a single unit of an installed energy efficiency measure or adopted efficiency practice that (a) is determined ex-ante and applied to all such measures *without* further measurement or verification, and (b) has been developed using data sources and analytical methods that are widely considered acceptable for the measure and purpose (EVO, 2018). Deemed savings are therefore pre-determined, validated estimations of energy savings attributable to an Energy Efficiency action of a particular type of application as opposed to savings determined through measurement and verification activities. Deemed savings *calculation values* are agreed upon, in advance of the implementation of any energy saving measures or energy plans. Besides deemed savings, also individual parameters and indicative values, as well as calculation methodologies, can be deemed, meaning they are developed from commonly accepted data sources, evidence-based data and analytical methods. Deemed savings can also take the form of an algorithm, providing a formula of inputs for calculating a savings estimate.

Although deemed savings estimations present several benefits as they are fast, easy to calculate, constant and predictable, the quality of the deemed saving estimations can vary significantly. A recent study stated that "static efficiency assumptions are inherently imprecise" (Cadmus, 2016). Also, impact assessment studies identified discrepancies regarding the energy savings MS were claiming and the heterogeneity for similar measures (Rosenow, 2019; Tsemekidi, 2018; Ricardo, 2016; EU TaskForce, 2019) and emphasize the need to increase the reliability of energy savings estimates reported by MS (Santini, 2020), (Labanca, 2016). If deemed savings values are not regularly updated using recent data, the results are questionable because deemed savings values rely on multiple assumptions and can vary widely from the actual savings (Economidou, 2020).

Like other investments, investments in energy efficiency, whether implemented under obligation schemes (EEOs) or alternative measures, supported by ratepayers or

[1] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02012L0027-20210101&from=EN

taxpayers, should be evaluated for their cost-effectiveness. However, cost-effectiveness analysis on energy efficiency, besides the costs, require information on the energy savings achieved. If data collection is not well planned, it will be a major administrative burden. Therefore, even though questioned by some experts, particularly for larger projects, deemed savings estimations play an important role in the planning and evaluation of energy efficiency programs as long as the assumptions are validated through existing practices, good examples, best case studies, …

Recent studies and ongoing projects show that the countries where EEOs are in place seem to have better energy saving evaluation practices as EEOs require obligated parties to report to National Authorities the results of their actions (Rosenow, 2017; Fawcett, 2019; streamSAVE D4.1, 2021; Santini, 2020; Bere, 2020). The stakeholder consultation performed at the beginning of the streamSAVE project (streamSAVE D4.1, 2021) showed that the lack of quality data is among the main challenges MS face when implementing EED Article 3 and Article 7. Defining the baseline and data collection has been identified as one of the main topics where stakeholders would appreciate streamSAVE guidance and knowledge sharing. The experiences with EEOs indicate that establishing the data requirements that ensure a smooth data collection process at the time the scheme is designed is a major driver for the success and acceptance of deemed savings estimations practices, with several advantages in terms of evaluation efforts and without penalizing the savings reported.

Purpose and scope of the report

This report presents an assessment of the existing situation starting from documents containing bottom-up methodologies within Member States. Next to the status, the report identifies the gaps in sectoral coverage of energy savings calculation methodologies MS face when preparing energy efficiency plans and evaluating energy efficiency measures in the scope of EED Art.7 and Art.3. The gap analysis is about *identifying sectors and end-uses* which are not yet well reflected in the existing catalogues. Analyzing and mapping the current situation in MS in terms of end use and sectoral coverage will help us understand the gaps that remain which are the basis to identify the priority actions that need to be tackled by MS to ensure their achievement of the reduction goals required by the Directive. Therefore, the findings of this report aim to help MS to develop further energy efficiency actions considering the priority areas where there are more needs and where the savings potential is higher.

Chapter 1 Collection of deemed savings methodologies

In order to analyze the existing situation in the EU, a combination of approaches was used to collect relevant data and understand the challenges Member States face. The activities consisted of the conducted needs assessment (streamSAVE D4.1, 2021), review of existing BU methodologies from Member States and existing projects and the estimation of Final Energy Consumption per end-use and per sector (sectors of Industry, Commercial, Residential and Transport). Figure 1 shows the main data sources used in this study, comprising stakeholder's consultation (online survey and interview), existing documents from MS including BU methodologies complemented with project's results from multEE (2016) or EMEEES (2009), Eurostat energy balances combined with estimates from existing studies on end-use energy consumption as well as own estimations.

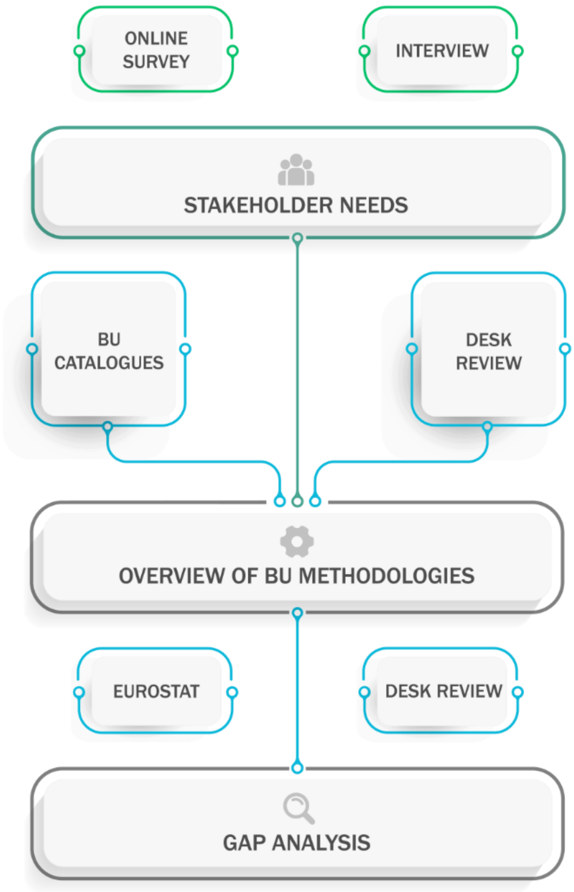

Figure 1: Data collection to support the overview of existing calculation methodologies and identification of gaps.

With the objective of collecting in a consistent and efficient manner all publicly available BU methodologies in EU27+UK, all project partners were asked to provide specific details according to common templates, based on catalogues available in the Member States their organisation was responsible for, in two steps:

1. The *first step* was to translate, for each catalogue available, the table of contents, by indicating the title of each methodology, the sector where the methodology can

be applied and its related end-use, as well as an indication if (any) calculation values were available. This was done in an Excel-Sheet, in English.

2. In addition to this template, in a *second step*, the partners provided a translation to English language of all calculation methodologies falling under the scope of the *streamSAVE 5 Priority Actions*, by filling in a word template. This document includes a brief description of the methodology, the equations used for estimating the savings, indicative calculation values prepared for the MS and if and how cost-effectiveness or CO_2 savings are evaluated. These methodologies have been compiled and consolidated in one document which is available as Annex II to this report.

In order to analysis the gaps from the overview of collected MS methodologies, desk research and analysis based on Eurostat statistics was undertaken to understand how the Final Energy Consumption is divided into the different sectors at EU level and identify the energy intensity of each sector in perspective. The gap analysis is about identifying sectors and end-uses which are not yet well reflected in the existing catalogues or recent and ongoing projects. It can support MS in developing energy efficiency actions in those areas where there are more needs and where the savings potential is higher to ensure their achievement of reduction targets.

1.1 Evaluation framework for Priority Action methodologies

The various BU methodologies identified have been organised by the sector they cover and classified according to the main end-use category. The methodologies target one or several sectors, namely the Industrial, Transport, Commercial or Services, Residential or Household, and Agriculture, Forestry & Fishing[2] sectors.

For the *Priority Actions falling under the scope of streamSAVE*, the calculation methodologies were summarized. In addition, the review assessed the indicative values and correction factors being used, i.e., how energy savings were estimated to adjust for situational factors, such as weather and other factors of bias (e.g. double counting, free-riders, and direct rebound effects). A template has been designed to collect the data in a uniform format, including the following elements:

- Description of the action;
- Application area or scope of the standardized calculation methodology (e.g. subsector; boundary conditions of methodology);
- Calculation formula to estimate the savings and costs; parameter definition and indicative values (e.g. lifetime), including a description of sources for these standardized values;
- How the baseline consumption has been determined for each action; how frequently and according to which criteria and data these baselines should be updated; and
- Correction factors for behavioural effects (e.g. rebound effects) and/or geographical factors.

[2] Agriculture, Forestry and Fishing sectors: the sectors are defined according to the Energy Balances from Eurostat. In this report, Agriculture, Forestry & Fishing are combined given their similar relevance in frame of energy saving methodologies.

The information herein presented is based on a review carried out by all partners for all BU methodology catalogues identified in MS and information from recent project reports. The table below summarizes the countries the streamSAVE partners were responsible for.

Partner	Country coverage catalogues catalogues or guidelines on BU methodologies are available in MS *in Italic.*
VITO	Belgium, *Luxembourg*
IEECP	the Netherlands, *Denmark*, Finland, Sweden, *Croatia*
ECI	*United Kingdom*, *Ireland*
AEA	*Austria*, Germany, *Italy*
ISR	*Portugal*
LGI	Hungary
CRES	*Greece*, Cyprus, *Bulgaria*
SEVEN	Czech, Poland, Slovakia
JSI	Romania, *Slovenia*
LEA	Estonia, Latvia, Lithuania
ADEME	*France*
CIRCE	*Spain,* Malta

Table 1: Country coverage of partners to translate and summarize BU methodologies from catalogues.

The information was collected from:

- Existing catalogues within Member States. This is the main source of information.
- Estimation methods (incl. cost-effectiveness) used by public authorities to estimate savings *(Article 7 – EEO and alternative measures)* or expected energy consumption *(Article 3 – target setting)* by 2020 or 2030. This information was retrieved from the streamSAVE's online survey and interviews (streamSAVE D4.1, 2021), or from official EU reporting, for example from the National Energy Efficiency Action Plans NEEAPs, and the National Energy and Climate Plans NECPs. These are the most reliable sources of information, when there were no catalogues available and when MS use alternative measures in the frame of Article 7.
- Existing methodologies for savings calculation and/or energy consumption reduction prepared by other projects (like multEE and EMEEES) have been examined and considered in the analysis, as well as other initiatives, scientific literature, grey reports, etc., offering guidance on bottom-up methodologies for energy savings calculation.

In addition, other relevant methodology information that can be useful for the streamSAVE, particularly for Article 3 and Article 7, such as lifetimes of measures, benchmarks, climate correction factors, default parameters, literature references, etc., have also been collected.

Box: Template to document the BU calculation methodologies

Name of MS or project the methodology was taken from]

Exact name of the calculation methodology

Short **explanation** on what this calculation methodology is about.

- Application area: What is its application area? For example, for which type of technology, end-use or sector can this methodology be used?
- Boundary conditions: Under which conditions (which sector, which geographical or climate coverage) can it be used? Are there other restrictions for using this formula or the values prepared? (example: values are only prepared for retrofitted/non-retrofitted buildings)

Calculation Formula:

- Indication whether the formula applies for estimation of savings (Article 7) or consumption (Article 3); Indication if the formula calculates first year savings/cumulative savings].
- Description of savings formula:

$$\boldsymbol{TFES} = (\boldsymbol{FEC_{before}} - \boldsymbol{FEC_{after}}) * rb * so * fr * lt$$

TFES	Total final energy savings [kWh/a]
FEC_{before}	Final energy consumption before implementation of the action [kWh/a]
FEC_{after}	Final energy consumption after implementation of the action [kWh/a]
rb	Factor to calculate a rebound effect
so	Factor to calculate a spill-over effect
fr	Factor to calculate a free-rider effect (=1)
lt	Factor for the lifetime of savings
…	…

Cost Effectiveness

Providing information on cost effectiveness of the measure. How has this information been calculated? What costs were included in the analysis? What criteria were used to evaluate the cost benefits (e.g. NVP, payback time)? Indication of sources used for the calculation, including which year(s).

Brief description of sources

Describing whether this methodology was taken from officially published legal documents; or suggestions made by the government; or if this methodology is common practice in the relevant country. If there is a document available online, weblinks are included. Additionally, the language(s) of the original document are stated.

Calculation values

In case there are calculation values available, explaining (in a short and concise manner) how they were defined. What data was used? Where was this data taken from? How often are the values updated?

Bibliography

Listing all references cited in bibliography style

1.2 Collection of deemed savings methods in all sectors and end-uses

In total, in EU27 + UK, it was possible to identify 16 catalogues and guidelines containing bottom-up calculation methodologies, and a total of 582 different methodologies with application in the various sectors, covering a wide range of technologies and end-uses. Sometimes, catalogues did not indicate details for some methodologies, and only described general approaches without indication about calculation parameters or assumptions. Old catalogues exist in some countries, but these are probably outdated as they were developed within the scope of the implementation of the first NEEAPs (back to 2012-2014). In general, it can be stated that where EEOs are in place, catalogues or other documents like guidelines or ordinances are wider available.

Table 2 lists all end-use categories that were identified in connection to the collected BU methodologies. The screening of the methodologies could not find some of these end-uses, and therefore, for the gap analysis, a slightly different set of categories was used to be better aligned with the best available consumption breakdown by end-use.

End-use category	
Household appliances	Household appliances like white goods, consumer electronics
IT systems	ICT and office equipment
Lighting	Reduction of energy demand by lighting
Process Heat (> 200 °C),	High-temperature process heat, furnaces
Process Heat (< 200 °C), Steam&Hot Water	Low-temperature process heat, steam&hot water
RES electricity generation	Electricity generation from renewable sources
RES heat generation	Heat generation from renewable sources
Process cooling	Includes central compression refrigeration units, industrial refrigeration, compression cooling
Domestic hot water	Includes boilers, insulation pipes, etc.
Space Heating & Cooling	Includes building envelope (new construction & retrofitting), changes in heating systems)
Stationary Engines	Electric motors, pumps, fans, compressors, compressed air, ...
Transport	Includes vehicles, changes in modal shift, changes in fuel, on-site transport like conveyor bands, etc.
User behaviour	Cross-cutting changes in behaviour (e.g. energy advice for households in general)
Ventilation	Adaption of ventilation systems
Others	

Table 2: List of initial end-use categories for the categorization of the BU methodologies.

Table 3 lists the links for the catalogues with calculation methodologies for the countries where the methodologies are publicly available in their national languages.

	Weblinks to available catalogues
AT	https://www.ris.bka.gv.at/Dokumente/BgblAuth/BGBLA_2016_II_172/COO_2026_100_2_1241958.pdfsig
	https://www.monitoringstelle.at/fileadmin/i_m_at/pdf/Carpooling_in_Unternehmen.pdf
	https://www.monitoringstelle.at/fileadmin/i_m_at/pdf/Lueftungsanlage_mit_Waermerueckgewinnung.pdf
	https://www.monitoringstelle.at/fileadmin/i_m_at/pdf/Modernisierung_einer_Bestandslueftungsanlage.pdf
	https://www.monitoringstelle.at/fileadmin/i_m_at/pdf/Neuinstallation_und_Ersatz_industrieller_Schaltschrankkuehlungen.pdf
	https://www.monitoringstelle.at/fileadmin/i_m_at/pdf/Reduktion_von_Leckagen_in_Druckluftsystemen.pdf
	https://www.monitoringstelle.at/fileadmin/i_m_at/pdf/Tausch_elektrisch_betriebener_Standmotoren.pdf
	https://www.monitoringstelle.at/fileadmin/i_m_at/pdf/Tausch_elektrisch_betriebener_Standmotoren_mit_Leistungsanpassung.pdf
	https://www.monitoringstelle.at/fileadmin/i_m_at/pdf/Methode_Aufzugsschachtentlueftung_202003.pdf
BG	https://seea.government.bg/bg/metodiki/2-uncategorised/9912-specializirani-metodiki-za-ocenqwane-na-energijnite-spestqwaniq-utwyrdeni-ot-me
CY	https://ec.europa.eu/energy/sites/ener/files/documents/cy_neeap_2017_en.pdf
EU	https://multee.eu/system/files/D2.1_Document%20with%20general%20formulae%20of%20bottom-up%20methods.pdf
	http://www.emeees.eu/emeees/en/evaluation_tools/index.html
DK	https://ens.dk/ansvarsomraader/energibesparelser/energiselskabernes-energispareindsats/standardvaerdikatalog
FR	https://www.ecologie.gouv.fr/operations-standardisees-deconomies-denergie#scroll-nav__7
GR	http://www.cres.gr/obs/yliko.html
HR	https://narodne-novine.nn.hr/clanci/sluzbeni/2020_03_33_723.html
IR	https://www.seai.ie/business-and-public-sector/business-grants-and-supports/energy-efficiency-obligation-scheme/
IT	https://www.mise.gov.it/images/stories/normativa/DD-2019-Allegato-1-Guida-operativa.pdf
LU	http://data.legilux.public.lu/eli/etat/leg/rgd/2015/08/07/n1/jo
PT	https://www.sgcie.pt/files/adene2019/Adene_jul2019.html
	https://ec.europa.eu/energy/sites/ener/files/documents/pt_neeap_2017_en.pdf
ES	https://www.idae.es/publicaciones/guia-tecnica-de-eficiencia-energetica-en-iluminacion-oficinas ; https://www.idae.es/publicaciones/guia-tecnica-procedimientos-para-la-determinacion-del-rendimiento-energetico-de https://www.idae.es/publicaciones/
SI	http://www.pisrs.si/Pis.web/pregledPredpisa?id=PRAV12443
UK	https://www.ofgem.gov.uk/publications-and-updates/eco2t-guidance-and-associated-documents

Table 3: List of catalogues (weblinks) per country.

Chapter 2 Overview of deemed savings methodologies for Priority Actions

This chapter presents the existing methodologies available in EU 27+UK for each of the five Priority Actions under analysis in the first round of streamSAVE, namely

- Heat recovery (district heating and excess heat from industry)
- Building Energy Management System (BEMS) and Building Automation and Control Systems (BACS)
- Commercial and Industrial Refrigeration System (C&I Refrigeration)
- Electric Vehicles (private & public) and related infrastructure (charging stations)
- Lighting Systems and public lighting

Besides the application area, the methodologies are classified by sector (Industry, Commercial, Residential, Transport, Agriculture, Forestry & Fishing). Furthermore, the report presents the analysis of the different calculation methodologies regarding the formulas used to calculate energy savings, correction factors and indicative calculation values, as far as available.

2.1 Sectoral coverage

It should be noted that each methodology may target several different sub-sectors and even sectors, end-uses, or technologies. The quantification of energy savings relies on deemed savings and enhanced engineering estimates and therefore, sector-specific indicative values need to be considered even though the aim is to collect streamlined calculations.

Audits and direct measurements are common in several countries, particularly in the industrial sector, where these are binding under Article 8 of EED. The definition of deemed savings estimations, particularly the indicative calculation values, are established based on measured savings from a vast number of already implemented actions to ensure the reliability of the indicators and to increase the accuracy of results. Therefore, because they are often based on direct measurements, deemed estimates are very accurate and yet very simple to use.

2.2 Comparison of existing practices for Priority Actions

Based on the compilation of all methodologies within the scope of the Priority Actions available in the Member States, this section presents the main characteristics of the collected methodologies focusing on the equations and the indicative values being used for the calculations, whether the equations estimate energy savings or energy consumption, or rational for cost-effectiveness. The complete compilation of methodologies can be found *in Annex II of this report*.

Table 4 presents an overall picture of the situation in Europe, regarding existing BU methodologies related to the five PAs listed above. In the next sections a short summary is given for each PA, describing the main characteristics of the methodologies being used in Europe, areas of application and comparison between different methods.

Priority Action	N° of methods	Member State	Indicative values
Heat Recovery	11	BG, CY, FR, LU, SI	Based on European standard
BEMS&BACS	6	BG, FR, HR	Based on European standard, energy savings by sector & end-use; definition of climate regions
Refrigeration	12	AT, BG, FR, HR, IT, LU	Standardized values according to climate regions and Energy savings factor per sub-sector
EVs	12	AT, HR, CY, CZ, GR, IR, LU, SI	Mainly based on statistical data
Lighting	19	AT, BG, CY, FR, GR, HR, IR, PT, SI	Energy savings factors for some lighting systems and lifetime of savings

Table 4: Overview of the identified deemed methodologies per Priority Action.

2.2.1 Heat Recovery

Member States use various BU methodologies on how to calculate savings from heat recovery in different parts of an industrial production process:

- Compressed air systems (Bulgaria, Luxembourg);
- Furnaces and (condensing) economizers (Bulgaria, Luxembourg, France);
- Cooling units and cooling towers (Bulgaria, France).

Other methodologies available offer calculation options for the installation of heat recovery systems in general (Cyprus, Slovenia).

The calculation formulas either compare the final energy consumption before the installation of a heat recovery system to the final energy consumption after the installation; or multiply the installed power and operating time or final energy consumption with a savings factor or percentage of heat recovered. Therefore, for all methodologies prepared in the Member States, additional information like energy consumption metering data or installed power has to be prepared by implementing parties in order to calculate savings.

Given the significant variety of process areas where heat recovery systems in industry can be implemented and the technological solutions for this, rather generic formulas are needed in order to not exclude certain solutions. Additionally, the scalability of such systems depending on the application area limits the definition of standardized calculation values. It is therefore advised to provide guidelines on how formulas and calculation values can be defined in accordance with the EED framework instead of preparing a deemed savings methodology not fit for most use cases.

2.2.2 BEMS & BACS

Although the streamSAVE survey pointed out a high interest for BEMS/BACS, the number of Member States that have a calculation methodology implemented already is rather low. Only Bulgaria, Croatia and France have implemented measures that correspond with the definition used here. As the terms BEMS and BACS seem to be used interchangeably, and as there is no clearly delineated definition for BEMS only, BACS form the focus. For

BACS several definitions and approaches exist, the definition used here is the following, stemming from "EN ISO 16484 - Building automation and control systems (BACS)"[3] comprising "*all products and engineering services for automatic controls (including interlocks), monitoring, optimization, for operation, human intervention and management to achieve energy-efficient, economical and safe operation of building services. Controls herein do not only refer to control but also to the processing of data and information.*"

Applying that definition, six methodologies were found, namely, the evaluation of energy savings in the installation of automation and heating control systems in residential buildings (BG), the evaluation of energy savings in the installation of an energy-efficient management system at a distribution station (BG), the installation of heating system regulation equipment (HR), the installation of equipment for automatic regulation of lighting systems (HR), the installation of equipment for automatic regulation of electricity consumption (HR), and the installation of automation and heating control systems & hot sanitary water in residential buildings (FR). All other methodologies, referring to either the introduction of an energy management system or the use of intelligent metering, were not considered a good fit with the definition and the focus on automated control.

The selected methodologies differ in two ways. Firstly, the methodologies differ *in the way the energy demand is calculated* for a building using various automation functions. On the one hand, the so-called BACS factor method[4] can be used, on the other hand, a more detailed, technology-specific approach exists. The advantage of the BACS factor method lies in the fact that no information is needed about any specific control and automation function installed, as energy use is calculated with a reference BACS efficiency class. These then result in BACS efficiency factors, i.e. estimations of the impact of BACS on thermal and electrical energy demand of the building according to the BACS efficiency classes A, B, C and D. An example of this method is the evaluation of energy savings by installing automation and heating control systems in residential buildings (BG), where the total final energy savings equals the difference between the heat consumption of residential buildings before and after the installation of automation and heating control systems, which is provided for two classes of automation and heating control systems (classes A and B). To illustrate the technology-specific method, the example of the installation of equipment for automatic regulation of lighting systems (HR) can be considered. There, unit savings per set are calculated first, taking into account installed power of the light sources and annual operating hours. Summing the unit savings of all sets of equipment then results in the total final energy savings.

Secondly, the methodologies differ in the *use of deemed or scaled savings*. Whereas deemed savings rely on standardized values, scaled savings makes use of on-site measurements, like water temperature, surface, etc. A good example of the latter can be

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[3] https://ec.europa.eu/eip/ageing/standards/home/domotics-and-home-automation/en-iso-16484_en.html

[4] Standard EN 15232 specifies methods to assess the impact of Building Automation and Control System (BACS) and Technical Building Management (TBM) functions on the energy performance of buildings, and a method to define minimum requirements of these functions to be implemented in buildings of different complexities. The calculation of the impact of the building automation and control and building management functions on the energy efficiency of a building can be accomplished using either a detailed method or the simplified BACS factor method. The BACS factor method gives a rough estimation of the impact of BACS and TBM functions on thermal and electric energy demand of the building according to the efficiency classes A, B, C and D. The impact of BACS functions on the building's energy demand is established with the aid of BACS efficiency factors.

found in the savings methodology dealing with the installation of an energy-efficient management system at a distribution station (BG), where the measured consumption for thermal energy (space heating and hot water) and the measured quantity of cold water are used in the calculation. An example of the deemed savings can be found in the methodologies for the installation of heating system regulation equipment (HR), where standardized calculation values are used for the annual thermal needs of a building, the efficiency of the subsystems, etc.

Important to note is that none of these methodologies consider behavioural effects like a rebound, spill-over and free-ridership. Additionally, no information is available on the calculation of cost-effectiveness.

2.2.3 Commercial and Industrial refrigeration systems

Based on the availability of BU methodologies and stakeholders' needs (streamSAVE D4.1, 2021), the application of centralised compression refrigeration systems is selected as the target action for developing streamlined methodologies by the streamSAVE project. Centralized commercial and industrial refrigeration systems are not well covered by the BU methodologies to calculate energy savings from efficiency improvements in refrigeration systems.

However, the catalogues cover other cooling technologies, such as "installation of natural cooling systems" and "free cooling (water)" which are referring to free cooling systems, both with air or water, whose outdoor temperature is below or equal to the desired temperature. This technology is more applicable to buildings' air conditioning than to industrial refrigeration. Due to the temperature level, this measure is less useful for industrial or commercial purposes, where more extreme temperatures are required.

Some other identified measures are related to the replacement or installation of new efficient cooling equipment in buildings for industrial or commercial use. Italy and Croatia are examples here. In this methodology, the annual cooling requirements, based on the European Seasonal Energy Efficiency Ratio (ESEER), are crucial to determine the energy savings. In Italy several measures have been collected in relation to the "Replacement of electric compression refrigeration units by absorption cooling units or by refrigerating units with indirect absorption". For these absorption cooling related calculations, complex or detailed, monitored data need to be gathered, which makes standardised data collection difficult. Same applies to the methodology of "Replacement or new installation of electric compression refrigeration units", also from Italy, requiring a lot of detailed information to be completed.

Both methodologies from Luxembourg, tackling increasing evaporator temperature and lowering condenser temperature, might be implemented with almost no additional costs. In addition, there is a constraint on the number of operating hours to apply the methodology.

The methodologies for central compression refrigeration systems in Austria and developed by the multEE project are the same. In this methodology the following formula is used to determine possible energy savings when this technology is applied:

$$TFES = n * Pc * hFL * (1/ESEER_{Ref} - 1/ESEER_{Eff}) * rb * so * fr$$

TFES	Total final energy savings [kWh/a]
n	Number of cooling systems installed at a specific cooling power

Pc	Installed cooling power of the cooling system [kW]
hFL	Full-load hours related to the maximum installed cooling power [h]
ESEERRef	European Seasonal Energy Efficiency Ratio of the reference compression refrigeration system [-]
ESEEREff	European Seasonal Energy Efficiency Ratio of the more efficient compression refrigeration system [-]
rb	Factor to calculate a rebound effect (=1)
so	Factor to calculate a spill-over effect (=1)
fr	Factor to calculate a free-rider effect (=1)

As mentioned, comparison of calculation formulas and related indicative values from each methodology or country is not possible, given the variety of cooling & refrigeration measures, level of methodological detail as well as availability of indicative values. The Austrian and MultEE methodologies are the only methodologies covering the streamSAVE scope of centralized commercial and industrial refrigeration systems, and having indicative values available as well. No cost-effectiveness estimations are provided for any of the calculations, however some standardized values are provided for ESEER (2015, that would need an update), lifetime, EERef, etc.

2.2.4 Electric vehicles

Several countries have developed methodologies to calculate savings associated with the purchase of alternative vehicle technologies. This is the case for Austria, Croatia, Cyprus, Greece, Luxembourg and Slovenia. A similar methodology was also developed by the multEE project. Moreover, Ireland estimates the savings related to fleets (public vehicle fleets managed by a centralized fleet operator), by monitoring the energy consumption of the old and new fleets, as well as the actual distance travelled of the entire fleet .

The calculation is usually based on the number of purchased vehicles, the difference of energy consumption between a reference and the efficient vehicles, and the yearly mileage. In some cases, the savings methodology also includes conversion factors between different units of energy consumption, namely between kWh/l or kWh/kg and kWh/100km (as in Croatia); or including the fuel density in kg/lt and the heating value of the fuel in kWh/kg (as in Cyprus); or dividing the consumption of electricity and other fuels with the respective calorific values (as in Luxembourg). In the case of Slovenia, the reference energy consumption is calculated based on the average projected specific emissions of CO_2.

The consumption can also be adjusted for behavioural effects, such as rebound, spill-over, and free-ridership, as well as for the lifetime of savings. This is the case for Austria, as well as the methodology developed by the multEE project, but without presenting indicative values for behavioural effects. To fulfil the criterion of additionality, the requirements of the EU regulations 443/2009 and 510/2011 were introduced by Greece into the specific final energy consumption of reference vehicles.

For example, the methodology developed by the multEE project calculates first-year savings using the following formula:

$$TFES = n * (sFEC_{Ref} - sFEC_{Eff}) * \frac{Mil}{100} * rb * so * fr * lt$$

TFES	Total final energy savings [kWh/a]
n	Number of efficient cars purchased
$sFEC_{Ref}$	Specific final energy consumption of the reference passenger car [kWh/100 km]
$sFEC_{Eff}$	Specific final energy consumption of the efficient passenger car [kWh/100 km]
Mil	Average yearly mileage [km/a]
rb	Factor to calculate a rebound effect
so	Factor to calculate a spill-over effect
fr	Factor to calculate a free-rider effect (=1)
lt	Factor for the lifetime of savings

2.2.5 Lighting systems including public lighting

Lighting is one of the Priority Actions where most European countries have developed several methodologies. There are BU methodologies for lighting systems in almost all sectors, such as street lighting, traffic lighting, industrial lighting, building lighting and residential lighting. Most of the measures are dedicated to the implementation of more energy efficient technologies, including the use of lighting control systems.

The calculation formulas are based on the number of lighting points/lamps, the difference between the power of both technologies (inefficient and efficient) and the total annual operating hours. All available methodologies calculate first-year savings, presenting mostly the lifetime for the savings as well, although not calculating the total costs of ownership (TCO). When lighting controls are applied, their contribution is accounted by using a different number of annual operating hours (with and without sensors), reference indicative values (e.g. Bulgaria), or different reduction factors according to the type of control used (e.g. Austria and Croatia).

Almost all methodologies estimate the baseline consumption by using the power of the installed lighting points/lamps and the annual operating hours, requiring access to the existing characteristics of installed technologies. One of the exceptions, is, for example, Greece where more simplified methods have been collected, although these are very particular and can only be used for savings actions that promote *"the replacement of energy-inefficient lamps (conventional light bulbs until their total phase-out, halogen lamps) with energy-efficient ones (CFL, LED)".*

In just two methodologies (i.e. Austria and multEE), the consumption can also be adjusted for behavioural effects, such as rebound, spill-over and free-ridership, although there is lack of research information at the moment to provide values for such effects. None of the analysed methodologies calculates the cost-effectiveness, the total cost of ownership or considers any quality criteria.

Two of the most simplified approaches are the ones followed by Slovenia and France, which use annual standardized energy savings (kWh/year – defined in a table) when replacing or improving outdoor lighting systems. Indicative values consider the power of the old mercury lamps and new equivalent more efficient technologies (e.g. Slovenia), or the use of two different efficiency levels for the new lamps (e.g. France).

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As an example, the methodology developed by Slovenia calculates first-year savings for street lighting using the following formula:

$$PE_{Lighting} = \sum_i NP_i \cdot n_i$$

$PE_{Lighting}$	Energy savings [kWh/year] due to the use of energy-efficient or improved lighting system
n_i	Number of lighting systems or improvements installed or sold
NP_i	Standardized energy savings [kWh/year per system] when replacing or improving various lighting systems as set out in a table with the indicative values

Chapter 3 Status of deemed savings methodologies across sectors and end-uses

Besides the analysis of existing methodologies for the streamSAVE Priority Actions presented before, this chapter explains the gap analysis or status of BU savings methodologies by mapping a range of sectors and end-uses having limited coverage in Europe. This mapping of the sectors in need for BU methodologies was carried out by comparing all identified existing methodologies from the catalogues, with simplified energy balances which were estimated based on Eurostat Energy Balances (consulted in 2021). As explained in Chapter 2, the list of all collected BU methodologies in EU27 + UK is based on the translation of the catalogues' table of contents and can be consulted in *Annex I of this report*. The assessment takes into account existing needs as well as main challenges among stakeholders which were identified during the online survey and interviews carried out in October-November 2020.

Box: What is an energy Balance?

"The Energy Balance is the most complete statistical accounting of energy products and their flow in the economy. The energy balance allows users to see the total amount of energy extracted from the environment, traded, transformed and used by end-users. It also allows seeing the relative contribution of each energy carrier (fuel, product). The energy balance allows studying the overall domestic energy market and monitoring impacts of energy policies. The energy balance offers a complete view on the energy situation of a country in a compact format, such as on energy consumption of the whole economy and of individual sectors.

The energy balance presents all statistically significant energy products (fuels) of a country and their production, transformation and consumption by different types of economic actors (industry, transport, etc.). Therefore, an energy balance is the natural starting point to study the energy sector." (Eurostat, 2020a)

Energy balances can be an important tool for multiple purposes. In the scope of streamSAVE, the energy balance can provide a wide-ranging picture on the overall energy demand per sector and per end-use. This picture will provide a better understanding of where the load is while stressing the relative importance of sectors, energy carriers and end-uses.

3.1 Mapping simplified energy balances per end-use

This section presents the methodology used to map end-use energy balances based on the final energy statistics provided by Eurostat for the year 2019 (Eurostat Energy Balances, 2021).

It is important to note, that streamSAVE is not about characterisation of end-use energy consumption, nor about disaggregation of energy consumption per sector or end-uses. Therefore, *the approach to derive the final energy balances per end-use, was rather simplified*. Nevertheless, a comparison of the resulting final energy demand by end-use and energy carriers in each sector (industry, commercial, residential and transport) with the results of other studies, indicates similar outcomes or no significant differences.

Box: Final energy consumption, as defined in Eurostat

Final energy consumption covers the energy consumption of end-users, such as industry, transport, households, services and agriculture. It excludes consumption of the energy sector itself and losses occurring during transformation and distribution of energy (e.g. power plants, district heating plants, oil refineries, coke ovens, blast furnaces). It is also excluding all non-energy use of energy carriers (e.g. natural gas used for producing chemicals, oil-based lubricants, bitumen used for road surface). Quantities delivered to international aviation and international marine bunkers are also excluded from the final energy consumption (Eurostat, 2020a).

Complete energy balances for primary and final energy carriers for all Member States are available in the Eurostat database, providing a final energy balance for industry, commercial, residential and transport sectors on an aggregate level for EU27, for all energy carriers (Figure 2).

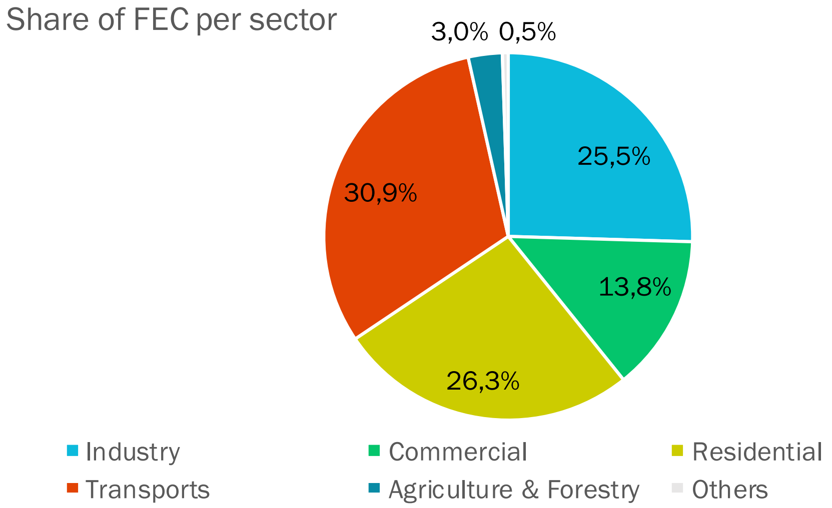

Figure 2: Disaggregation of final energy consumption by sector, in 2019 for EU-27 (Eurostat Energy Balances, 2021).

A set of two energy carriers, namely *Electricity and Other Energy* (i.e. all types of energy carriers, except electricity) have been applied for the gap analysis, based on the break-down of individual energy carriers available in Eurostat by sector for 2019. These two carriers have been considered because of the scope of streamSAVE, namely focusing on the implementation of Article 3 and Article 7 of EED. The graph below presents the final energy consumption per sector for the two considered energy carriers (Electricity and Other Energy) in 2019.

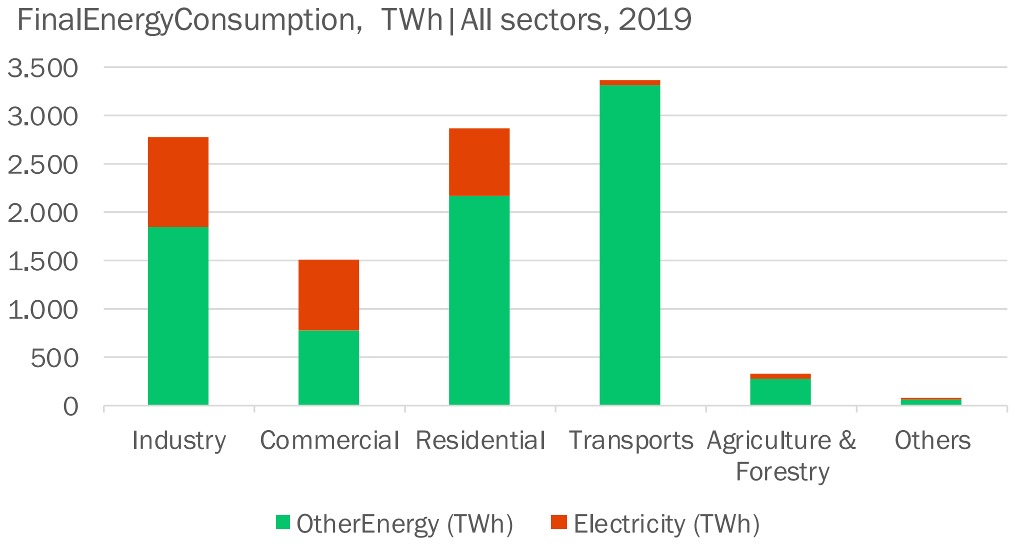

Figure 3: Total final energy consumption per sector, in 2019 (Eurostat Energy Balances, 2021).

Since a detailed breakdown of *final energy consumption per end-use* is not available for all sectors in Eurostat, the analysis has been carried out based on different reliable sources, collected from desk review, by using a top-down approach. The end-uses considered in the analysis are based on the definitions of Eurostat combined with the best available end-use consumption estimates from following sources: .

- Residential: (Economidou, 2020; EC DGE, 2016; Eurostat Energy Balances, Eurostat Households, 2021; Eurostat, 2020b).
- Commercial: (Economidou, 2020; EC DGE, 2016; Eurostat, 2020b; Eurostat Energy Balances, 2021; Elizarov, 2020; Fleiter, 2017; Toleikyte, 2021; Tsemekidi, 2018).
- Industry: (De Almeida, 2017; Economidou, 2020; EC DGE, 2016; Eurostat, 2020b; Eurostat Energy Balances, 2021; Elizarov, 2020; Fleiter, 2017; Fleiter, 2018; MotorStudy, 2016; Toleikyte, 2021; Tsemekidi, 2018).
- Transport, Agriculture, Forestry & Fishing: (Eurostat 2020a; Eurostat Energy Balances, 2021).

In relation to heating and cooling, the Eurostat energy balances and similar statistics provide only an incomplete picture of the EU sector (EC DGE, 2016). Data is scattered, incomplete or not available, such as the disaggregation to individual end-use categories, nevertheless the major share of heating and cooling in final energy demand in Europe (Fleiter, 2017).

As regards the sectoral and end-use categorisation being used for the gap analysis, the starting point was the disaggregation in Eurostat, but there was a need to compromise between the best available energy consumption breakdown and the end-uses for which BU methodologies were found. Figure 4 presents the final energy consumption split by main end-use categories, such as heating & cooling (disaggregated into space heating; heating process; other H|C - water heating; cooking; space cooling; process cooling) and transport. The second largest share is for transport and then for electric motors in industry as well as for appliances in residential and services sector (lighting, appliances & ICT).

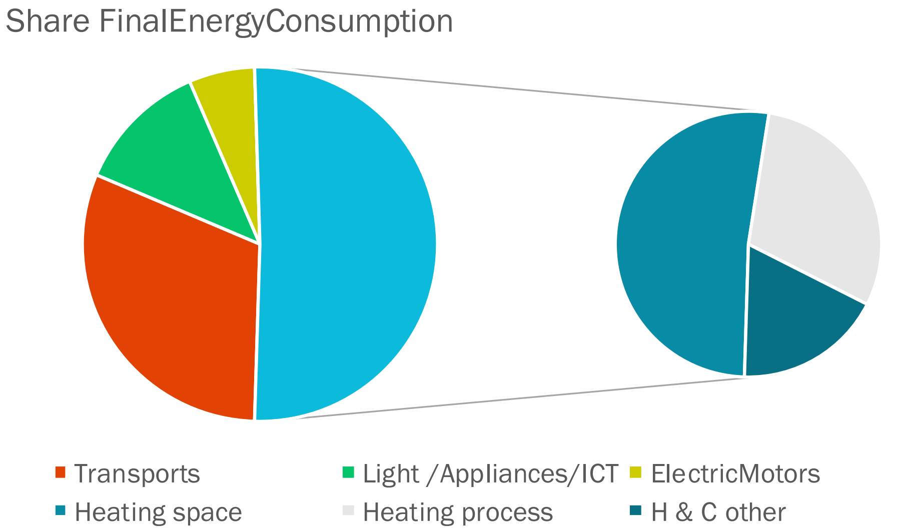

Figure 4: Breakdown final energy consumption by main end-uses covering all sectors in EU-27 (EC DGE, 2016; Eurostat Energy Balances, 2021; Elizarov, 2020; Fleiter, 2017).

By considering the best available disaggregation per end use, i.e. combining several sources and using a top-down approach, it was possible to estimate the final energy consumption per end-use and per sector, as represented in Figure 5. It can be observed that road transport represents the largest share of final energy use followed by space heating in commercial and residential buildings. Space heating holds the largest share of energy consumption in buildings, commercial and residential, representing 48% and 59% of their total energy consumption, respectively. Thinking of the importance of implementation of Article 3, it is relevant to remind the reader that both uses are mostly powered by fossil fuels.

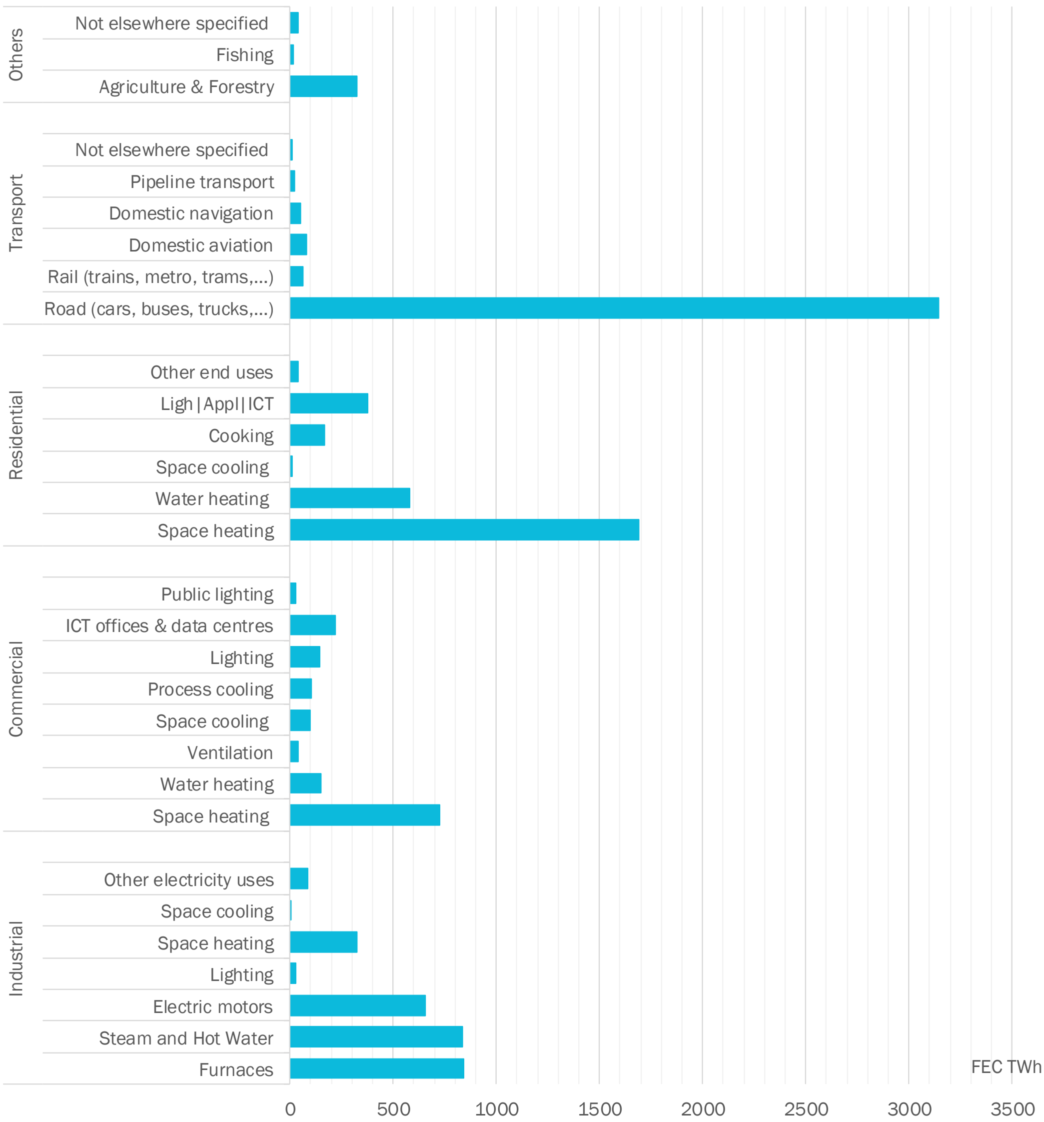

Figure 5: Disaggregation of final energy consumption by sector and main end-use, in 2019 (De Almeida, 2017; Economidou, 2020; EC DGE, 2016; Eurostat Energy Balances, 2021; Elizarov, 2020; Fleiter, 2017; Fleiter, 2018; Toleikyte, 2021; Tsemekidi, 2018).

3.2 Status of bottom-up methodologies across Europe

This section presents the list of available BU energy savings calculation methodologies identified, per energy consumption sector and per end-use, in EU-27+UK. As explained in Chapter 2, the list of all collected methodologies is based on the translation of the catalogues' table of contents and can be consulted in *Annex I of this report*.

In total, as Table 5 shows, it was possible to *identify 16 catalogues with bottom-up calculation methodologies, in 14 different countries and two research projects* (multEE, 2016; EMEEES 2009); these catalogues cover a total of 582 methodologies with application in various activity sectors, covering a wide range of technologies and end-uses. However, it should be noted that catalogues do not always indicate details for some methodologies, and describe sometimes only general approaches without indication about calculation parameters or assumptions. Furthermore, EMEEES has developed very detailed methodologies, but the scope of their methodologies, targeting the old Energy

Services Directive requirements, is no longer useful for the present framework of the Directive. Nevertheless, the project outcomes are interesting for guiding the improvement or development of new energy savings equations. Lessons learned from previous projects focusing on the EED experiences so far, provide valuable input for the successful implementation of future requirements under the new energy and climate framework. In general, it can be stated that where EEOs are in place, catalogues or other documents like guidelines or ordinances do exist.

Countries	Art. 7 implementation	N° BU methodologies
Austria	EEO & Alternative Measures	50
Bulgaria	EEO & Alternative Measures	36
Croatia	EEO & Alternative Measures	34
Cyprus	Alternative Measures	22
Denmark	EEO	34
France	EEO	214
Greece	EEO & Alternative Measures	25
Ireland	EEO & Alternative Measures	16
Italy	EEO & Alternative Measures	7
Luxembourg	EEO	34
Portugal	Alternative Measures	17
Slovenia	EEO & Alternative Measures	33
Spain	EEO & Alternative Measures	6
UK	EEO	3

Table 5: Number of BU calculation methodologies identified per Member State.

The methodological approaches for quantifying energy savings exist for individual actions and the equations being used are similar among countries. The equations apply mostly to energy savings calculations under Article 7, and seldom under Article 3. Indicative values are available for most identified methodologies, such as lifetime, energy savings factor (average savings) and hours of operation. In contrast, correction factors for behavioral effects and methodologies to estimate cost effectiveness of the Priority Actions could not be gathered from the country catalogues.

The conditions in terms of end-uses, technical options, actors and organizational factors, however, vary widely across different sub-sectors, both in industry and in the commercial sector, and even between countries and regions within the same country. From the collection of different methodologies identified in the 16 catalogues, *we were not able to classify the methodologies across sub-sectors for any country, neither in the industrial nor in the commercial sector*. While in the residential sector, apart from standards of living and climate region, the end-uses and profiles of use can be more standardised, in other sectors, particularly in the commercial sector, end-uses are relatively heterogeneous with different needs for energy and energy services. To implement the EED, it is therefore not surprising that MS report mostly aggregated energy savings, compromising and/or penalizing the verification of the results and the eligibility of the energy efficiency measures (streamSAVE D4.1, 2021; Bere, 2020; EC, 2020; Labanca, 2016; Ricardo, 2016; Zangheri, 2019). This is particularly important for the requirements of Article 7, as MS needs to comply with additionality and materiality criteria, preventing double-counting, reporting on actual savings and efficiency improvements. The diversity of end-use sectors requires streamlined methodologies powered by representative indicative values and correction factors. Some countries, for example, have established geographical areas to account for climate regions by defining a geographical factor that impacts the calculation (e.g. air conditioning measures in France).

The collected methodologies were classified not only per Member State, but also per type of end-use and sector they cover. Table 6 shows the result of this classification presenting the number of BU methodologies (top) and related indicative calculation values (bottom) to estimate savings for the sectors and related end-uses. In general, the review of existing methodologies shows that there is considerable experience in estimating *various types of energy efficiency improvement measures in all sectors, targeting different end-uses*. *Space heating and cooling in buildings, particularly residential buildings, are well covered by the catalogues*, both in terms of bottom-up methodologies and calculation values. In terms of sectors, A*griculture, Forestry & Fishing, next to Transport are less represented in the catalogues' methodologies*. Regarding end-use categories, ICT and office equipment, process heat (furnaces, steam & hot water), process cooling and water heating are not well covered by the catalogues.

BU methodologies	Appliances	ICT/Office eq.	Lighting	Steam&Hot water	Furnaces	RES electricity generation	RES heat generation	Process cooling	Water heating	Space heating&cooling	Electric motors	Transport	User behaviour	Ventilation	Other	**Grand Total**
Industry	4	2	16	9	9	4	7	3	0	32	46	0	6	5	13	156
Transport	0	0	0	0	0	0	0	0	0	1	0	72	2	0	2	77
Commercial	7	3	33	3	3	7	9	8	4	117	6	1	10	9	21	241
Residential	19	0	12	0	1	8	14	0	6	171	2	0	12	7	11	263
Agriculture & Forestry	0	0	3	0	0	1	2	2	0	22	3	2	1	1	3	40
Fishing	0	0	1	0	0	1	2	0	0	5	0	1	1	1	2	14
Grand Total	30	5	65	12	13	21	34	13	10	348	57	76	32	23	52	

Indicative values	Appliances	ICT/Office eq.	Lighting	Steam&Hot water	Furnaces	RES electricity generation	RES heat generation	Process cooling	Water heating	Space heating&cooling	Electric Motors	Transport	User behaviour	Ventilation	Other	**Grand Total**
Industry	0	2	7	2	3	3	2	2	0	21	32	2	2	3	7	88
Transport	0	0	0	0	0	0	0	0	0	1	0	64	1	0	0	66
Commercial	6	2	28	1	2	7	6	7	3	93	5	1	8	10	18	197
Residential	15	0	8	0	1	7	12	0	5	144	2	0	11	7	9	221
Agriculture & Forestry	0	0	0	1	0	0	0	2	0	16	3	2	0	0	0	24
Fishing	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2
Grand Total	21	4	43	4	6	17	20	11	8	275	42	70	23	20	34	

Table 6: Number of BU methodologies collected per end-use and sector (top) - Overview of available calculation values per end-use and sector (bottom).

The measures in relation to RES electricity generation and RES heat generation can be applied to all sectors (cross-cutting), although these are most prevalent in the residential sector here as well. The different methodologies per RES technology area that could be identified in the catalogues are summarized in the BOX.

Box: List of identified RES generation measures cross-cutting all sectors

- Measures driving the use of renewable heat in all sectors: solar thermal for domestic hot water in buildings, space heating/cooling systems using solar energy, central active solar water heating systems using solar energy, solar swimming pool water heating systems, heat pump with ground heat exchanger for space heating and cooling.
- Measures promoting RES electricity generation: installation of cogeneration; photovoltaic modules (panels) for own consumption (auto production) and also net-metering schemes, in industry and in buildings (applicable to all sub-sectors); installation of solar energy receivers (Solar thermal and PV). In total, 10 RES electricity generation measures were found in, which have also been the subject of research in the multEE project.

3.2.1 Industrial sector

There are in total 156 BU methodologies from 12 Member States (AT, BG, CY, ES, FR, GR, HR, IR, IT, LU, PT, SI) available for the industrial sector. 88 of those methodologies feature calculation indicative values. Regarding end-uses, similar technologies are covered in different countries. Some MS indicate they have replicated the methodologies from their neighboring countries, if these are well developed, or adopted the same methodologies from most experienced countries.

To better identify the gaps, it is important to understand where final energy is being used. Figure 6 presents the final energy consumption per end-use for the industrial sector (2019), so the availability of methodologies can be checked for the end-uses with the highest impact on the final energy consumption. As mentioned, the disaggregation by energy carrier is limited to two types, Electricity and Other Energy, given streamSAVE's scope.

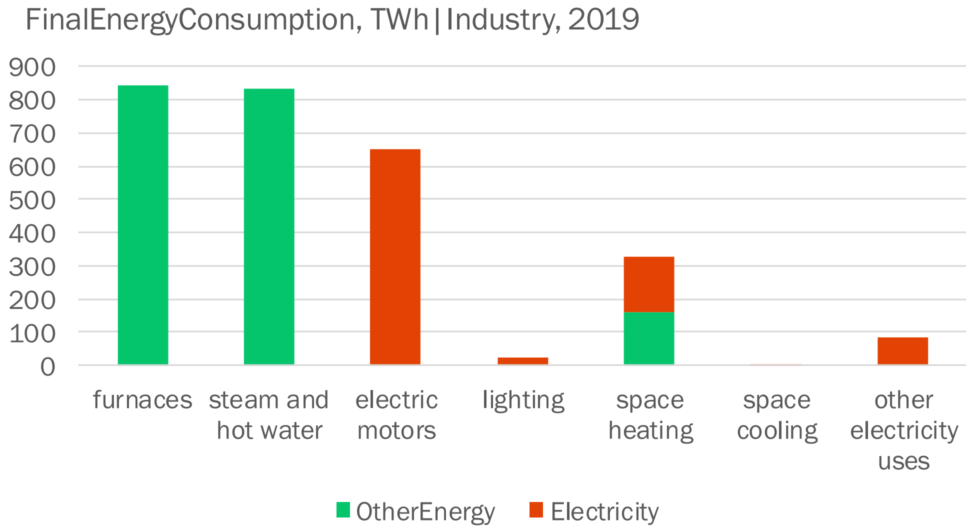

Figure 6: Final energy consumption for industry by energy carrier and end-use (De Almeida, 2017; Economidou, 2020; EC DGE, 2016; Eurostat EB, 2021; Elizarov, 2020; Fleiter, 2017, 2018; MotorStudy, 2016 ; Toleikyte, 2021; Tsemekidi, 2018).

The different methodologies per application area that could be identified in the catalogues are summarized in the BOX.

Box: List of BU methodologies identified for industry per end-use type

Methodologies for the following industrial application areas have been identified:

- Methodology for estimating energy savings when installing a suitable burner and waste heat recovery system in industrial furnaces; appliances for the production of heat and cold.
- Installation of an economizer and condensing economizer for industrial boilers; Increasing the evaporator temperature; Decreasing the condenser temperature; Utilization of excess heat, steam plant and condensate collection and distribution network; refrigeration systems.
- Renew/replacement of motors and VSDs by higher energy efficiency class motors and drives (IE2, premium class IE3, IE4 class asynchronous motors); installation of VSDs in induction motors; resizing of rotational electrical motors; ; installing a frequency converter (inverter) for regulating the speed of electric motors of air compressors above 11kW rated power, in ventilation systems, for flow control in pump systems with power over 20 kW; Reduction of compressed air leaks; Reduction of compressed air pressure; energy savings when using compressors with external cold air supply; reduced compressed air inlet temperature; utilization of waste heat in compressed air systems; heat recovery from a compressed air system; replacement of the regulation of a circulation pump by a speed variator; reduction of the operating time of a circulation pumps; High efficiency refrigeration condensing system, Permanent magnet or reluctance synchronous motor-drive, Low pressure screw or centrifugal air compressor; Adsorption compressed air dryer using heat input for regeneration, Efficient transmission system, Fully electric or hybrid injection moulding machine; Electronic control system for an electric motor with energy recovery, Motor-regulated system.
- Efficient lighting in non-residential buildings, in industrial buildings, in buildings of the tertiary and industrial sectors, new lighting system in the commercial and industrial sectors. Non-directional lamp and Directional lamp of energy efficiency class A or better, Installation of a motion detector, Installation of a timer, Skylights and Natural lighting pipes. Technical guide on lighting energy efficiency – behaviour measure for offices in industrial buildings.
- Space heating and space cooling was not broken down in the methodologies collected and were presented together. However, most measures target heating of industrial buildings and just four measures target space cooling. Measures identified are related with: Efficient decentralized heating; circulation pumps for heating; Optimization of the heating system in buildings with several individual parts, insulation of hot water tanks, central compression refrigeration units, central compression installation and refurbishment of control switch cooling in industry, cooling system, district cooling; ventilation and air conditioning; Free cooling by cooling water replacing a cold unit; Systems for heat recovery in buildings; ventilation systems with heat recovery; thermally improved building envelope of newly constructed non-residential buildings and of existing non-residential buildings, thermal improvement of single building elements; Complete renovation of the heating station; Renovation of the distribution network of the district heating system; Connection of the building to the district heating system; Replacement of electric heating system with central heating with efficient hot water boilers.

3.2.2 Commercial sector

There are in total 241 BU methodologies available that apply to the commercial sector, from 13 countries (AT, BG, CY, DK, ES, FR, GR, HR, IR, IT, LU, PT, SI). 197 of those methodologies feature calculation indicative values. 197 of those methodologies feature calculation indicative values. Regarding end-uses, like in the industrial sector, similar technologies are used in the different countries. Some MS indicated they have replicated the methodologies from their neighbouring countries, when methodologies are well developed, or adopted the same methodologies from most experienced countries.

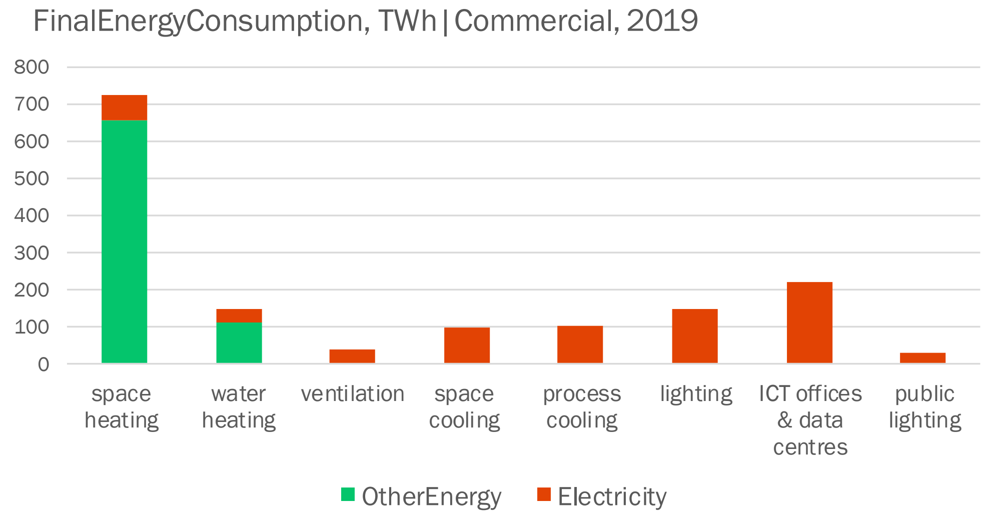

Figure 7: Final energy consumption for the commercial sector, by energy carrier and by end-use (Economidou, 2020; EC DGE, 2016; Eurostat Energy Balances, 2021; Elizarov, 2020; Fleiter, 2017; Toleikyte, 2021; Tsemekidi, 2018).

Figure 7 presents the final energy consumption per end-use for the commercial sector (2019), so the availability of methodologies can be checked for the end-uses with the highest impact on the final energy consumption. The different methodologies per application area that could be identified in the catalogues are summarized in the BOX.

Box: List of BU methodologies identified for commercial sector per end-use type

Methodologies from the following application areas have been identified:

- Central heating, retrofitting of non-residential buildings, Air conditioning units < 12 kW for non-residential buildings, replacing non-functioning condensing pots or installing new ones, installation of systems for automation and control of heating, installing heat recovery systems before entering cooling towers, MEPS, upgrade of the existing heating systems with high-efficient ones….
- Methodology used to calculate savings from the solar water heaters replacement scheme, installation of heat pumps for domestic water in non-retrofitted buildings and water saving fittings.
- Modernisation of ventilation systems, ventilation of elevator shafts, Installation of controlled mechanical ventilation system with heat recovery, High efficiency fan and Reduction of the operating time of a ventilation system.
- Methodology for estimating energy savings when installing free cooling systems with natural source, ventilation and energy efficient air-conditioning systems; energy efficient cooling systems; Room air conditioner < 12 kW cooling capacity, district cooling, Improved cooling; Free cooling and energy recovery (from air conditioning) energy savings.
- Central compression refrigeration units, Central compression cooling system and industrial refrigeration.
- Methodologies for lighting mainly address the replacement of old inefficient lamps for LEDs, for non-directional lamps and directional lamps of A efficiency class or better, the installation of sensors for lighting control, like occupancy sensors and timers. The improvement of the overall lighting system is not often addressed and among 33 different BU methodologies

collected for lighting, only two methodologies mention the lighting systems: renovation of outdoor lighting systems and new lighting system in the commercial and industrial sector. The methodologies address efficient lighting in office buildings, in non-residential buildings, like hotels and restaurants, replacing incandescent lamps at traffic lights with LED lamps, compact fluorescent lamps campaign, installation of sensors for lighting control. Then, there are technical guides promoting energy-efficient lighting for offices, hospitals and educational centres.

- New office appliances and office equipment.
- Energy Efficient street lighting.

3.2.3 Residential sector

The residential sector is the sector where more methodologies exist: in total, there are 263 different methodologies from 14 countries (AT, BG, CY, DK, ES, FR, GR, HR, IR, IT, LU, PT, SI, UK); 221 of those methodologies feature calculation indicative values. Figure 8 presents the final energy consumption per end-use for the residential sector (2019).

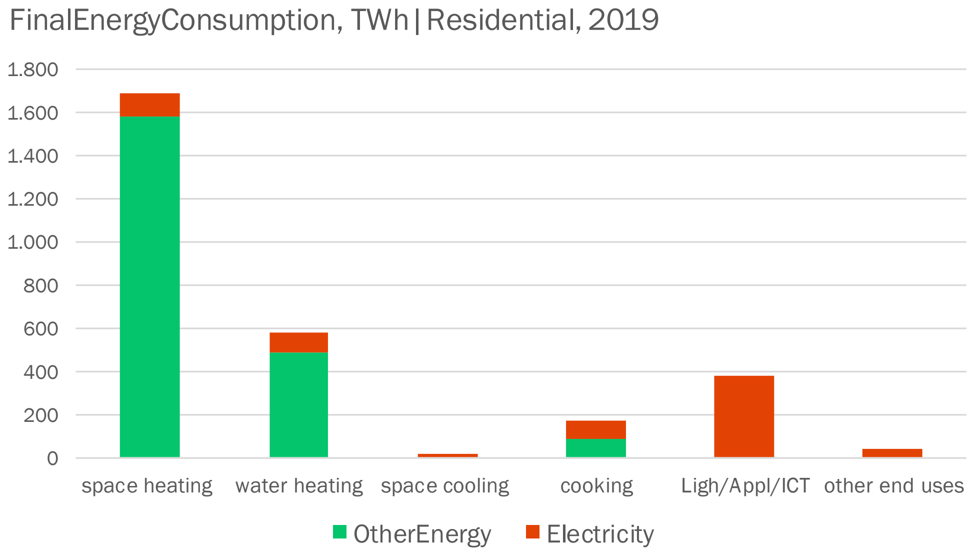

Figure 8: Final energy consumption for the residential sector, by energy carrier and by end-use (Economidou, 2020; EC DGE, 2016; Eurostat EB, Eurostat Households, 2021).

Measures target mainly: a) technologies (heating system and components, mainly space heating, but also hot water production), b) switch of energy carriers and c) construction works (retrofitting). The different methodologies per technology area that could be identified in the catalogues are summarized in the BOX.

Box: List of BU methodologies identified for residential sector per end-use type

Main BU methodologies include the following technologies:

- Central heating in non-retrofitted residential buildings; district heating in non-retrofitted residential buildings and new constructions, including fuel change; replacing existing hot water installations with new and completely isolated for new customers of district heating companies; ventilation systems with heat recovery; installing cooling systems with a natural source.
- Condensing boilers, high-efficiency gas boilers, reflective radiator panels, etc. for dwellings in non-retrofitted residential buildings; condensing boilers and heat pumps for dwellings in newly built residential buildings; replacing a boiler with electric heat pumps air / air, water to air for

heating in newly built or renovated buildings; soil-water heat pumps; installing an absorption heat pump with a nominal power higher than 400 KW for heating and hot water production; Insulation of heating pipes, Insulation of hot water tanks, insulating material between radiators and walls, circulation pumps for heating, Retrofitting of single building components, thermostatic valves, regulating solar radiation through glazed walls during summer cooling.

- Replacement of hot water boilers with new higher efficient ones; heat pumps for domestic water in non-retrofitted buildings; electric heat pump with a system for production of hot water for domestic use in existing installations; solar water heaters to replace old systems; Clock control of circulation pump for domestic hot water (2 types of values); Water-saving fittings.
- Efficient lighting in residential buildings; New lighting system in households; Non-directional lamp of energy efficiency class A or better; Directional lamp of energy efficiency class A or better; Compact fluorescent lamps campaign; sensors for lighting control; Technical guides on lighting energy efficiency – offices.
- Highly efficient white goods (purchase and early replacement), New household appliances (eco-design)-refrigerators, freezers, dishwasher, washing machines, tumble dryer, Replacement of electric heater for domestic hot water; Stand-by reduction in households (stand-by killer).

3.2.4 Transport

The sector of transport raised more interest during the stakeholder's consultation, in all Member States (streamSAVE D4.1, 2021). Stakeholders indicated electric vehicles (EVs) and related infrastructure as the areas they would like streamSAVE to focus. The collection of BU methodologies and indicative values, identified 77 BU methodologies in the transport sector across 13 MS (AT, BG, CY, DK, FR, GR, HR, IR, IT, LU, PT, SI, SP), and 66 indicative calculation values. Concerning end-uses, 56 methodologies out of 77 apply to road transport and only five apply to rail (incl. two measures on energy management systems), a similar distribution as the sectoral split of the final energy consumption (Figure 9).

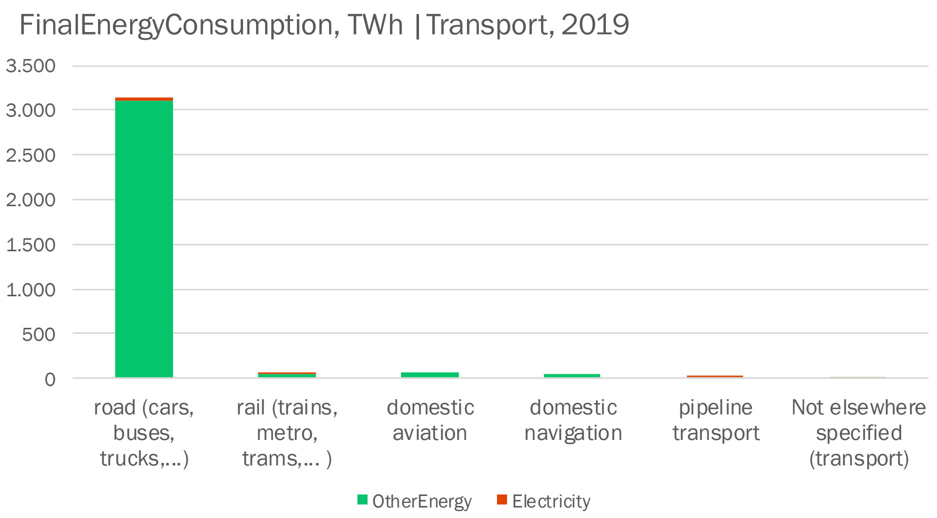

Figure 9: Final energy consumption for transport, by energy carrier and by end-use (Eurostat Energy Balances, 2021).

The different methodologies that could be identified in the catalogues are summarized in the BOX.

Box: List of BU methodologies identified for transport sector per end-use type

Methodologies from the following application areas have been identified:

- Methodologies address the alternative vehicle technologies, mainly incentives for EVs, replacement or new cars in all sectors (cars, vans, buses and trucks) as well as rechargeable hybrid cars and Eco-fleets.
- There are also behavioural measures such as: fuel saving App, fuel-saving training programmes, eco-driving, tyre pressure monitoring for passenger cars and trucks, etc, and measures addressing modal shift, like electric bikes and carpooling for companies.
- Measures using fuel additives in the fuels of internal combustion engines, installation of higher energy class tires, with low coefficient of resistance in case of contact of vehicles with the road surface for heavy freight vehicles, for light delivery vehicles and in passenger cars with an internal combustion engine. LPG in the transport sector is being promoted in Greece.
- A methodology used to calculate savings for vehicle scrapping scheme is available in Cyprus, and a roadmap to decarbonise European cars in Spain.
- Measures for the subsector of rail include railway motorway wagon, intermodal transport unit for combined rail-road and modal shifts in passenger transport.

3.2.5 Agriculture, Forestry and Fishing

Measures that can be specifically applied to the sectors of Agriculture, Forestry and Fishing are only found in France and Denmark (e.g. replacement of tractors). However, several methodologies are identified that are cross-cutting all sectors and can therefore be applied to the sectors of Agriculture, Forestry & Fishing as well. In total, the catalogues' collection identified 54 possible BU methodologies that are eligible for application in these sectors, and 26 indicative values in five MS (AT, DK, FR, HR, SI). However, looking to the end-uses, most of the measures relate to space heating and cooling, lighting, behavioural measures and renewable heat generation, which coincide with measures from other sectors.

3.3 Gap analysis of bottom-up methodologies

After providing an overview of existing practices in terms of BU calculation methodologies within MS, the project tries to identify existing gaps. The purpose of this gap analysis is to provide background and basis for developing new calculation methodologies under the implementation of the EED. The *gap analysis is about identifying sectors and end-uses which are not yet well reflected in the existing catalogues or recent and ongoing projects.* As the analysis focuses on the gaps in BU energy savings calculation methodologies that MS face when preparing energy efficiency plans or evaluating EE measures in the scope of EED, it can support MS in developing EE actions in those *areas where there are more needs and where the savings potential is higher* to ensure their achievement of reduction targets. Next to that, the assessment of sectoral coverage supports the streamSAVE consortium in identifying a new set of Priority Actions to be analyzed in the second round.

As explained in Section 1.2, 14 end-use categories were selected covering all sectors, as presented in the table below. This mapping of sectors and end-use types in need for BU methodologies was carried out by comparing all identified existing methodologies from the catalogues, with the *simplified energy balances, as estimated at sectoral and end-use level*.

End-use category	
Household appliances	Household appliances like white goods, consumer electronics
IT systems	ICT and office equipment
Lighting	Reduction of energy demand by lighting
Process Heat (> 200 °C),	High-temperature process heat, furnaces
Process Heat (< 200 °C), Steam&Hot Water	Low-temperature process heat, steam&hot water
RES electricity generation	Electricity generation from renewable sources
RES heat generation	Heat generation from renewable sources
Process cooling	Includes central compression refrigeration units, industrial refrigeration, compression cooling
Domestic hot water	Includes boilers, insulation pipes, etc.
Space Heating & Cooling	Includes building envelope (new construction & retrofitting), changes in heating systems)
Stationary Engines	Electric motors, pumps, fans, compressors, compressed air, etc.
Transport	Includes vehicles, changes in modal shift, changes in fuel, on-site transport like conveyor bands, etc.
User behaviour	Cross-cutting changes in behaviour (e.g. energy advice for households in general)
Ventilation	Adaption of ventilation systems
Others	

Table 7: List of end-use categories for the categorization of BU methodologies in the gap analysis.

In general, the review of existing methodologies shows that there is considerable experience in estimating various types of energy efficiency improvement measures in all sectors, targeting different end-uses (see Section 3.2).

As mentioned, the methodological approaches for quantifying energy savings exist for individual actions and the equations being used are similar among countries. The equations apply mostly for energy savings calculations under Article 7. Indicative values are available for most identified methodologies, such as lifetime and hours of operation, in contrast to correction factors for behavioral effects. Cost-effectiveness analysis of the actions is not a regular practice although it's critical for the appraisal of measures according to the stakeholders' consultation (streamSAVE D4.1, 2021). In the following paragraphs, the gap analysis is further explained for each sector separately. Hereto, the assessment of gaps started from comparing following indicators at sectoral level: a) the share of each end-use type in final energy consumption (simplified energy balances); b) the number of methodologies per country (presented by its median) as well c) the number of countries having methodologies covering the different end-uses.

3.3.1 Industrial Sector

In the next Figure, we present the share of FEC and the median number of bottom-up methodologies in a country for its main end uses, for the sector of industry. It also lists the countries where the methodologies are available.

INDUSTRY: Main end-uses	%sector	FEC: TWh	Share end-use in FEC of sector	Total n° BU	Median n° BU	n° Countries	Countries|Projects
Furnaces	30,4	842,2	30,4%	9	2	4	BG,FR, IR, IT
Steam & hot water	30,1	833,9	30,1%	9	2	4	FR, LU, PT, SI
Electric motors	23,3	653	23,6%	46	3	8	AT, BG, HR, FR, IR, LU, PT, SI, EMEEES, multEE
Lighting	0,9	24,9	0,9%	16	1	9	AT, ES, HR, FR, GR, IR, LU, PT, SI, EMEEES
Space heating	11,8	325	11,7%	32	5	5	AT, FR, IR, PT, SI, multEE
Space cooling	0,3	5,5	0,2%				
Other electricity uses	3,1	85,9	3,1%	13	1	5	CY, GR, HR, LU, SI, EMEEEs
TOTAL		2770,4					

Table 8: Breakdown of final energy consumption and the median number of BU methodologies by end-uses for the industrial sector.

Taking into consideration the best available energy consumption breakdown for industry (presented in Section 3.2.1 and in Table 8), it can be concluded that furnaces (Process Heat > 200 °C) and steam & hot water (Process Heat < 200 °C), which represent 60% (around 30% each) of the total final energy consumption, are the main existing gaps in this sector. Only 9 methodologies have been identified for each in four different countries, and not all methodologies provide indicative values. This evidence can be linked to the main stakeholders' concerns regarding their need to develop savings methodologies related to heat recovery, considering the complexity and variety of heat recovery technologies (streamSAVE D4.1, 2021). Moreover, methodologies for calculating energy savings generated by the excess heat from industry, especially in cases where excess heat is distributed "in house" and to district heating, are also imposing methodological challenges towards MS.

When a methodology was available, it was eligible to be applied in all industrial sub-sectors, without indicating specific parameters per subsector.

3.3.2 Commercial sector

The commercial or services sector is about buildings, which account for a significant share of final energy consumption in Europe, particularly for space heating purposes. However, buildings are transversal to commercial, residential and also industrial sectors. Nevertheless, as shown in Table 9, the breakdown of energy consumption in the commercial sector clearly identifies space heating as the main end-use in this sector, representing 48% of the total final energy consumption. ICT in offices and data centres and water heating are having the second-largest share, representing 14,6% and 9,9% in total FEC, respectively.

COMMERCIAL: Main end-uses	%	FEC: TWh	Share end-use in FEC of sector	Total n° BU	Median n° BU	n° Countries	Countries|Projects
space heating	48,2	723,4	48,2%	118	9	12	AT, BG, HR, CY, DK, FR, GR, IR, LU, PT, ES, SI, multEE
water heating	9,9	148,7	9,9%	4	1	3	AT, CY, FR
ventilation	2,4	36,5	2,4%	9	3	3	AT, FR, LU
space cooling	6,3	95,0	6,3%	14	1	8	AT, BG, DK, FR, HR, GR, IR, ES, multEE
process cooling	6,8	102,3	6,8%	8	1	3	AT, IR, FR, multEE
lighting	9,7	146,1	9,7%	33	2	11	AT, BG, HR, CY, FR, GR, IR, LU, PT, ES, SI, multEE
ICT in offices and data centres	14,6	219,2	14,6%	3	1	2	HR, GR, multEE
public lighting	1,9	29,2	1,9%	3	1	3	AT, FR, GR, multEE
TOTAL		1500,4					

Table 9: Breakdown of final energy consumption and the median number of BU methodologies by end-uses for the commercial sector.

Space heating has been the main target of climate and energy policy within Member States so considerable efforts are made in improving energy performance of buildings under the scope of EPBD with multiple actions ranging from renovation works to renewables integration. However, *less methodological guidance* has been given regarding *water heating*, with only four methodologies being identified in three countries, and *ICT in offices and data centres* with three measures in two countries.

Table 9 also indicates that methodologies are needed for *public lighting*, as only three methodologies have been collected from three countries. Moreover, the need for streamlined energy savings calculation methodologies for BEMS&BACS was widely acknowledged by stakeholders (streamSAVE D4.1, 2021).

3.3.3 Residential sector

Table 10 presents the share of FEC and the median number of bottom-up methodologies across countries for the main end uses in the residential sector, as well as a list of countries where the methodologies are publicly available.

RESIDENTIAL: Main end-uses	%	FEC: TWh	Share end-use in FEC of sector	Total n° BU	Median n° BU	n° Countries	Countries|Projects
Space heating	52,27881	1688,9	59,0%	170	8	13	AT, BG, CY, DK, ES, FR, GR, HR, IR, LU, PT, UK, SI, multEE
Water heating	26,8848	579,1	20,2%	6	1	5	AT, BG, CY, DK, SI
Space cooling	0,443373	12,7	0,4%	8	1	5	BG, DK, ES, HR, GR, multEE
Cooking	2,85729	166,5	5,8%		-		
Lighting		75,2	2,6%	12	1	9	AT, BG, CY, ES, FR, GR, HR, LU, PT, multEE
Appliances		206,9	7,2%	19	2	9	AT, BG, CY, FR, GR, HR, LU, PT, SI, multEE
ICT		94,0	3,3%	0	-		
Other end uses	1,453277	41,6	1,5%	11	1	4	HR, GR, SI, SL
TOTAL		2864,9					

Table 10: Breakdown of final energy consumption and median number of BU methodologies by end-uses for the residential sector.

Space heating, especially based on fossil fuels, holds by far the highest share of final energy consumption in the residential sector, making up 59% of the total residential energy consumption. It is followed by water heating with a 20% share, and then appliances, lighting and ICT, together representing 13% of the total final energy consumption. While MS have been sensible to the heating burden by preparing several calculation methodologies in this area, *water heating and cooking are less covered* with only 6 methodologies identified in five MS for water heating, and no methodology for cooking. However, it needs to be noted that for many residential buildings, space heating and hot water are performed by one boiler, so above-mentioned methodologies might cover both end-uses. *No methodologies for ICT* were identified. Furthermore, *space cooling lacks attention* from MS (8 methodologies in total), although it is a load that is rising due to climate change (temperature rise) and increasing standards of living.

3.3.4 Transport, Agriculture and Fishing

Apart from RES electricity generation and RES space heating & cooling, *methodologies targeting energy efficiency improvements in the Agricultural sector have not been widely identified*: two methodologies for process cooling, one for tractors and one for ventilation. Moreover, the RES electricity generation and RES heat generation measures are identified for the other sectors as well. Therefore, given its importance in terms of emissions reductions, the sectors of Agriculture, Forestry and Fishing may deserve more attention, for instance, under the scope of the Priority Actions EVs and refrigeration.

TRANSPORT: Main end-uses	%	FEC: TWh	Share end-use in FEC of sector	Total n° BU	Median n° BU	n° Countries	Countries|Projects
road (cars, buses, trucks,...)	93,41097	3143,9	93,4%	56	2	13	AT, BG, CY, DK, ES, FR, GR, HR, IR, IT, LU, PT, SI, multEE
rail (trains, metro, trams,...)	1,824614	61,4	1,8%	5	1	1	FR, multEE
domestic aviation	2,289419	77,1	2,3%	2	1		multEE
domestic navigation	1,446752	48,7	1,4%	9	1	1	FR, multEE
pipeline transport	0,709766	23,9	0,7%	5	1	4	AT, FR, HR
Not elsewhere specified	0,318476	10,7	0,3%				
TOTAL		3365,7					

OTHERS: Main end-uses	%	FEC: TWh	Share end-use in FEC of sector	Total n° BU	Median n° BU	n° Countries	Countries|Projects
Agriculture & Forestry	85,41289	324,3	85,4%	40	1	5	AT, DK, FR, HR, SI, multEE
Fishing	4,211972	16	3,5%	14	1	3	AT, FR, HR
not elsewhere specified	10,37514	39,4	3,5%				
TOTAL		379,70					

Table 11: Breakdown of final energy consumption and the median number of BU methodologies by end-uses for the transport sector (top) and for agriculture, forestry & fishing (bottom).

As the transport sector accounts for a significant share of final energy consumption (Section 3.1) and has a high potential for achieving savings, it is considered a very important sector to be addressed in all countries. Moreover, it is a strategic sector for decarbonization, and it has not been widely addressed in previous EED reporting periods (Bere, 2020; EC COM(2020)564, 2020; Economidou, 2020; Tsemekidi, 2018). However, even though there are already 77 BU methodologies, with a median of 2 per country, and 24 indicative values identified in 13 MS, this sector raises several challenges that urge to be tackled when preparing BU deemed savings methodologies: how to collect data about energy consumption from private electric vehicles which charge energy from private stations or stations without accounting; baseline definition; indicative values taking into account additionality and double counting; free riders; the persistence of savings; data sources for imports and exports, etc. Another important challenge is related to the modal shift of private cars towards cycling, walking and collective transport, car sharing and other smart transport services and behavioural aspects of sustainable transition in transport, as not many methodologies calculating savings of these measures are yet developed, in contrast to their significant impact for reaching the overall target.

Chapter 4 Conclusion

The purpose of this report is to review existing experiences on BU savings methodologies in European countries, as well as to draw and discuss conclusions that can guide the development of new or improved deemed savings methodologies and identify further Priority Actions for the Capacity Support Facility of streamSAVE.

In total, it was possible to identify **16 catalogues with bottom-up calculation methodologies, from 14 different countries** (Austria, Bulgaria, Croatia, Cyprus, Denmark, France, Greece, Italy, Ireland, Luxembourg, Portugal, Slovenia, Spain and United Kingdom) and two research projects (multEE, 2016; EMEEES, 2009), and **a total of 582 different methodologies with application in various activity sectors, covering a wide range of technologies and end-uses.** Sometimes, catalogues are not explaining well the methodological details without any indication about existing calculation parameters or assumptions.

For the Priority Actions, the **methodologies for quantifying energy savings are similar across countries** in terms of formulas being used. The main challenge during implementation of these methodologies lies within the availability of data, which has a direct impact on the baseline definition and the estimation of lifetime savings. Data collection was indeed reported as the main challenge by the streamSAVE stakeholders (streamSAVE D4.1, 2021): high administrative burden, requiring large administrative resources, and consistent data collection processes to avoid misalignments with the requirements of the Directive.

According to the online survey (streamSAVE D4.1, 2021), studies on the cost-effectiveness of energy savings actions are available in 14 EU countries with diverse degrees of experience (Czechia, France, Germany, Greece, Hungary, Ireland, Italy, Lithuania, The Netherlands, Poland, Portugal, Slovenia, Spain and Sweden). However, the research carried out for this report, concluded that **cost-effectiveness analysis is not widely publicly available.** Nevertheless, cost-effectiveness analysis can be sometimes a merit order list of different actions that can be used to guide obligated parties. In countries where white certificates schemes are implemented, like France and Italy, cost-effectiveness analysis is more consistently implemented (Certificats, 2020; Santini, 2020; Rosenow, 2017).

Based on the identified catalogues and guidelines containing bottom-up calculation methodologies within Member States, the **main methodologies aligned with the Priority Actions were characterized. Indicative values are available for most Priority Actions, in contrast to correction factors for behavioral effects.** The methodologies for heat recovery either compare the final energy consumption before the installation of a heat recovery system to the final energy consumption afterwards, or multiply the installed power and operating time or final energy consumption with a savings factor or percentage of heat recovered. For BEMS/BACS in some cases the so-called BACS factor method is applied; other countries use more technology-specific approaches. For industrial or commercial refrigeration, the methodologies determine the savings of centralized systems by means of the efficiency ratio of the before and after situation (ESEER of old and new cooling unit) and the cooling load (based on power and operation hours). Concerning alternative vehicle technologies, the savings estimation is usually based on the number of purchased vehicles, the difference of energy consumption between a reference and efficient vehicles, and the yearly mileage. Similarly, the number of lighting points/lamps, the difference between the power of both technologies (inefficient and efficient) and the total annual operating hours are factors included in the calculation methodologies of lighting measures.

From the collection of different methodologies across all sectors and end-uses, we can learn that space heating in buildings, particularly residential and commercial buildings, are well covered by the catalogues. In terms of sectors, **Agriculture, Forestry & Fishing, next to Transport are less represented** in catalogues. The main **methodological gaps apply to the end-use categories of industrial process heat & cooling, ICT in offices and data centers, space cooling, water heating, cooking and public lighting**, as these are not yet well covered by existing calculation guidelines. The identified gaps correspond with the main sectoral areas where support towards Member States in developing energy efficiency actions can improve the achievement of their reduction targets.

To increase a higher implementation and understanding of savings estimations, the preparation of new calculation methodologies needs to involve different type of stakeholders (e.g. technical experts, obligated parties, market actors, advocacy groups) and the methodologies must evolve and be adapted to the measures and contexts at hand (streamSAVE D4.1, 2021). This will not only benefit the (cost-effective) implementation of the Directive, but also provide a basis for future and surely more ambitious energy efficiency policy efforts.

Annex I – List of measures identified in available catalogues

See the Excel (streamSAVE_List_BU_Methodologies.xlsx) listing all measures identified in the table of contents of available catalogues in EU27 + UK.

GA N°890147

Annex II - Translation of methodologies of first round of Priority Actions

See Annex II report including the translation of methodologies under the scope of first round of Priority Actions:

- Heat recovery (district heating and excess heat from industry)
- Building Energy Management System (BEMS) and Building Automation and Control Systems (BACS)
- Commercial and Industrial Refrigeration System (C&I Refrigeration)
- Electric Vehicles (private & public) and related infrastructure (charging stations)
- Lighting Systems and public lighting

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