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Evaluation and Monitoring for the EU Directive on Energy End-Use Efficiency and Energy Services

General bottom-up data collection, monitoring, and calculation methods

- Final report -

Harry Vreuls
Stefan Thomas
Jean-Sébastien Broc

SenterNovem
Wuppertal Institute
ARMINES

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The Project in brief

The objective of this project is to assist the European Commission in developing harmonised evaluation methods. It aims to design methods to evaluate the measures implemented to achieve the 9% energy savings target set out in the EU Directive (2006/32/EC) (ESD) on energy end-use efficiency and energy services. The assistance by the project and its partners is delivered through practical advice, technical support and results. It includes the development of concrete methods for the evaluation of single programmes, services and measures (mostly bottom-up), as well as schemes for monitoring the overall impact of all measures implemented in a Member State (combination of bottom-up and top-down).

Consortium

The project is co-ordinated by the Wuppertal Institute. The 21 project partners are:

Project Partner	Country
Wuppertal Institute for Climate, Environment and Energy (WI)	DE
Agence de l'Environnement et de la Maitrise de l'Energie (ADEME)	FR
SenterNovem	NL
Energy research Centre of the Netherlands (ECN)	NL
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Fraunhofer-Institut für System- und Innovationsforschung (FhG-ISI)	DE
SRC International A/S (SRCI)	DK
Politecnico di Milano, Dipartimento di Energetica, eERG	IT
AGH University of Science and Technology (AGH-UST)	PL
Österreichische Energieagentur – Austrian Energy Agency (A.E.A.)	AT
Ekodoma	LV
Istituto di Studi per l'Integrazione dei Sistemi (ISIS)	IT
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Electricité de France (EdF)	FR
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Department for Environment, Food and Rural Affairs (DEFRA)	UK
ISR – University of Coimbra (ISR-UC)	PT
DONG Energy	DK
Centre for Renewable Energy Sources (CRES)	GR

Contact

Dr. Stefan Thomas, Dr. Ralf Schüle
Wuppertal Institute
for Climate, Environment and Energy
Döppersberg 19
42103 Wuppertal, Germany

Tel.: +49 (0)202-2492-110
Fax.: +49 (0)202-2492-250
Email: info@evaluate-energy-savings.eu
URL: www.evaluate-energy-savings.eu
www.wupperinst.org

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– DRAFT final report –

Harry Vreuls, SenterNovem
Stefan Thomas, Wuppertal Institute
Jean-Sébastien Broc, Armines

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1 Introduction

The objective of the **EMEEES** project is to assist the European Commission in the elaboration of **methods for monitoring and evaluation of the energy savings** achieved by the Member States (MS) in the framework of the EU Directive on energy end-use efficiency and energy services (ESD). This assistance includes the development of concrete methods for cost-effective bottom-up calculations to be used for harmonised reporting by the MS.

This paper presents the general approach for the bottom-up calculation methods, based on the work in the EMEEES project including a number of case applications for appliances (e.g. white goods, office equipment), systems (e.g. renovation of buildings) or policies, programmes, and energy services (e.g. energy audits).

A harmonised model of bottom-up calculation methods should be developed for the ESD reporting. Harmonisation should give a reasonable freedom for the MS, while the results reported can be compared. Therefore, the methods and the 20 case applications developed by the EMEEES project are a starting point, but by no means excluding the use of own methods and further methods for other sectors, end uses, and kinds of energy services and energy efficiency improvement measures by the MS. However, harmonisation should be ensured by key elements covered in this report: a general structure for documentation of bottom-up energy savings and the calculation, the selection of baseline and baseline parameters as well as correction factors, and a dynamic approach to ensure improvement over time. These must also be consistent with the top-down methods that constitute the other type of methods that can be used for calculating ESD energy savings. The development of this harmonised model is a learning process, and the methods should be improved in the future as more experiences for MS will become available and lessons can be learned.

Bottom-up evaluation entails a cost. This is one reason for EMEEES to propose a pragmatic three-level approach with increasing accuracy but also increasing cost from level 1 to level 3. However, it should also be noted that bottom-up evaluation will also deliver knowledge on how effective an energy efficiency improvement measure has been in delivering energy savings, and can deliver insights in why it has been effective. It therefore facilitates improvement of measures. And it allows collecting data on implementation costs of all parties involved, which can be compared to the benefits achieved from saving energy.

This summary report starts with presenting the general principles of bottom-up methods, continues with the methods for data collection mentioned in the ESD and elaborates on seven types of bottom-up evaluation methods that the

EMEEES project identified in its analysis, and which make use of the methods for data collection mentioned in the ESD.

The EMEEES project provides detailed information on almost 20 different case applications. This gives a solid basis for **a starting point and a perspective for future development**. One element that will continue to receive attention in further development is the reference situation or 'baseline': unlike energy consumption, energy savings can usually not be directly measured. **Energy savings must be calculated from the difference** between the actual energy consumption after the measure and a reference situation or 'baseline' (which both can be measured or estimated). The question that will be discussed is, which reference situation is relevant in which cases of EEI actions and measures: 'before and after' situation; or 'with and without measures'.

Furthermore, for the simplified approach (level 1) a conservative benchmark for calculation of energy savings is suggested. This is the starting point for more sophisticated approaches some countries now already use, while for others this might be the way to move foreward.

Appendix 1 gives a preliminary overview of the use of data collection and overall evaluation methods in combination with the three levels of evaluation efforts in the case applications of bottom-up methods developed by EMEEES.

Appendix 2 provides general considerations on the baselines that could be applied and includes an overview of the baselines proposed in the case applications.

Appendix 3 gives an overview of terms for more clearly describing the subject of an evaluation method that the EMEEES project developed for use in the project.

Appendix 4 presents two evaluation methods that can be classified either as bottom-up or as top-down methods, depending on the circumstances.

Appendix 5 provides an overview of EU level default values proposed in the case applications of bottom-up methods.

Appendix 6 is a proposal for a checklist for reporting on bottom-up evaluations of the energy savings from an energy efficiency improvement measure.

2 EMEEES – general principles of bottom-up methods

2.1 A harmonised cost-effective evaluation system: why? and how?

The ESD is the first European Directive requiring Member States to report for energy savings. MS already have their own experiences and skills in this field, but it should not be expected that all MS will be able to use up-to-date evaluation methods right away. And the Commission will also have to set up its own evaluation system to comment the National Energy Efficiency Action Plans (NEEAP) reported by the MS. Therefore, the first ESD interim implementation phase (for the second NEEAP, i.e. 2008-2010/11) should be used as a formative process for all stakeholders to issues raised when evaluating energy savings.

One of the main challenges of the ESD methodology requirements for the work of the EMEEES project is to enable the definition of **harmonised** methods. It has to take into account that some countries have a longer history in monitoring and evaluating energy efficiency activities than others. "Harmonised methods" does not mean that the MS already using their own evaluation systems will have to change them. The EMEEES project develops bottom up calculation methods that are to be seen as **general principles for the way to report the results** and as **guidelines** to perform evaluations for MS which may look for support.

MS can use their own monitoring systems, based on their specific needs and experience. But at the end, the principles of calculation and reporting they use for their NEEAP should be harmonised for all MS. In most of the cases, it will be possible to use existing monitoring methods and schemes, but then the results should be processed to fit ESD reporting needs. In some cases, also the monitoring methods and schemes may have to be adapted to collect the data needed for calculating energy savings according to the ESD.

The **harmonisation** covers the following issues:

- using the **same accounting unit** (as defined in ESD Annexes I and II) ;
- using **common basic assumptions**, especially while defining the use of a **baseline** ;
- providing a **minimum set of information**;
- using a **consistent level of evaluation efforts** ;
- a learning and **improvement process** over time.

These general principles are to ensure that the results are reported with a **minimum quality level**, so that results can be considered reliable (in the ESD context).

In addition, the ESD requires its evaluation system to be **cost-effective**. Therefore, the aim is not to provide results with maximum accuracy, but to find a **compromise between evaluation costs and accuracy**. Simplifying assumptions may be used when relevant, and if accuracy is not compromised too much. However, a method can both be cost-effective to use (requiring easy-to-collect data and using easy-to-perform calculation models) and using a sophisticated treatment (based on reference data and underlying assumptions) ensuring a good accuracy level.

The **main principles** of our methodology to reach this double objective of harmonisation and cost-effectiveness are:

- addressing the quantification of energy savings by **breaking down the whole calculation process into four main steps**, in order to deal with the different issues raised one after the other, making the calculation work easier to prepare and more transparent (see section 2.3);
- proposing a **progressive approach** based on **three levels of evaluation efforts**, in which the MS have to comply with minimum requirements but are free (and induced) to go beyond these requirements, **according to their own evaluation practice and objectives** (see section 2.4).

As mentioned above, harmonisation implies minimum requirements so that results can be consistently assessed and compared. However, it does not mean that all MS shall use exactly the same data collection techniques or focus their efforts on the same items. They remain free to choose their strategy both for action and evaluation (principle of subsidiarity). It is therefore necessary to clarify to what level of requirements (‘could, should or shall’) the EMEEES proposals correspond. We hereafter distinguish supporting resources, reporting check-list and general principles, as described in the table below.

Table 1. Three main categories of methodological outcomes.

Supporting Resources	Reporting Checklist	General Principles
Concrete evaluation methods Member-States ***COULD*** use when they are looking for technical support. *(example of provided information: examples of algorithms, formulae, or data commonly used to calculate a baseline for heating systems)*	List of questions Member-States ***SHOULD*** answer in their future NEEAP to get a consistent set of information about how they assessed their energy savings results. *(e.g.: reporting what data were used to calculate the baseline values)*	Harmonised rules Member-States ***SHALL*** apply when evaluating their energy savings results. *(e.g.: update frequency for baselines)*
To be available for all MS (no need for decision)	To be discussed by the ESD Committee (but no need for decision)	To be decided by the European Commission and the ESD Committee
*From **specific** issues…* ►►►		►►► *…To **general** issues*

The **supporting resources** are made available by the Commission to Member States. These materials are mainly developed by Intelligent Energy Europe projects, such as EMEEES, for concrete evaluation methods and pilot tests. Data on average annual energy consumption (for equipment stocks or markets) can also be found in preparatory studies for implementing the EuP (Energy-using Products) Directive (EU, 2005).

When calculating energy savings, a MS can use these resources either as values for a level 1 evaluation, or as examples of guidelines for level 2 or 3 evaluations. As they are not mandatory, they do not require a decision (validation) from the ESD Committee.

The **reporting checklist** is to address issues that do not necessarily need to be harmonised at an EU level, but that are relevant when evaluating energy savings. This checklist is a quality assurance (on data, sources, etc.) that would enable the Commission to well compare data provided by the MS on their achieved energy savings. An example of such a checklist can be found in [Vine and Sathaye, 1999]. The checklist specific to ESD proposed by the EMEEES project will have to be validated by the European Commission and is included in **Appendix 6**.

The checklist does not require MS to apply a given method neither to include all possible issues in their evaluations. But they are asked to report whether they address the listed issues, and how. By pinpointing the main evaluation issues, the aim is to induce better evaluation designs. And by structuring the evaluation reporting, the checklist will also facilitate the collection and analysis of feedback (related to evaluation) for experience sharing between MS.

General principles correspond to the major and priority issues, for which harmonisation is required in order to get a harmonised evaluation system for all MS. Their application will be mandatory, so they require a consensual decision from the ESD Committee and the Commission.

These principles are proposed, e.g., by the ESD Committee's Working Groups. The EMEEES work provided analysis about possible options as inputs for the needed decisions.

2.2 The subject of evaluation

From the definitions provided by the ESD, it is not directly clear what an "energy efficiency improvement (EEI) measure" is, as this is presented in Article 3, Definition (h) as "all actions that normally lead to verifiable and mesurable or estimable energy efficiency improvement". This can be very broad, as Annex III of the ESD, Indicative list of examples of eligible energy efficiency improvement measures, starts with "This Annex provides examples of areas in which energy efficiency improvement programmes and other energy efficiency improvement measures may be developed and implemented in the context of Article 4". Many of these examples of areas are technical, organisational, or behavioural action taken at an end-user's site (or building, equipment, etc.) that improve the energy efficiency of that end-user's facilities or equipment, but some of the examples given are also energy services or policy instruments (as Article 4 and Annex I 1(d) state, The national indicative energy savings target shall: "be reached by way of energy services and other energy efficiency improvement measures").

We therefore make an analytical clarification on terms for more precisely presenting the subject of evaluation in the EMEEES project:

- An **end-use** energy efficiency improvement **action** (end-use (EEI) action) is a technical, organisational or behavioural action taken at an end-user's site (or building, equipment, etc.) that improves the energy efficiency of that end-user's facilities or equipment, and thereby saves energy. It can be a result of a facilitating measure.
- An energy efficiency improvement **facilitating measure** ((EEI) facilitating measure) is an action by an actor that is not the final consumer him-/herself, which supports the final consumer in implementing an end-use action, or implements it for the final consumer. Examples are energy efficiency programmes, energy services or mechanisms.

In Appendix 3, the analytical clarification is introduced with more detail.

2.3 Four steps in the calculation process

The harmonised rules for bottom-up evaluation methods are organised around four steps in the calculation process (see figure 1). These steps and their sub-steps are presented in detail in a separate report (The development process for harmonised bottom-up evaluation methods of energy savings) and are used in each case application.

Figure 1. A four steps calculation process.

Step 1: unitary gross annual energy savings (in kWh/year per participant or unit)
Example: how much energy is saved annually by using an A+ fridge instead of an A fridge?

+ ***number of participants or units***

Step 2: total gross annual energy savings (taking into account the number of participants or units, in kWh/year)
Example: how many A+ fridges were sold (within the EEI programme)?

+ ***double counting, multiplier effect***, *+ other gross-to-net correction factors (e.g., free-rider effect*)*

Step 3: total ESD annual energy savings in the **first year** of the EEI measures (taking into account double counting, multiplier effect, and other gross-to-net correction factors, in kWh/year)
Example: how many A+ fridges are promoted by more than one EEI programme and might be double-counted?

+ ***timing and lifetime (within ESD period)***

Step 4: total ESD energy savings achieved in the year 2016 (in kWh/year, taking account of the timing of the end-use EEI action, and its lifetime)
Example: how many A+ fridges due to the programme are still in use in 2016?

* the free-rider effect will only be relevant, if the aim of the evaluation is to calculate energy savings additional to those that energy consumers, investors, or other market actor would have achieved by themselves anyway, cf. chapter 4.1. This effect is not mentioned in the ESD.

Step 1 → Unitary gross annual energy savings means annual energy savings resulting from a unitary end-use (EEI) action. The **unit of an end-use action** may be:

- either a unit of energy-efficient **equipment** (e.g., a compact fluorescent lamp or an appliance) ;
- or a **participant**'s premises (dwelling, building, company; e.g., a single family home being insulated or a company benefiting from an energy audit programme).

Assessing unitary gross annual energy savings means using a **calculation method** specifying rules for:

- **baseline**: what is the reference case the action has to be compared to? A baseline will always be needed, as energy savings result from a **difference** of energy consumption levels "*before and after implementation of one or more energy efficiency improvement measures*" (see ESD Art.3(d)).
- **normalisation factors**: how to take account of exogenous factors (e.g. climate conditions, growth of production) (see ESD Annex IV (1.2))?
- ***potentially***, for addressing the **direct rebound effect**: Are final users using the energy-efficient technology or building more extensively, since they know these are energy-efficient? This effect is not mentioned in the ESD, but MS may wish to calculate it in order to know, what are the energy savings additional to baseline projections of energy consumption.

Step 2 → Total gross annual energy savings refer to the amount of energy saved as observed/perceived by all the participants/final users taking advantage of the evaluated EEI measures. Assessing total gross energy savings means using an **accounting method**[1], i.e. how the actions/participants are registered/accounted for (e.g. national registries for energy savings certificates or for energy audit participants).

Step 3 → Total ESD annual energy savings refer to the amount of energy saved as surveyed by the European Commission (i.e. from the point of view of ESD implementation), which means taking account of gross-to-net correction factors. These include factors correcting for **double-counting** and **multiplier effects**[2], explicitly mentioned in the ESD Annex IV, in any case. In addition, **free-rider effects** need be taken into account to the extent feasible when accounting for "additional" savings (for the difference between "all" and "additional" savings, see section 4.1 about baseline).

Step 4 → checking whether the evaluated energy savings are still effective in the target year (2016), using **lifetime** values and eventually persistence/retention studies[3].

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1 Accounting for the number of actions/participants **at the EEI measure level** is the specificity of bottom-up evaluations compared to top-down evaluations (see ESD Annex IV(1.1)).

2 The *multiplier* (or spill-over) *effect* enhances the initial effect of EEI measures. According to Annex IV-5 of the ESD the multiplier effect means that "the market will implement a measure automatically without any further involvement from the authorities or agencies referred to in Article 4-4 or any private-sector energy services provider".

The *free-rider effect* regards end-users who make use of facilities or support, provided for by EEI programmes, policies, or energy services, but would have implemented energy-saving actions anyway. This effects is not mentioned in the ESD.

3 These studies look at factors which may reduce the size and/or average lifetime of energy savings (e.g. performance degradation over time). However, it will obviously not be possible to include all

2.4 Three levels of harmonisation

To be as practicable as possible and stimulate continued improvement, the harmonised reporting on bottom-up evaluation is structured on three levels (see figure 2).

Figure 2: Three levels of harmonisation

	Data scale	Main data sources	Data processing and documenting
Level **1**	**European default values**	**existing/available** European regulation, studies and statistics	**Reliability coefficient** according to the data basis for the default value
Level **2**	**National** representative **values**	**up-to-date** national statistics, surveys, samples, registries	requirements = **minimum set of data and justifications** to be reported
Level **3**	**Programme- or Participant-specific**	**specific** monitoring systems, registries, surveys, measurements	requirements to report on the specific data and justifications **in detail** (standard report at least available)

These three levels correspond to the **three main cases** (1, 2, or 3) that may occur when a MS wants to evaluate the energy savings related to a given EEI measure:

1 the MS has only a few data about this measure (e.g. number of participants) and needs other data sources to complete the evaluation: for that case, the proposal is to provide MS with European **default values** (= **level 1** evaluation) ;

2 the MS can evaluate the energy savings by using mainly data available at national level (e.g. national statistics or surveys): for that case, the proposal is to provide MS with **general guidelines** (for ensuring harmonisation at the EU level) (= **level 2** evaluation) ;

3 the MS can evaluate the energy savings by using mainly data specific to the evaluated measure (e.g. registry of participants' data): for that case, the proposal is to provide MS with **detailed guidelines** (for ensuring harmonisation at the EU level), (= **level 3** evaluation).

evaluation issues in the ESD evaluation system from the start. These persistence factors are not considered a priority issue now, but should be considered in a later phase of ESD implementation.

The basic idea behind these three levels is that the more evaluation efforts a Member State makes, the more accurate the results, and so the more rewarded/recognised the results should be by the Commission. This approach is indeed **to induce a progressive improvement** of the values used by the MS, **rewarding their evaluation efforts**. It is also assumed to be a cost-effective way to address the uncertainties related to energy savings evaluations. This approach makes it possible to learn from experience and improve the methods over time.

Features of the proposed three levels are presented hereafter and summarised in Figure 2 above.

- **level 1** = values that every Member State may use

One of the principles of our methodology is that **default values** are to be conservative for two reasons, taking account of the diverse reliability level of the available data[4] and inducing MS to perform their own (level 2 or 3) evaluation studies. The EMEEES proposal is therefore to use different levels of reliability coefficient to multiply the original data for average unitary gross annual energy savings obtained from the sources mentioned in the footnote:

- for "reliable" values (i.e. original value can be assumed to be representative at the European level[5]): 80%;
- for "realistic" values (i.e. based on significant studies, but non-representative, i.e. varying with location in the EU): 50%;
- for "pure estimates" (i.e. based on expert's word or on very few national experiences, or if results depend very much on location or the specific design of the EEI measure evaluated[6]): 25 to 30%.

For each method, the reliability coefficient would be applied once on the European average value defined for the unitary gross annual energy savings (and not for each parameter of the calculation).

For some values of energy saving lifetimes and maybe for a few other parameters (such as average heating degree days for the main climate zones), there could also be **harmonised values**. These would be decided by the European Commission and the ESD Committee, and would have to be used for any evaluation of ESD energy savings for the subject they are valid for.

4 The aim of EMEEES was not to create new data, but to use the best available data and experience (applicable to the European context). According to the data looked for, different situations or data sources were met: representative European study, study involving "only" a few MS, detailed national experience, literature (e.g. scientific journals, IEA reports), experts knowledge and experience. The corresponding data may have quite different reliability level.

5 E.g., the average seasonal energy efficiency of a condensing and a non-condensing boiler

6 Such as energy audit schemes or voluntary agreements

Appendix 5 presents, for which of the 20 EMEEES case applications which kind of default values for unitary gross annual energy savings we were able to propose, and which lifetimes we propose.

- **level 2** = guidelines and minimum requirements to be complied with in all MS methods
  - **distinction between** what the MS "**should**" do (guidelines), and what they "**shall**" do (minimum requirements) ;
  - **level 2 guidelines** = evaluation toolbox (e.g. guidelines for a registry, a participants' survey, a market analysis, a statistical study), which could be built using the components of bottom-up methods developed by the EMEEES project ;
  - **minimum requirements** = thresholds or quality criteria to insure that the performed evaluations are complying with a minimum quality level (and so that their results are at least more reliable than level 1 default values) (e.g. minimum size of samples).

- **level 3** = guidelines and minimum requirements recommended for **special cases**
  - main principles are the same as those of level 2 ;
  - other evaluation tools may be needed (e.g. measurement campaigns, enhanced engineering analysis).

Member States are free to combine different levels in their evaluations. Guidelines are then proposed about when to choose which level:

- **level 1** = default values → a starting point (or a conservative benchmark)
  - default values may be used when this is a cost-effective option or the start of an improvement process for future reporting.
  - the EMEEES project was not to address all possible energy efficiency actions. Consequently, additional default values will be needed. Two main options seem plausible to define new values: using results from the preparatory studies for implementing the EuP Directive[7], or using a standardisation process within the CEN (European Committee for Standardisation)[8].

[7] see http://ec.europa.eu/energy/efficiency/ecodesign/studies_en.htm

[8] The EuP studies would be preferable as these studies will be done anyway, and so this would cause no extra costs. The CEN option may generate extra costs and more risks of lobbying. Moreover, EuP studies are free to download on the Commission website, whereas CEN standards must be purchased. So EuP studies will enable more transparency. Anyway, the decision about rules for

- **level 2** = the usually recommended level
  - aim of the methodology: inducing each MS to have/improve its own evaluation practice/know-how.

- **level 3** = for special cases, to claim for higher results
  - for some parameters, which may **easily be registered** (e.g. number of participants) ;
  - to improve some key parameters by using level 3 on **samples**;
  - in case of **special programme features** (e.g. promotion of a new technology, use of a special policy instrument, targeting of a special market segment, regional measures, participant-specific unitary gross annual energy savings, as it is often the case with energy services).

Conclusions: the above proposal is more a guideline (“should”) than a requirement (“shall”). It could be discussed for future development of the system whether requirements are needed, i.e. special thresholds/conditions making level 2 (or 3) required (and not only advised). More experience should be collected during the years to come, so as to be able to decide on this after the second round of NEEAPs is available (by 2011).

defining default values is up to the ESD Committee and the Commission, and will be discussed in their future meetings.

3 EMEEES methods for data collection (monitoring) and evaluation

The ESD provides in Annex IV(2) a list of methods for data collection (cf. Appendix 1 for full text):

Data and methods based on measurements (Annex IV(2.1))

1. Bills from distribution companies or retailers
2. Energy sales data
3. Equipment and appliance sales data
4. End-use load data

Data and methods based on estimates (Annex IV(2.2))

5. Simple engineering estimated data, Non-inspection
6. Enhanced engineering estimated data, Inspection

These methods correspond to the step 1 (unitary gross annual energy savings) of the EMEEES 4-steps calculation process. However, due to experience from many evaluations and other evaluation guidebooks, EMEEES decided to both regroup and differentiate these methods further (cf. chapter 3.3).

Step 1 holds six substeps:

- Step 1.1: formula for unitary gross annual energy savings
- Step 1.2: baseline issues
- Step 1.3: normalisation factors
- Step 1.4: selection of the calculation methods
- Step 1.5: conversion factors
- (Step 1.6: rebound effect)

Step 1.1 and 1.4 are linked to each other, but the final choice of the calcultion method can only be made after steps 1.1 to 1.3.

In this section we are dealing with steps 1.1, 1.3 and 1.4. The baseline issues (step 1.2) will be discussed in chapter 4.

3.1 Unitary gross annual energy savings (step 1.1)

In this step 1.1, two approaches according to data availability are presented.

1 when energy consumption data are **directly available**, at least for a sample of participants (therefore always corresponding to a level 3 of evaluation efforts), the general calculation formula is:

Equation 1.

unitary gross annual energy savings $= ([\text{annual energy consumption}]_0 - [\text{annual energy consumption}]_1) +/- \text{normalisation factors}$

Annual energy consumption data for situations before (0) and after (1)[9] implementation of the end-use (EEI) action are directly known:

- either from energy bills or meter reading
- or from energy end-use measurement

2 when energy consumption data are **not directly available**, the formula is broken down in **intermediate parameters** (for which data are easier to access/assess) to calculate energy consumption.

For instance, energy consumptions may be broken down in two terms, load and duration of use:

Equation 2.

unitary gross annual energy savings $= ([P*ALF*D]_0 - [P*ALF*D]_1) +/- \text{normalisation factors}$

where:
- 0 and 1 : situation respectively before and after implementation of an end-use action[7]
- P : average nameplate power
- ALF : average load factor
- D : average annual duration of use

According to the type of end-use action, energy consumption may be broken down in other sets of parameters (e.g., average consumption per cycle and number of cycles for washing machines). And as for energy consumption, these parameters may be related to additional parameters (e.g., number of persons

[9] In some cases, the situations 'with' and 'without' an EEI measure are relevant, instead of 'before' and 'after', cf. chapter 4.1.

per dwelling for the number of cycles). Each of these parameters may be defined either at level 1, 2 or 3 of evaluation efforts.

3.2 Normalisation factors (step 1.3)

In ESD Annex IV (1.2), attention is given to adjustments: "Energy savings shall be determined by measuring and/or estimating consumption, before and after the implementation of the measure, while ensuring adjustment and normalisation for external conditions commonly affecting energy use". Examples from the indicative list of normalisation factors given in Annex IV of the ESD are weather conditions (such as degree days), occupancy levels and plant throughput.

Concerning normalisation factors, in case some are necessary, they may be applied in practice at the level of the parameter they actually affect and not at the level of the whole equation.

The energy efficiency of the item, which is addressed by the energy efficiency measure in the pre-implementation status and in the post-implementation status, can be presented in the general formula (1)

$$\frac{\text{Output}_{pre}}{\text{Input}_{pre}} \longleftrightarrow \frac{\text{Output}_{post}}{\text{Input}_{post}} \qquad (1)$$

To achieve equal levels of output and energy service, the evaluated item is normalised. For this, there are 3 options:

1. the variables are set to the values of the pre-implementation status.
2. the variables are set to the values of the post-implementation status.
3. the variables are set to some transformation of both (e.g. average value for a reference period).

In the case applications analysed in EMEEES, for normalisations the situation of use after the measure (output_{post}) is the "normal" situation. This is also the only way for new buildings and equipment to be dealt with.
There is one exception: the weather condition. For this, there is the convention to use a standard (degree-days per year). So the energy use related to heating and cooling is normalised in the pre-situation as well as in the post-situation to a standard year.

3.3 Selection of calculation methods (step 1.4)

In Step 1.4 *(selection of the calculation methods),* attention is given to the relation between categories of calculation methods and the data sources needed, which relate to the data collection methods presented in ESD Annex IV(2) (cf. list 1 to 4 at the beginning of this chapter 3 and Appendix 1). In our table 2 below, the methods are grouped by decreasing accuracy within the two categories of "measured" and "estimated". Table 2 further describes for each main category, what is the preferred formula (either equation 1 or 2 in Chapter 3.1 or both combined), and whether methods consider participants or equipment as unit of action. The table 2 also provides details about what are possible options of additional data treatment, and then special analysis and/or tools required[10]. Equipment and appliance sales data are measured data but are presented in combination with simple engineering estimated data, as estimates for the use of the equipment are needed and this is common practice, e.g. in the White Certificate Schemes. There are two further methods (modelling of the whole stock based on surveys and diffusion indicators) that are between top-down and bottom-up methods. These are not included in Table 2, but presented in Appendix 4.

Table 2: five general bottom-up calculation methods

Category of method	**Main input data** (cf. Annex IV(2))	**Type of formula**	**Options**	**additional analysis / tools required**	**Characterisation of costs and data collection**
Methods mainly based on measurement					
1) direct measure-ment	end-use load data (ESD 4)	Equation 1 *unit = participant* *[≈ IPMVP option B]*	a) without any normalisation		can be costly; usually restricted to large buildings or sites, or for samples
			b) with normalisations	analysis of required normalisation factors	
2) billing analysis	energy bills (ESD 1) or energy sales data (ESD 2)	Equation 1 *unit = participant* *[≈ IPMVP option C]*	a) without any normalisation	to be allowed only if savings > 10 %	can be very costly to collect and analyse, particularly d); may be the only way of evaluation for information campaigns
			b) with normalisations	analysis of required normalisation factors	
			c) with control group comparison	forming control groups	
			d) other billing analysis	econometric or discrete choice modelling	

10 The table refers to [IPMVP 2002] when a category is similar to a M&V option proposed by IPMVP.

Category of method	Main input data (cf. Annex IV(2))	Type of formula	Options	additional analysis / tools required	Characterisati on of costs and data collection
Methods mainly based on estimates					
3) enhanced engineer-ing estimates (e.g. calibrated simulation)	energy bills and/or end-use metering and/or equipment/ building data from inspection (ESD 6)	Equation 1 or 2 *unit = participant or equipment* *[≈ IPMVP option D]*	variable level of details	simulation tool calibrated with billing or metering data	can be costly; however, if an energy audit is done anyway, small extra cost of monitoring results
4) mixed deemed and ex-post estimate	simple engineering estimates (ESD 5) and measure-specific data (e.g., from equipment and appliance sales data (ESD 3), inspection of samples, monitoring of equipment purchased by participants (ESD 6)	Equation 1 or 2 *unit = equipment* *[≈ IPMVP option D]*	combinations of reference values and measure-specific values	analysis of parameters to be included in calculations ; definition of reference ex-ante values for some of these parameters	costs depend on level of accuracy and gross-to-net correction required; monitoring usually straightforward
5) deemed savings	simple engineering estimates (ESD 5) or sample measurements (e.g., from equipment and appliance sales data (ESD 3), inspection of samples before	Equation 1 or 2 *unit = equipment* *[≈ white certificates[11]]*	method 5) is actually an option of method 4) (all ex-ante)	analysis of parameters to be included in calculations ; definition of reference ex-ante values for all of these parameters	costs can be quite low, monitoring of number of measures and savings per measure may be combined with ”anyway” contacts

In Step 1.4.a (*how calculation methods are usually chosen),* attention is given to main issues that should be taken into account choosing a calculation method, such as:

- what are the available or easy-to-access data?
- what would be the possibilities and costs of collecting additional data?
- what would be the possibilities and costs of performing additional analysis?
- “*cost-effectiveness of decreasing uncertainty*” (ESD Annex IV (3))

[11] for standardised actions

Considering data availability, it is advised to use as much as possible statistics or indicators already defined at EU level (e.g. EU energy labels, Energy Performance Certificates (EPCert) resulting from EPBD[12]). Besides, data availability should be considered in practice and not in theory, especially some market data (e.g. equipment sales data) may be difficult to collect. Likewise, individual energy bills may be difficult to collect, due to separation between energy distributors and retailers, or due to confidentiality and/or privacy conditions.

Moreover, choosing calculation methods is also to be linked with the three levels of evaluation efforts. The above criteria should then be considered for each level of effort. This combination is presented in table 3 below.

Table 3: specifying 3 levels of evaluation efforts for calculation methods

Category of method	Level of effort	Details
1) direct measurement	level 1	can not be applied at level 1 (EU default values)
	level 2	samples representative of national averages + see details in IPMVP option B
	level 3	see IPMVP option B
2) billing analysis	level 1	can not be applied at level 1 (EU default values)
	level 2	samples representative of national averages + see IPMVP option C
	level 3	samples representative of measure participants + see IPMVP option C
3) enhanced engineering estimate	level 1	can only be applied at level 3 (measure-specific)
	level 2	
	level 3	see IPMVP option D
4) mix of ex-ante and ex-post	level 1	same ex-ante values for all MS, other parameters ex-post
	level 2	MS-specific ex-ante or ex-post values
	level 3	measure-specific values (for ex-post values)
5) deemed savings	level 1	same ex-ante values for all MS
	level 2	MS-specific ex-ante values
	level 3	No level 3 for unitary annual energy savings, as deemed savings are all ex-ante

Codes for level of evaluation effort

1. Basic/ EU default (minimum evaluation efforts)
2. Country-specific (intermediate evaluation efforts)
3. Detailed, case-specific (enhance evaluation efforts)

[12] provided these statistics or indicators are reliable. For example, it is not known yet, if the use of EPCert can be assumed to be reliable enough in all Member-States, as the application of the EPBD is recent and may be heterogeneous from one MS to the other.

In practice, most of the evaluation systems combine several categories of methods to organise their monitoring. For example, for a white certificates scheme, the average energy savings per standardised actions correspond to method 5 (deemed savings). However, these values are often based on past studies involving other methods such as method 1 (direct measurement) or method 4 (mix of ex-ante and ex-post) applied on samples. Likewise, these values may be updated afterwards, using ex-post surveys on samples.

Combining several categories of methods according to the monitoring needs is a pragmatic way to find a good compromise between evaluation costs and precision/reliability.

4 Special issues: baselines (step 1.2), double-counting and technical interaction (steps 3.2 and 3.3), multipliers (step 3.4) as well as free-riders (step 3.5)

4.1 Baseline (step 1.2)

As said above, a baseline is needed as a reference situation or 'counterfactual', against which to calculate the unitary energy consumption after an EEI measure. But what should this baseline be?

In Annex IV, the ESD states (section 1.1, general): "In measuring the realised energy savings as set out in Article 4 with view to capturing the overall improvement in energy efficiency **and** to ascertaining the impact of individual measures, a harmonised calculation model… shall be used to measure the annual improvements…"

The ESD requires MS to achieve their indicative 9 percent annual energy savings target by 2016 "by way of energy services and other energy efficiency improvement measures. Member States shall take cost-effective, practicable and reasonable measures designed to contribute towards achieving this target." (Art. 4 ESD). On the other hand, the ESD defines energy efficiency improvement measures as "all actions that normally lead to verifiable and measurable or estimable energy efficiency improvement" (Art. 3h ESD). The ESD does ***not explicitly*** mention that these actions and the resulting energy savings shall be ***additional*** to those that energy consumers, investors, or other market actor would have done by themselves anyway.

In October 2006, the European Commission published the Action Plan for Energy Efficiency: Realising the Potential (COM(2006)545 final). It stated that there is a cost-effective potential for energy savings of over 20 % compared to baseline projections by 2020. Based on this Action Plan, the European Council on 8/9 March 2007 stressed "the need to increase energy efficiency in the EU so as to achieve the objective of saving 20 % of the EU's energy consumption ***compared to projections***[13] by 2020, as estimated by the Commission in its Green Paper on Energy Efficiency, and to make good use of their National Energy Efficiency Action Plans for this purpose." This is, therefore a target for ***additional*** energy savings. The reference to the National Energy Efficiency Action Plans suggests that the European Council expects a significant contribution from the ESD towards these additional energy savings.

What does this mean for a harmonised model including bottom-up methods to evaluate energy savings for the ESD? The structure should be such that one is

[13] Highlighting introduced by EMEEES, not in orginal text

able to **both** calculate **all** energy savings and the **additional** energy savings as an impact of (combinations of) individual measures.

Evaluating the additional energy savings will also enable the calculation of reduction of greenhouse gas emissions due to energy efficiency improvement measures, which are at the same time measures to reduce greenhouse gas emissions. This would be a side-benefit, since this must be reported under the UNFCCC.

If the objective is to evaluate **all** energy savings, the guiding question will be:

What would have happened if all equipment had stayed at the same energy efficiency level as before? ("before-after" situation)

In this case, there are two options for the situation before the EEI measure:

A. There is a real situation 'before', and this can be taken and the energy use can be measured or estimated; e.g. for the renovation of a building;
B. There is no situation before, so one has to create a reference situation (e.g., for a new building).

If the objective is to evaluate **additional** energy savings as an impact of (combinations of) individual measures, the guiding question will be:

What would have happened in the absence of the EEI measure that is to be evaluated? ("with and without" situation)

In this case, one always has to create a reference situation.

Moreover, three general cases can be distinguished for the **reference situation**:

- Case 1: replacement of existing equipment (e.g., appliances, boilers, cars; lighting system)
    - Baseline = Before action situation (for all energy savings)
    - Baseline = Without measure situation (for additional savings)
- Case 2: energy efficiency retrofit (add-on energy efficiency investment or management, without replacement of existing equipment or building; e.g., thermal insulation, energy management, lighting controls)
    - Baseline = Before action situation (both for all and additional energy savings)
- Case 3: new building or appliance: the before situation does not exist and a reference has to be created (for all as well as for additional savings).
    - Baseline = A reference situation (both for all and additional energy savings)

In the Appendix 2 we present a more detailed overview on these three cases, here we restrict ourselves to the general items.

There are several options to **create** a reference situation (when it can not be measured or directly monitored):

1. The average annual energy consumption of the existing **stock**;
2. The average annual energy consumption of the **not energy-efficient** equipment on the existing **market**;
3. The legal minimum **energy performance**;
4. The average annual energy consumption of the Best Available Technology (**BAT**) (only for technology procurement and similar measures that aim to bring technologies better than BAT to the market).

The EMEEES case applications show that existing stock and existing market are often used as the reference situation for level 2 evaluations.

Table 4 presents, which additional factors need to be taken into account for the calculation in either case ("all" and "additional") for the EMEEES bottom-up methods. In the second column, we included 'before EEI measure', as we assume that a cost-effective bottom-up data collection will in most case be done in relation with an EEI measure. The calculation could also be done for all changes that can be measured and monitored. In Appendix 4, we include two other methods (whole stock modeling and diffusion indicators) that are some mix of top down and bottom-up methods.

Table 4: Choices for calculating energy savings and EMEEES bottom-up methods

EMEEES Bottom-up method	Choices for calculating all energy savings (before-after situation)	Choices for calculating additional energy savings only (with-without situation)
1) direct measurement	Baseline = the situation before the EEI measure; taking account of multiplier effects, but not correcting for free-rider and rebound effects	Baseline depending on the end-use action as described in Appendix 2 (in theory; in practice, often the situation before the EEI measure is taken); taking account of multiplier, and correcting for free-rider effects and rebound effects if these exist
2) billing analysis	May be possible if unitary energy savings are large and lead to absolute reduction of energy consumption of the participant group. Then, savings are estimated as being just the absolute reduction of energy consumption of the participant group (options 2 a or b, cf. Table 2).	Use control group to calculate baseline development of energy consumption for comparison with actual development of participant group (option 2 c, cf. Table 2); or perform econometric or discrete choice modelling (option 2 d, cf. Table 2)

EMEEES Bottom-up method	Choices for calculating all energy savings (before-after situation)	Choices for calculating additional energy savings only (with-without situation)
3) enhanced engineering estimate	Baseline = the situation before the EEI measure; taking account of multiplier effects, but not correcting for free-rider and rebound effects	Baseline depending on the end-use action as described in Appendix 2 (in theory; in practice, often the situation before the EEI measure is taken); taking account of multiplier, and correcting for free-rider and rebound effects if these exist
4) mix of ex-ante and ex-post	Baseline = the situation before the EEI measure; taking account of multiplier effects, but not correcting for free-rider and rebound effects	Baseline depending on the end-use action as described in Appendix 2; taking account of multiplier, and correcting for free-rider and rebound effects if these exist
5) deemed savings	Baseline = the situation before the EEI measure; taking account of multiplier effects, but not correcting for free-rider and rebound effects	Baseline depending on the end-use action as described in Appendix 2; taking account of multiplier, and correcting for free-rider and rebound effects if these exist

4.2 Double-counting and technical interaction (steps 3.2 and 3.3)

The ESD Annex IV(5) specifies that no energy savings from different EEI measures may be counted more than once. EMEEES understands this provision to also cover technical interaction, e.g., between thermal insulation of a building, and an energy-efficient heating system.

In general, double-counting can best be avoided and technical interaction best be considered, if the combined effect of all EEI measures for one final consumer (e.g., a building or a factory) or one type of end-use actions (e.g., purchase of energy-efficient appliances) is calculated in a package. For the ESD, it does not matter which actor contributed how much to the energy savings.

How can this be done in practice? Within EMEEES, there are case applications dealing with types of end-use actions, e.g., thermal insulation of a building or purchase of energy-efficient appliances, and case applications dealing with types of facilitating measures, e.g., voluntary agreements (VA), energy audits, and energy performance contracting (EPC).

There are three options to avoid double counting:

a) all savings that are also influenced by other policies, programmes or energy services are substracted from the savings calculated for the facilitating measure under evaluation (VA, energy audit, EPC);
b) all savings that are also influenced by other facilitating measures are substracted from the savings calculated for those facilitating measures;
c) all savings that are also influenced by other facilitating measures are divided between the facilitating measure under evaluation and the other facilitating measures, and so a part of savings are substracted from the savings calculated for the facilitating measure under evaluation;
d) reporting a single result of energy savings per targeted energy end-use (either by selecting the result of one single measure, or by evaluating the group of measures targeting this end-use as a whole).

Ad a. Substract from savings for the facilitating measure under evaluation

Other policies like subsidy schemes, tax reductions, or regulations are often focussed on appliances, installations or buildings. To translate energy savings (that are accounted for) to other policies, programmes, and energy services, information is needed on the deemed or measured savings from these other facilitating measures that are attributed to participants in the facilitating measure under evaluation.

It should also be assured that savings are calculated in line with the normalisation of energy use/savings within the facilitating measure under evaluation. The (deemed or measured) energy use related to the appliances etc. should be excluded from the energy savings for the lifetime period of savings being used outside the facilitating measure under evaluation.

Ad b. Substract from savings due to other facilitating measures

Other policies, programmes, and energy services like subsidy schemes, tax reductions or regulations are often only focussed on appliances, installations or buildings. If the participants in the facilitating measure under evaluation are known, it should be easy to mark them during the implementation of the other facilitating measures and to exclude their savings resulting from other facilitating measures in the calculated results for these.

Whenever possible, an approach of direct tracking through registering participants in databases is recommended (proposal agreed by the Commission), as it enables both an easy monitoring of double counting, and sampling to perform ex-post verifications.

(Example based on the Finnish experience:

- *measure 1, energy audit in industry: registry (database) of companies, sites, and measures proposed in each energy audit, with estimated savings and investment*
- *measure 2 and 3, voluntary agreement and tax rebate or direct subsidy or soft loan for implementation of measures: registry (database) of companies, sites, and measures implemented with financial incentive*
- *measure 4, energy performance contracting: registry (database) of companies, sites, and measures implemented by contractors*

Then double counting is avoided by comparing these three databases (or even integrating databases for measures 1, 2, and 3).

If a direct tracking is not possible, a survey of a sample of final consumers or other beneficiaries of the different measures targeting an end use or sector can deliver results on how many have been influenced by more than one measure. Basd on this, a double-counting coefficient to correct the total annual energy savings can be calculated. Such a survey comes at a cost, but it can be used to gather information on how the different measures act and interact. This will be valuable for improving the effectiveness and cost-effectiveness of individual measures and the package.

Ad c. Divide savings between faciltating measures

This is the same situation as described under ad a., but with additional efforts to attribute part of the savings to the different policies. This attribution (%) can be kept the same over the whole period or changing over time. This attribution has to be motivated and reported/argued.

Ad d. One single result per energy end-use

According to the way energy savings are accounted for on the one hand, and the way facilitating measures are designed on the other one, it could be easier to report one single result per energy end-use.

For example, if an information campaign and a financial measure are combined to induce households to insulate their homes, it can be assumed that all the participants who were informed by the campaign then took advantage of the financial measure. So the result of the financial measure would represent the total result for both measures.

Another example could be a combination of measures, where participants are registered for only one of these measures. In that case, it could be easier to assume that the number of registered participants is the result for the whole package of measures.

Options b and d seem to have the lowest workload, as they are simple approaches. Option a is more complicated, as one has to take care of normalisation and lifetime, which indeed differs between the participants in different facilitating measures. Furthermore, this option neglects interaction between various facilitating measures at one site/consumer and neither does it take into account the sequence of implementation of end-use actions. Taking all together, option a leads to inappropriate outcomes. Option c holds the highest workload as it needs additional research on proper attribution; a possible solution may be to agree upon the arbitrary division of the total savings over the various facilitating measures once every three to five years.

4.3 Calculating Multiplier effects (step 3.4)

The *multiplier* (or spill-over) *effect* enhances the initial effect of EEI measures. According to Annex IV-5 of the ESD, the multiplier effect means that “the market will implement a measure automatically without any further involvement from the authorities or agencies referred to in Article 4-4 or any private-sector energy services provider”.

Evaluating multiplier effects is similar to market transformation studies. Most common practices are sales data analysis (market modelling), surveys among representative samples of (non-)participants and surveys with trade allies and/or other relevant stakeholders. Moreover, it should be looked at whether multiplier effects were expected a priori and included in the calculations used in the (first) NEEAPs. This can be checked through process or theory-based evaluations[14].

In practice, multiplier effects may mostly occur after a delay (compared to “direct” savings). Such results should then be tracked over time.

There is a link between baseline definition, free-rider, and multiplier effects for methods using an average equipment energy consumption baseline, but no general approaches are available to deal with these links.

14 See the AID-EE project for more information: http://www.aid-ee.org/.

4.4 Calculating free-rider effects (step 3.5)

The *free-rider effect* regards market actors who make use of facilities or support, provided for by EEI programmes, policies, or energy services, but would have taken energy-saving actions anyway[15]. Therefore, free-rider effects will only have to be excluded from the calculated value of energy savings, if the objective is to calculate **additional** energy savings.

Three main options are relevant to account for free-rider effects :

1. option A : taking account of free-rider risks while defining the baseline, by using market surveys or applying special additionnality criteria[16] ;
2. option B : using free-rider ratios, which may be defined according to the three levels of evaluation efforts ;
3. option C : mix of options A and B, defining free-rider ratios mainly by using market surveys and considering common stages of market evolution.

In most EMEEES case applications, the practices encountered are that it is assumed that the free-rider and multiplier effects compensate for each other and that no calculations are implemented. The reason for this assumption is that the two effects work in the opposite direction: the multiplier effect increases the energy savings, while the free-rider effect decreases them.

Since both the multiplier and free-rider effects usually require surveys of participants and non-participants to a measure, and of other market actors, it can be assumed that calculating these effects causes additional costs for monitoring and evaluation. These can easily reach 100,000 Euros. If the aim is to limit the costs of monitoring and evaluation to 1 % of the overall energy cost savings for society, it will be advisable to only embark on this effort for EEI measures that are saving in excess of 50 million kWh/year, or 10 % of the national ESD energy savings target, whatever is met first. For all measures with a lower total gross annual energy savings, the above assumption that free-rider and multiplier effects compensate for each other could be applied.

[15] The free-rider effect is not mentioned in the ESD.However, Commission officials asked the EMEEES project to analyse it.

[16] A part of free-rider effects is addressed this way in the French White Certificates Scheme, by defining performance requirements for an end-use action to be eligible to White Certificates. Moreover, when several efficient technologies compete for the same end-use, only the most efficient one is rewarded at 100% of their energy savings contents. Other technologies are rewarded at only 50%, to induce the choice of the Best Available Technology.

5 References

Other EMEEES documents of the WP4 (bottom-up):
(these are available at www.evaluate-energy-savings.eu)

- Bottom-up methodological report: The development process for harmonised bottom-up evaluation methods of energy savings, with the details on the 4-steps calculation process;
- Compilation of EMEEES formulae for unitary gross annual energy savings, baselines, and default values as well as data to collect;
- 20 case applications (cf. Appendix 1 for the list);

Main references used within EMEEES WP4:

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Appendix 1: Case applications and data collection methods

20 bottom-up case applications were developed by EMEEES. The tables below present an overview on the EMEEES evaluation methods and the ESD data collection methods in combination with the 3 levels of evaluation efforts.

Table A1: Bottom-up case applications and EMEEES evaluation methods, combined with level of evaluation efforts, overview

End-use, end-use action, or facilitating measure	Sector	Measured data		Estimated data			
		1	2	3	4	5	6
Building regulations for new residential buildings	Residential	(3)		2S, 3	2		
Improvement of the building envelope of residential buildings	Residential	(2S, 3S)		2S, 3	maybe 2b	2b	2a
Biomass boilers	Residential			3	2	2	
Residential condensing boilers in space heating	Residential				3	1, 2	
Energy efficient cold appliances and washing machines	Residential				3	1, 2	
Domestic Hot Water – Solar water heaters	Residential			3	2		
Domestic Hot Water - Heat pumps	Residential			3	2		
Non residential space heating improvement in case of heating distribution by a water loop	Tertiary			3		1, 2	
Improvement of lighting systems (tertiary sector)	Tertiary (industry)			3	2, 3	1, 2	
Improvement of central air conditioning (tertiary sector)	Tertiary			2S, 3		1, 2	
Office equipment	Tertiary				3	1, 2	
Energy-efficient motors	Industry	3		2S		1, 2	
Variable speed drives	Industry	3		(3)		1, 2	
Vehicle energy efficiency	Transport				3	2	
Modal shifts in passenger transport	Transport	(3)			1, 2, 3		
Ecodriving	Transport				3	1, 2	
Energy performance contracting	Tertiary and industry end-uses	(3)	3	3	2		
Energy audits	Tertiary and industry end-uses	(2,3)		2b, 3	2a	1	
Voluntary Agreements - billing analysis method	Tertiary and industry end-uses		2				
Voluntary agreements with individual companies - engineering method	Tertiary and industry end-uses			2, 3	2 (partly)	1	

Codes for EMEEES evaluation methods (**columns** in table), following the numbering as presented in section 4
1. direct measurement
2. billing analysis
3. enhanced engineering estimates
4. mix of ex-ante and ex-post
5. deemed savings (with some participant monitoring data)
6. modelling of the whole stock

Codes in the table indicate the level of evaluation effort (S = method used for sample only)
1. Basic/EU default (minimum evaluation efforts)
2. Country specific (intermediate evaluation efforts)
3. Detailed, case specific (enhanced evaluation efforts)

Table A2: Bottom-up case applications and ESD data collection methods, combined with level of evaluation efforts, overview

End-use, end-use action, or facilitating measure	**Sector**	**Measured data**				**Estimated data**	
		1	**2**	**3**	**4**	**5**	**6**
Building regulations for new residential buildings	Residential	(3)				2	2S, 3
Improvement of the building envelope of residential buildings	Residential	(2S, 3S)		2, 3		2b	2S, 3
Biomass boilers	Residential					2	3
Residential condensing boilers in space heating	Residential (tertiary)					1, 2, 3	
Energy efficient cold appliances and washing machines	Residential			2, 3		1, 2	
Domestic Hot Water – Solar water heaters	Residential					2	3
Domestic Hot Water - Heat pumps	Residential					2	3
Non residential space heating improvement in case of heating distribution by a water loop	Tertiary			1, 2		1, 2	3
Improvement of lighting systems (tertiary sector)	Tertiary (industry)			1, 2		1, 2	3
Improvement of central air conditioning (tertiary sector)	Tertiary			1, 2		1, 2	2S, 3
Office equipment	Tertiary			1, 2		1, 2, 3	
Energy-efficient motors	Industry				3	1, 2	2S
Variable speed drives	Industry				3	1, 2	(3)
Vehicle energy efficiency	Transport					2, 3	
Modal shifts in passenger transport	Transport		(3)			1, 2, 3	
Ecodriving	Transport					1, 2, 3	
Energy performance contracting	Tertiary and industry end-uses	3	3		(3)	2	3
Energy audits	Tertiary and industry end-uses				(2,3)	1, 2a	2b, 3
Voluntary Agreements - billing analysis method	Tertiary and industry end-uses	2	2				
Voluntary agreements with individual companies - engineering method	Tertiary and industry end-uses					*1, 2 (part-ly)*	2, 3

Codes for energy savings; numbers following the presentation in ESD (see below)
1. measured energy savings; Bills from distribution companies or retailers
2. measured energy savings; Energy sales data
3. measured energy savings; Equipment and appliance sales data
4. measured energy savings; End-use load data
5. estimated energy savings; Simple engineering estimated data, Non-inspection
6. estimated energy savings; Enhanced engineering estimated data, Inspection

Codes in the table indicate the level of evaluation effort
1. Basic/EU default (minimum evaluation efforts)
2. Country specific (intermediate evaluation efforts)
3. Detailed, case specific (enhance evaluation efforts)

The ESD holds in Annex IV six methods for collecting data to measure and/or estimate energy savings. Table A2 above presents, which of this are proposed in the 20 EMEEES bottom-up case applications.

For *measured energy savings*, four methods are given in ESD Annex IV(2.1):

“1. Bills from distribution companies or retailers

Metered energy bills may form the basis for measurement for a representative period before the introduction of the energy efficiency improvement measure. These may then be compared to metered bills for the period after the introduction and use of the measure, also for a representative period of time. The findings should be compared to a control group (non-participation group)

2. Energy sales data

The consumption of different types of energy (e.g. electricity, gas, heating oil) may be measured by comparing the sales data from the retailer or distributor obtained before the introduction of the energy efficiency improvement measures with the sales data from the time after the measure. A control group may be used or the data normalised.

3. Equipment and appliance sales data

Performance of equipment and appliances may be calculated on the basis of information obtained directly from the manufacturer. Data on equipment and appliance sales can generally be obtained from the retailers. Special surveys and measurements may also be carried out. The accessible data can be checked against sales figures to determine the size of energy savings. When using this method, adjustment should be made for changes in the use of the equipment or appliance.

4. End-use load data

Energy use of a building or facility can be fully monitored to record energy demand before and after the introduction of an energy efficiency improvement measure. Important relevant factors (e.g. production process, special equipment, heating installations) may be metered more closely.”

For *data and methods based on estimates* two options are presented in ESD Annex IV(2.2):

“5. Simple engineering estimated data, Non-inspection

Simple engineering estimated data calculation without on-site inspection is the most common method for obtaining data for measuring deemed energy savings. Data may be estimated using engineering principles, without using on-site data, but with assumptions based on equipment specifications, performance characteristics, operation profiles of measures installed and statistics, etc.

6. Enhanced engineering estimated data, Inspection

Energy data may be calculated on the basis of information obtained by an external expert during an audit of, or other type of visit to, one or several targeted sites. On this basis, more sophisticated algorithms/simulation models could be developed and be applied to a larger population of sites (e.g. buildings, facilities, vehicles). This type of measurement can often be used to complement and calibrate simple engineering estimated data.”

Appendix 2: Baselines applied in the EMEEES case applications

- Case 1: replacement of existing equipment
    - Baseline = Before action situation (for all energy savings)
    - Baseline = Without measure situation (for additional savings)
- Case 2: energy efficiency retrofit (add-on energy efficiency investment or management without replacement of existing equipment or building)
    - Baseline = Before action situation (both for all and additional energy savings)
- Case 3: new building or appliance: the before situation does not exist and a reference has to be created.
    - Baseline = A reference situation (both for all and additional energy savings)

Case 1: Replacement of existing equipment; baseline=base point / reference point

Case 1 is when an equipment (e.g. appliances, lighting) is replaced by a more energy-efficient one. The “all savings” baseline is therefore the energy consumption of the replaced equipment (when known, i.e. for level 3 evaluations) or the average consumption of the stock (for level 1 or 2 evaluations). To account for additional savings, the assumption is that the equipment would have been replaced anyway (normal turnover). The proposed baseline is then the energy consumption of the equipment which would have been bought without the measure, assumed to be the average of the “inefficient” market[17].

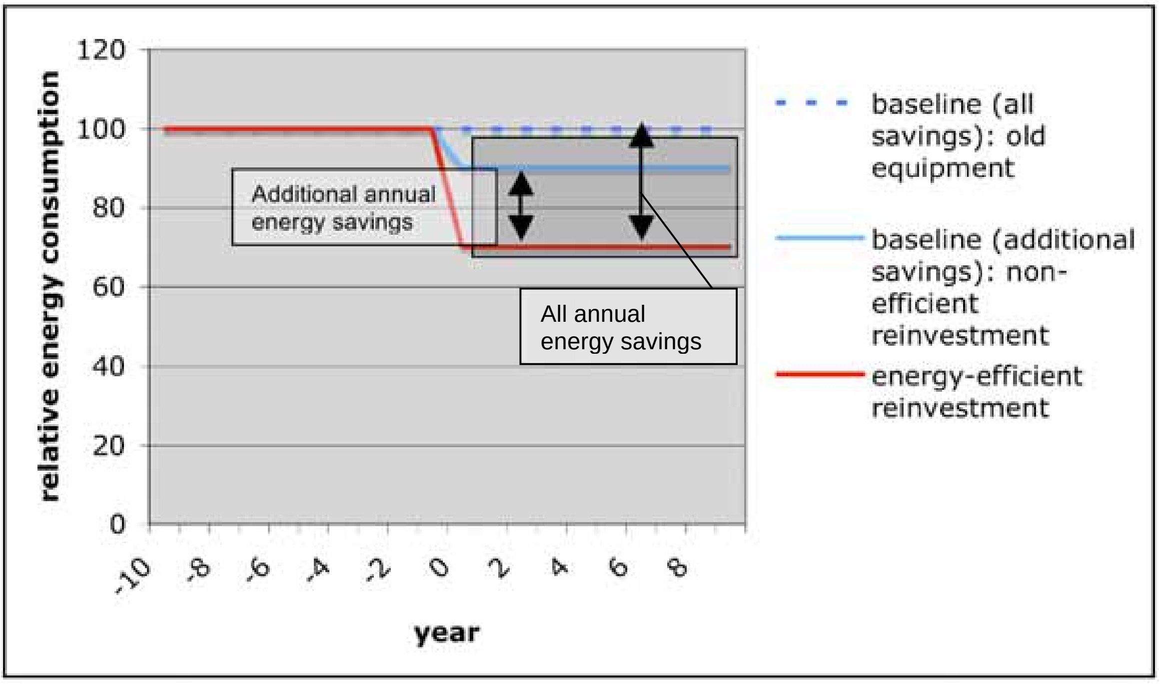
Figure 1 displays the development of the energy consumption of the end-use equipment for one customer who does the normal reinvestment (i.e., after the old equipment broke down or is replaced anyway for any other reason) in **year 0**.[18] In this example, the baseline for calculating additional energy savings is assumed at level 90 (i.e., already more energy-efficient than the old equipment that broke down, which is at 100 and constitutes the baseline for calculating all energy savings) and the relative average energy consumption of the efficient solution at level 70. Hence, in this example

[17] The “inefficient” market is here the market less the efficient models promoted by the measure. Consequently, the share of these efficient models, which would have been bought anyway, among the participants in or buyers affected by the measure represents the free-rider effect.

[18] As the unitary gross annual energy savings are calculated for year 0, the development of the lines in the figure after year one does not influence the savings calculation

- *all* unitary gross annual energy savings = 30 and this includes
- *additional* unitary gross annual energy savings = 20 (all in arbitrary units).

Figure A1: baseline and energy-efficient solution in the case of replacement of existing equipment (example)



Case 2: energy efficiency retrofit (add-on energy efficiency investment or management without replacement of existing equipment or building)

In this case, for the lifetime of the retrofit actions, energy is saved compared to the consumption of the equipment **before** the EEI measure. This is valid in both cases (**all** and **additional** energy savings). An example is the refurbishment of the outer wall of a building, or the installation of a variable speed drive on an existing electric motor.

Case 3: The new building or appliance

In this case no real "before" situation exists, so one has to select the reference situation. There are several options to create a reference situation, which may also apply to case 1 with replacement of existing equipment:

1. The existing stock;
2. The existing market;
3. The legal minimum performance;
4. Best Available Technology (BAT) (only for technology procurement and similar measures that aim to bring technologies better than BAT to the market).

Existing stock refers to the average energy performance level (or average unitary annual energy consumption) of the existing buildings / equipments in place. This average may be global (representing the whole stock), or differentiated by characteristics (e.g. age classes, individual/multi-family building, etc.) according to available data or evaluation requirements (in this case, there is a specific average for each sub-category of the stock).

Existing market refers to the average energy performance level (or average unitary annual energy consumption) of the market, taking into account only the categories of buildings/equipments considered as inefficient (i.e. not taking into account the categories considered as efficient, which are the categories promoted by the facilitating measures); this average is calculated by using the sales data (about what is really sold), as best option, however if these data are not available, a default option may be to use the manufacturers/retailers references (what is proposed on the market). Like for the existing stock, averages per sub-categories of market may also be used for the existing market (especially for buildings).

For both baseline options (stock and market), the remaining issue is whether to define a baseline once (i.e. the baseline is defined with 2008 as reference year for the whole ESD period), or to update the baseline periodically.

For the new buildings and the building regulation, the EMEEES case application suggests some kind of existing market: it takes the situation as it results from the first building regulation (1995 or later) as the reference situation.
For new cold appliances, the EMEEES case application suggests a market model for normal replacement (average of the A+ to C appliances on the market).

The table overleaf presents a **complete overview** of the kinds of baselines proposed in draft EMEEES case applications. It shows that for only 9 out of 20 case applications, the market model (without measure situation) is relevant for calculating additional energy savings, while for 11 out of 20 only the stock or individual before action situation can be chosen. In some of these cases, the without measure situation would be applicable to some end-use actions, but cannot be evaluated due to practical reasons. So we propose to neglect it.

Table A3: Bottom-up case applications and proposed baselines, overview

End-use or end-use action, technology, or facilitating measure	**Stock model (before action)**	**Individual before action situation**	**Market model (without measure)**	**Other**
Building regulations for new residential buildings			x	Minimum efficiency standard
Improvement of the building envelope of residential buildings	x			
Biomass boilers		x		
Residential condensing boilers in space heating	x		x	*
Energy efficient cold appliances and washing machines	x		x	*
Domestic Hot Water – Solar water heaters		x		
Domestic Hot Water - Heat pumps		x		
Non residential space heating improvement in case of heating distribution by a water loop	x	x	x	*
Improvement of lighting systems (tertiary sector)	x	x	x	*
Improvement of central air conditioning (tertiary sector)			x	*
Office equipment			x	*
Energy-efficient motors			x	*
Variable speed drives	x	x		
Vehicle energy efficiency			x	
Modal shifts in passenger transport	x			
Ecodriving	x			
Energy performance contracting		x		Project specific
Energy audits		x		
Voluntary Agreements - billing analysis method		x		
Voluntary agreements with individual companies - engineering method		x		

* For these case applications, baselines will need to be adapted after introduction of a EuP minimum energy performance standard, in order to allow splitting energy savings in those due to EuP requirements and those due to best available technology that is promoted by the EEI measures evaluated.

Appendix 3: Analytical clarification of the subject of monitoring and evaluation

Within the EMEEES project, an analytical clarification of the subject of monitoring and evaluation was introduced, since the term ‘energy efficiency improvement measure’ was considered too vague. It was concluded that the subject of monitoring and evaluation can be either, or a combination, of:

- an energy efficiency improvement facilitating measure (**(EEI) facilitating measure**),
- an end-use energy efficiency improvement action (**end-use (EEI) action**).

An energy efficiency improvement **facilitating measure** ((EEI) facilitating measure) is an action by an actor that is not the final consumer him-/herself, which supports the final consumer in implementing the end-use action, or implements it for the final consumer. Examples are energy efficiency programmes, energy services or mechanisms.

When facilitating measures “focus on groups of final customers”, they form **EEI programmes** (as defined in ESD article 3-g, e.g.: subsidies schemes). When the end-use action is “delivered on a basis of a contract”, it deals with **energy services** (as defined in ESD article 3-e, e.g.: energy performance contracting). And when facilitating measures use “general instruments”, they form **EEI mechanisms** (as defined in ESD article 3-f, e.g. energy taxation). A mechanism can be understood as a measure of a public body that supports or forces providers of facilitating measures to do this.

An **end-use** energy efficiency improvement **action** (end-use (EEI) action) is a technical, organisational or behavioural action taken at an end-user’s site (or building, equipment, etc.) that improves the energy efficiency of that end-user’s facilities or equipment, and thereby saves energy. It can be a result of a facilitating measure.

Appendix 4: Bottom-up and Top-down mixed calculation methods

In this Appendix, we include two methods that are between top-down and bottom-up methods:

- whole stock modelling based on surveys and
- diffusion indicators

Modelling of the whole stock will be a bottom-up method, if the surveys allow to detect the impact of EEI measures on the end-use actions taken. Otherwise, if the modelling just allows to better understand the development of energy consumption in a sector or subsector (and the related top-down indicators), it is a top-down method.
Diffusion indicators are mainly used in the top-down approach, but could also (in special situation) be used in the bottom-up approach, if their development is entirely due to EEI measures.

In Step 1.4 *(categories of calculation methods according to main data sources),* attention is given to the relation between categories of calculation methods and the data sources needed, which relate to the data collection methods presented in ESD Annex IV (cf. Appendix 1). In the table below we presented the situation for the two methods that are some kind of mixed TD and/or BU approach. This table further describes what is the preferred formula and whether methods consider participants or equipment as unit of action. The table also provides details about what are possible options of additional treatment, and then special analysis and/or tools required.

Table A4: Two mixed calculation methods

Category of method	**Main input data** (cf. Annex IV(2))	**Type of formula**	**Options**	**additional analysis / tools required**	**Characterisation of costs and data collection**
6) Modelling of the whole stock based on surveys of population samples:	end-use actions taken in total and induced by facilitating measures; engineering estimates (ESD 5 or 6) or sample measurements	Equation 1 or 2 unit = equipment or building	**Will be a bottom-up method, if** energy savings due to (EEI) facilitating measures can be distinguished from total change in energy consumption	modelling of energy savings from end-use actions in total and induced by facilitating measures, based on surveys	modelling has medium costs, but surveys can be costly if done especially for the evaluation

Category of method	Main input data (cf. Annex IV(2))	Type of formula	Options	additional analysis / tools required	Characterisation of costs and data collection
7) = TD 1) Diffusion indicators	Equipment and appliance sales data (ESD 3): statistical data on market diffusion of energy-efficient equipment	Equation 1 or 2 *unit = equipment*	**Will be a bottom-up method, if** diffusion of the equipment or appliances is entirely due to (EEI) facilitating measures	Unitary gross energy savings can either be deemed savings or be calculated from the equipment and appliance sales data if these include energy consumption of the equipment or appliances	Collecton or puchase of sales data can be quite costly. On the other hand, some ODYSSEE indicators may be used.

In the table below, the elements of calculation to be applied for these two methods are provided for the two kinds of objectives possible for evaluation: either for all energy savings (column 2) or for additional energy savings (column 3), cf. chapter 4.1.

Table A5: Two mixed calculation methods and choices for calculating energy savings

EMEEES Bottom-up method	Choices for calculating all energy savings (before-after situation)	Choices for calculating additional energy savings only (with-without situation)
6) modelling of the whole stock based on surveys	Model energy consumption with frozen energy efficiency of the existing stock vs. actual development of unitary energy consumption with the end-use actions taken (then this will be a **top-down method**)	Model energy savings from the end-use actions taken due to facilitating measures (based on the surveys of owners/investors, which end-use actions were caused by facilitating measures)
7) = TD 1) diffusion indicators	Calculate energy savings from all energy-efficient equipment or practice diffused, no matter what the cause (in this case this will be a **top-down method**)	Calculate energy savings from all energy-efficient equipment or practice diffused and prove that all this is due to facilitating measures Calculate autonomous development from a regression analysis or as a default value (in this case this will be a **top-down method**)

Appendix 5: Overview of Level 1 default values proposed in EMEEES bottom-up case examples

A5.1 Default values for the calculation of unitary gross annual energy savings

EMEEES has developed 20 case applications of bottom-up calculation methods for energy savings. To enable level 1 calculations, it was intended to propose as many EU default values as possible. These are derived from existing literature and experience, but a reliability coefficient is applied that considers both the reliability and the transferability of the values found in existing sources. The EU level default values are thus conservative: they enable Member States that do not have own values a calculation of energy savings, but provide an incentive to perform country- or measure-specific evaluations and calculations on levels 2 or 3, which will probably yield higher energy savings with higher precision.

The following table provides an overview of the types of EU level default values proposed in the 20 case applications of bottom-up calculation methods. It shows that there are some kinds of default values proposed for 16 out of the 20 case applications. Out of these 16, nine propose default values directly for the average unitary annual energy savings of an equipment or building, or for a percentage of the overall energy consumption of a participant, while seven only propose default values for some parameters of calculation. In these cases, other parameters for calculating the unitary annual energy savings need to be monitored for each unit of end-use action tapped by an energy efficiency improvement measure.

Table A6: Bottom-up case applications and default values for the calculation of unitary gross annual energy savings

End-use or end-use action, technology, or facilitating measure	**Default value 1**	**Default value 2**
Building regulations for new residential buildings	parameter for non-compliance	time lag 2 years
Improvement of the building envelope of residential buildings	none possible	none possible
Biomass boilers	none possible	none possible
Residential condensing boilers in space heating	EU **average unitary annual energy savings** in kWh/m2/year, for all and additional energy savings	average seasonal energy efficiency (%) of: condensing boilers (94%); new, not energy-efficient boilers (89%); boilers in existing stock (82%)

End-use or end-use action, technology, or facilitating measure	**Default value 1**	**Default value 2**
Energy efficient cold appliances and washing machines	**unitary annual energy savings** of cold appliances: 61 kWh/year	average energy savings per washing cycle of clothes-washers: 0,06 kWh/cycle
Domestic Hot Water – Solar water heaters	none possible	Per capita hot water consumption and standard hot water temperature
Domestic Hot Water - Heat pumps	none possible	Per capita hot water consumption and standard hot water temperature
Non residential space heating improvement in case of heating distribution by a water loop	EU **average unitary annual energy savings** in kWh/m2/year, for all and additional energy savings, for: condensing boilers efficient distribution system efficient heat emitters (including controls)	average seasonal energy efficiency (%) of: energy-efficient solution; new, not energy-efficient solution; existing stock; each for: boilers distribution system heat emitters (including controls)
Improvement of lighting systems (tertiary sector)	EU **average unitary annual energy savings** in kWh/year for: compact fluorescent lamps electronic ballasts occupancy sensors	average values for the power input (W) for energy-efficient and inefficient luminaires annual hours of use
Improvement of central air conditioning (tertiary sector)	**average unitary annual energy savings** in kWh/m2/year from use of Eurovent class A equipment for each of the EU-15 Member States, for four types of equipment	average unitary annual energy savings in kWh/m2/year from use of free cooling for each of the EU-15 Member States
Office equipment	EU **average unitary annual energy savings** from using **BAT** compared to market inefficient equipment in kWh/year for active, standby, and off modes for: desktop computers laptop computers CRT monitors LCD monitors	EU **average unitary annual energy savings** from using **EuP proposed values** compared to market inefficient equipment in kWh/year for active, standby, and off modes for: desktop computers laptop computers CRT monitors LCD monitors
Energy-efficient motors	average energy efficiency and energy savings (%) of motors, 22 load range categories, for IE1, IE2, and IE3 efficiency classes	EU average hours/year and load factors for 3 load range categories < 22kW, each for six types of end uses in industry and tertiary sector, in total 36 values

End-use or end-use action, technology, or facilitating measure	Default value 1	Default value 2
Variable speed drives	for motors < 22kW: **average energy savings** (%) from VSDs for six types of end uses; average energy efficiency (%) of motors, 22 load range categories, for IE1	EU average hours/year and load factors for 3 load range categories < 22kW, each for six types of end uses in industry and tertiary sector, in total 36 values
Vehicle energy efficiency	baseline energy consumption (kWh/km) by fuel, assuming 130 g CO_2/km as the baseline (N.B.: energy savings from the 130 g CO_2/km standard better to be evaluated top-down; this BU method mainly for additional energy savings from measures promoting BAT)	average energy savings (%) from fuel-saving lubricants and tyres, separate for private and commercial vehicles
Modal shifts in passenger transport	average specific energy consumption in kWh/person-km for: cars long-distance trains airplanes	–
Ecodriving	average share (%) of drivers changing behaviour as a consequence of a measure, each for: specific training including ecodriving in driver license training use of virtual trainers/simulators in-car devices	average energy savings (%) by drivers changing behaviour as a consequence of a measure, each for: specific training including ecodriving in driver license training use of virtual trainers/simulators in-car devices
Energy performance contracting	none possible	none possible
Energy audits	**average energy savings** (% of total consumption of final users receiving an energy audit), separate for electricity and heating fuels, and for industry and tertiary sector	average energy savings (% of total energy savings potential identified in an energy audit), separate for electricity and heating fuels, and for industry and tertiary sector
Voluntary Agreements - billing analysis method	none possible	none possible
Voluntary agreements with individual companies - engineering method	**average energy savings** (% of total consumption of final users participating in the scheme, **only** if it includes a full energy audit), separate for electricity and heating fuels	–

A5.2 Default values for lifetimes

The CWA27[19] defined a list of default and harmonised values for the saving lifetime. This was achieved by executing a survey of presently applied lifetimes in different EU countries. So this was the main source used for defining default values for lifetimes in the EMEEES method. As soon as the European Commission publishes a revised list of harmonised lifetimes, these will have to be considered instead of those presented here.

Table A7: Bottom-up case applications and default values for the lifetimes of energy savings

End-use or end-use action, technology, or facilitating measure	**Default/harmonised savings lifetime**	**Based on**
Building regulations for new residential buildings	Insulation: building envelope - >25 years (harmonised) Windows/glazing – 24 years (harmonised) [Small boilers – 17 years (harmonised)] [Large boilers – 17 years (default)] Energy performance standard – 25 years	CWA 15693:2007
Improvement of the building envelope of residential buildings	EU harmonised: Insulation of the building envelope: 25 years or more Windows: 24 years	CWA 15693:2007
Biomass boilers	EU harmonised: 17 years	CWA 15693:2007
Residential condensing boilers in space heating	EU harmonised: 17 years	CWA 15693:2007
Energy efficient cold appliances and washing machines	EU harmonised: Efficient cold appliances : 15 years Efficient wet appliances : 12 years	CWA 15693:2007
Domestic Hot Water – Solar water heaters	EU harmonised: 19 years	CWA 15693:2007
Domestic Hot Water - Heat pumps	EU harmonised: 17 years	CWA 15693:2007
Non residential space heating improvement in case of heating distribution by a water loop	Large boilers: 17 years (default value for residential sector, no value defined for commercial/public) Heat pumps: 20 years (harmonised) Heating control: 5 years (default value for residential sector, no value defined for commercial/public) Heat recovery systems: 17 years (harmonised)	CWA 15693:2007
Improvement of lighting systems (tertiary	EU harmonised:	CWA 15693:2007

19 A CWA (CEN Workshop Agreement) is the result of a CEN Workshop, which is a flexible working platform open to the participation of any company or organisation, inside or outside Europe, for rapid elaboration of consensus documents. The CWA27 is entitled "Saving lifetimes of Energy Efficiency Improvement Measures in bottom-up calculations".

End-use or end-use action, technology, or facilitating measure	Default/harmonised savings lifetime	Based on
sector)	New/renovated office lighting (Commercial /Public sector): 12 years Motion detection light controls (Commercial /Public sector): 10 years	
Improvement of central air conditioning (tertiary sector)	EU harmonised: Equipment (efficient chillers): 17 years Free cooling (efficient ventilation systems): 15 years	CWA 15693:2007
Office equipment	EU default: All energy efficient office appliances: 3 years PC desktop office: 6.6 years[1] (without 2nd life: 6 years) PC laptop office: 5.6 years[1] (without 2nd life: 5 years) Computer monitor office: 6.6 years[1] (without 2nd life: 6 years) Electro Photography (EP) printer and EP copier: 6 years Inkjet (IJ) printer, IJ MFD, scanner: 4 years Fax: 8 years	CWA 15693:2007 EuP Preparatory Studies (Lot 3 and 4)
Energy-efficient motors	EU default: 8 years	CWA 15693:2007
Variable speed drives	EU default: 8 years	CWA 15693:2007
Vehicle energy efficiency	EU default: Efficient vehicles: 100,000 km Low resistance tyres for cars: 50,000 km Low resistance tyres, trucks: 100,000 km Fuel-saving lubricants: 15,000 km	CWA 15693:2007 CWA 15693:2007 CWA 15693:2007 own estimate
Modal shifts in passenger transport	EU default: 2 years	CWA 15693:2007
Ecodriving	After 10 years, dimished to 35 % of first year savings	
Energy performance contracting	Lifetimes of EPC projects have to be evaluated from case to case.	
Energy audits	EU default: 6-year sliding average lifetime EU harmonised: n.a.	Method used in Finland
Voluntary Agreements - billing analysis method	10 % of energy savings: 2 years, 75 % of energy savings: 8 years, 15 % of energy savings: 25 years	
Voluntary agreements with individual companies - engineering method	EU default for technical actions: 12 years EU default for organisational (Energy Management System) actions: 2-4 years	CWA 15693:2007 CWA 15693:2007 (2 years), own suggestion (>2 years)

Appendix 6: Proposal for a reporting checklist for bottom-up evaluations

► Measure(s) and evaluation details

Name of the measure (or group of measures):

Contact person(s) for the measure(s):

Organisations involved in the measure(s) implementation:

Contact person(s) for the evaluation:

Organisations involved in the evaluation:

► Short description of the measure(s)

Target group:

Targeted type of final energy (fuel) and end use:

Concrete end-use actions facilitated (please list)[20]

Period for which the measure has been evaluated:

Short description of the measure(s) (including eligibility requirements for participation/actions, level of financial incentives, if any, and role of actors)[21]:

► Main results

It is possible to present values for *all* energy savings (compared to the status quo without any of the targeted end-use actions) and for energy savings *additional* to the end-use actions taken autonomously by final consumers or other actors.

All annual energy savings in 2016 (or 2010) (in GWh):

Additional annual energy savings in 2016 (or 2010) (in GWh):

[20] ESD Annex III provides examples (a) to (o) of end-use actions, which are not exhaustive

[21] The Appendix to this checklist provides a non-exhaustive list of types of measures

Other important results:

► Calculation process, STEP 1: Unitary gross annual energy savings

- **Is an average or a participant-specific value used** (in kWh per unit, per action or per participant):

is it :
- o a level 1 default average value ? Please provide the value:
- o a level 2 national average value? Please provide the value:
- o a level 3 measure-specific average value? Please provide the value:
- o a level 3 participant-specific value ?

- **calculation method(s) used**:
- o direct measurement
- o billing analysis
- o enhanced engineering estimates
- o mix of ex-ante and ex-post data
- o deemed savings
- o other:

- **definition of the baseline**:

for the calculation of the unitary gross annual energy savings:
- o level 1: implicit baseline in the default value ?
- o level 2: average energy consumption based on national statistics or samples ?
- o level 3 (measure-specific): average energy consumption based on measure-specific definition/eligibility requirements of energy-efficient end-use actions, regional statistics or samples ?

In these cases, is the baseline based on
- o the stock (before action) situation?
- o the inefficient market (without measure) situation?
- o another reference situation for new buildings or equipment? If yes which?

Or is the baseline a
- o level 3 (individual) baseline: before action energy consumption specific to the participants, based on measurements, metered data or energy bills ? Or energy consumption of the participants if they would not have taken advantage of the evaluated measure ?

- **definition of the value of specific energy consumption for the energy-efficient solution**:

for the calculation of the unitary gross annual energy savings:
- o level 1: implicit average value in the default value ?
- o level 2: average energy consumption based on national statistics or samples ? How has the energy-efficient solution been defined (e.g., threshold value for specific energy consumption or specific technology parameter or choice):

- o level 3 (measure-specific): average energy consumption based on measure-specific definition/eligibility requirements of energy-efficient end-use actions, regional statistics or samples ?

- **main data used**:

Level 1 (European) data (and vintage):
Level 2 (national) data (and vintage):
Level 3 (measure-specific) data:

- **normalisation factors**:

→ What normalisation factors (see ESD Annex IV(1.2)) were taken into account?
How were they applied:

- **conversion factors**:

→ Was it necessary to use conversion factors (see ESD Annex II + caution: for the ESD, Net Calorific Values shall be used)?
If yes, specify the factors used:

- *rebound effect (optional):*

→ Was a possible rebound effect considered:
If yes, how:

► Calculation process, STEP 2: Total gross annual energy savings

- **accounting method:**
  - o national (or specific) register or database of final consumers or other actors benefiting from the measure
  - o other direct accounting (e.g. by vouchers or applications):
  - o market analysis
  - o survey among participants (all or sample?)
  - o survey among a sample of the whole population

→ Was the accounting completed by ex-post verifications (e.g. on-site inspections):

- **main data used:**

Level 2 (national) data (and vintage):
Level 3 (measure-specific) data:

► Calculation process, STEP 3: Total ESD annual energy savings

- **double counting**[22] (see ESD Annex IV(5))**:**

→ are other measures targeting the same end-users' group or the same energy end-uses and/or end-use actions?
If yes, how were double counting risks managed:

→ is there any risk of overlap between national and regional or local measures?
If yes, how was it addressed:

- technical interaction[23] :

→ is there any possibility of overlap between actions?
If yes, how was it considered:

- **multiplier effects** (see ESD Annex IV(5))**:**

→ was the evaluated measure (or group of measures) designed to have multiplier effects?
→ what multiplier effects were expected?
→ how were these multiplier effects monitored over time:
→ what was the result (in GWh/year of the *all* or *additional* annual energy savings reported above)?

- free-rider effects (only if *additional* energy savings have been calculated):

→ were possible free-rider effects considered?
If yes, how were they taken into account:
→ what was the result (in GWh/year of the *all* annual energy savings reported above)?

- *time lag (if relevant):*

→ *was there any risk of time lag in the measure implementation?*
If yes, how was it addressed:

→ *does the evaluated measure (or group of measures) include energy efficiency requirements?*
If yes, how was the compliance ensured / monitored:

► Calculation process, STEP 4: Total ESD annual energy savings in 2016 (or 2010)

- **lifetime of energy savings:**
  - o a level 1 European value ? if yes, harmonised or default value?
  - o a level 2 national value ?

[22] Double counting may occur when two measures overlap (e.g. grants and energy audits schemes for industrial companies).

[23] Technical interaction may occur when two actions overlap (e.g. improving both the insulation and the heating system of a building). This is considered a special form of the double-counting issue.

- o a level 3 measure-specific value ?
- o a level 3 participant-specific value ?

- *persistence effect (optional):*

→ *were the results monitored / controlled over time?*
If yes how (and what reasons of changes in the results were considered):

- **early energy savings** (see ESD Annex I(3))**:**

→ were energy savings from end-use actions taken before 2008 but after 1995 (in special cases 1991) reported?
If yes,

- o how much savings do they represent (*in GWh/year of the all and additional annual energy savings reported above*)?
- o were special calculation rules applied (e.g., a different baseline)?
- o how is it ensured that they will be still effective in 2016?

► Evaluation quality and uncertainties

→ what are the specifications / guidelines used to ensure the evaluation quality?

→ how are missing data handled?

→ can the uncertainties on the results be assessed or qualified? If yes, please provide the results

► Monitoring and evaluation costs

→ What types of costs are related to the monitoring and evaluation of the measure (or group of measures)?

→ Can these costs be assessed (e.g. in € for the whole evaluation, or in €/kWh saved)?

► References
(mention here the reports produced and any document used for the evaluation)

Appendix to the Reporting Checklist: Non-exhaustive list of energy efficiency improvement measures and mechanisms

Category	Subcategories
1 Regulation	Standards and norms: 1.1 Building Codes and Enforcement 1.2 Minimum Equipment Energy Performance Standards
2 Information and legislative-informative measures (e.g. mandatory labelling)	2.1 Focused information campaigns 2.2 Energy labelling schemes 2.3 Information Centres 2.4 Energy Audits 2.5 Training and education 2.6 Demonstration* 2.7 Exemplary role of the public sector 2.8 Metering and informative billing*
3 Financial instruments	3.1 Subsidies (Grants) 3.2 Tax rebates and other taxes reducing energy end-use consumption 3.3 Loans (soft and/or subsidised)
4 Voluntary agreements and Co-operative instruments	4.1 Industrial Companies 4.2 Commercial or Institutional Organisations 4.3 energy efficiency public procurement 4.4 Bulk Purchasing 4.5 Technology procurement
5 Energy services for energy savings	5.1 Guarantee of energy savings contracts 5.2 Third-party Financing 5.3 Energy performance contracting 5.4 Energy outsourcing
6 EEI mechanisms and other combinations of previous (sub)ca-tegories	6.1 Public service obligation for energy companies on energy savings + “White certificates” 6.2 Voluntary agreements with energy production, transmission and distribution companies 6.3 Energy efficiency funds and trusts

* Energy savings can be allocated to these subcategories only if a direct or multiplier effect can be proven. Otherwise they must be evaluated as part of a package.