How much energy saving is 1% per year? We still don't know, but we know better how to find out

Stefan Thomas
Wuppertal Institute for Climate Environment Energy, Germany
stefan.thomas@wupperinst.org

Piet Boonekamp
Energy research Centre of the Netherlands, Netherlands
boonekamp@ecn.nl

Harry Vreuls
SenterNovem, Netherlands
h.vreuls@senternovem.nl

Jean-Sébastien Broc
École des Mines de Nantes, France
jean-sebastien.broc@emn.fr

Didier Bosseboeuf
ADEME, France
didier.bosseboeuf@ademe.fr

Bruno Lapillonne
ENERDATA, France
b.lapillonne@enerdata.fr

Nicola Labanca
end-use Efficiency Research Group
Politecnico di Milano
Dipartimento di Energia, Italy
nicola.labanca@polimi.it

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Abstract

A crucial prerequisite for the successful implementation of the Energy Service Directive (ESD) is the availability of harmonised calculation methods for the energy savings achieved. Such methods will enable the Member States to prove that they attain the overall target of 9% or more energy savings by 2016. Since 2006, the EMEEES project, implemented under the European Commission's Intelligent Energy Europe programme by 21 partners and co-ordinated by the Wuppertal Institute, has worked on a set of 20 bottom-up and 14 top-down evaluation methods. It developed (1) an integrated system of bottom-up and top-down methods for the evaluation of energy services and other energy efficiency improvement measures; and (2) a set of harmonised default values for the methods.

The paper presents the overview of the final results on EMEEES' methods. It discusses the importance of measurement for the effectiveness of the ESD, looking at the quantity to be measured – all or additional energy savings – and early action. It compares the main elements of calculation needed to ensure consistent results between bottom-up and top-down methods and presents how EU Member States can prove achievement of ESD targets by EMEEES' methods. It also includes preliminary results from field tests of some of the developed methods.

Finally, general conclusions are drawn, e.g., about the difficulties and opportunities of doing research within a political environment with such a mixed consortium, and of trying to reach consensus or compromises in developing a harmonised evaluation system.

Introduction

The Directive on energy end-use efficiency and energy services (2006/32/EC; for the remainder of this paper abbreviated as the ESD) has raised concerns among the Member States about how they could evaluate the energy savings from energy services and other energy efficiency improvement measures implemented in order to achieve the indicative target of 9% energy savings in 2016. The constitution of an ad-hoc Committee of the Member States (hereafter named ESD Committee) has therefore been included in the Directive to assist the European Commission in the task of elaborating common and harmonised methods for the evaluation of energy savings. Due to the difficulties related to this task, the Commission also needed support from independent experts.

From November 2006 to April 2009, the IEE[1] project "Evaluation and Monitoring for the EU Directive on Energy End-Use Efficiency and Energy Services" (EMEEES) worked on a set of calculation methods and case applications, with 21 partners and co-ordinated by the Wuppertal Institute. The project partners were able to bring strong experience in evaluation methodology and practice as well as different perspectives to the consortium. They included energy agencies, a ministry, two energy companies, and several research institutes and consultancies; they are listed in the acknowledgements. The objective of this project

1. Programme Intelligent Energy Europe of the European Commission: http://ec.europa.eu/energy/intelligent/index_en.html

was to assist the Commission in the elaboration of evaluation methods through delivering practical advice, support and results. This included the development of concrete methods for the evaluation of single programmes, services and measures (mostly bottom-up), as well as with schemes for monitoring the overall impact of all measures implemented in a Member State (combination of bottom-up and top-down methods[2]).

The paper presents the overview of the final results on EMEEES' methods, concentrating on general results about the calculation methods that are overarching or integrating bottom-up and top-down methods, and on general conclusions. Two further papers for the 2009 eceee Summer Study (3176 Vreuls et al.; 3270 Bosseboeuf and Lapillonne) are presenting the results on bottom-up and top-down calculation methods in more detail. First results on evaluation methods already in use in EU Member States, and which methods are appropriate for which type of energy efficiency improvement measure, as well as preliminary results on bottom-up and top-down methods were already presented at the 2007 eceee Summer Study (Thomas et al., 2007).

This paper starts with a short presentation of the elements and results of the EMEEES project, followed by some proposals on addressing harmonisation issues. It continues with a discussion of the importance of measurement for the effectiveness of the ESD, looking at the quantity to be measured – all or additional energy savings – and early action. It compares the main elements of calculation needed to ensure consistent results between bottom-up and top-down methods both for all or additional energy savings. The paper then presents how EU Member States can prove achievement of ESD targets by EMEEES' methods. It also includes preliminary results from field tests of some of these methods for measuring the impact of energy efficiency improvement measures and energy services.

Finally, general conclusions are drawn, e.g., about the difficulties and opportunities of doing research within a political environment with such a mixed consortium, and of trying to reach consensus or compromises in developing a harmonised evaluation system.

The EMEEES project – overview of results

The direct results of EMEEES are (1) a system of bottom-up and top-down methods and their integrated application for the evaluation of around 20 types of energy efficiency technologies and/or energy efficiency improvement measures, harmonised between Member States; (2) a set of harmonised input data and benchmarks for these evaluation methods; (3) a template and a guide for Member States for the Energy Efficiency Action Plans; and (4) a method for the European Commission to assess the plans.

The overall results were presented at a one-day conference in Brussels in October 2008. All reports and case applications produced by the project are available at www.evaluate-energy-savings.eu. With regard to the methods developed by EMEEES, they include:

- Two summary reports on methods: bottom-up (Vreuls et al., 2009) and top-down (Lapillonne et al., 2009)
- Bottom-up methodological report
- 20 bottom-up case applications papers (cf. paper 3176, Vreuls et al., for the list)
- Compilation of EMEEES formulae for unitary gross annual energy savings, baselines, and default values as well as data to collect for bottom-up case applications
- Compilation report on 14 top-down case studies (cf. paper 3270, Bosseboeuf and Lapillonne, for the list)
- A report on consistency and the integration of the savings from bottom-up and top-down methods (Boonekamp and Thomas 2009)
- The EMEEES checklist for reporting the results of energy efficiency improvement (EEI) measures.

In the longer run, the project is expected to make an important contribution to a smooth implementation of the Directive on energy end-use efficiency and energy services. It will build trust and confidence that the overall target of 9% energy savings within 9 years can be achieved, and will thus support Member States in attaining their target.

Addressing harmonisation issues

A harmonised model of bottom-up and top-down calculation methods should be developed and used for the ESD reporting (cf. ESD article 15). Harmonisation should give a reasonable freedom for the Member States (following the principle of subsidiarity), while the results reported can be compared. Therefore, the methods and the 20 bottom-up and 14 top-down case applications developed by the EMEEES project are a starting point, but these methods and applications are not intended to exclude 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 Member States. However, harmonisation should be ensured by key elements proposed by EMEEES: a general structure both for the documentation of bottom-up and top-down energy savings and for the calculation itself, with the selection of baseline and baseline parameters as well as correction factors, and a dynamic approach to ensure improvement over time. In bottom-up measurement, a three-level approach has been proposed by EMEEES to facilitate such improvement over time: Level 1 is based on EU default values for energy savings per unit or for other parameters to allow countries that don't have monitoring and evaluation experiences a quick start. The default values are conservative and yield relatively low energy savings results, in order to encourage own monitoring, survey, and measurement activities at least at level 2, the national level. Evaluation of samples can be used to calculate national average default values that can be used to calculate overall energy savings. At level 3, measure-specific values can be developed to prove that savings are higher than national averages, or individual energy savings

2. Bottom-up methods start from data at the level of a specific energy efficiency improvement measure (e.g. energy savings per participant and number of participants) and then aggregate results from all the measures. Top-down methods start from global data (e.g. national statistics for energy consumption or equipment sales), then going down to more disaggregated data when necessary (e.g. energy efficiency indicators already corrected for some structural or weather effects).

Table 1. Three main categories of methodological outcomes.

Supporting Resources	Reporting Check-List	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 provide 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 Member States (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*

can be calculated for larger final consumers benefiting from an energy efficiency improvement measure.

These EMEEES proposals were based on past experiences and existing literature (e.g. CPUC 2006, SRCI et al. 2001, Tec-Market Works et al. 2004, Vreuls et al. 2005), taking account of the ESD specificities. Bottom-up and top-down methods can both be used for calculating ESD energy savings. In order to avoid "adding up apples and oranges" the key elements for top-down and bottom-up should also be mutually consistent. EMEEES findings on how to achieve such consistency will be presented later in this paper. The development of such a harmonised model is a learning process, and the methods should be improved in the future since more experiences from Member States will become available and lessons can be learned.

In the ESD process, the EMEEES results are not to be directly compulsorily used by the Member States. They are inputs to the work of the Commission and the ESD Committee. According to the harmonisation level needed for the ESD implementation, the decisions from the Commission and the ESD Committee may correspond to different levels of requirements ("could, should or shall"). It is therefore necessary to clarify what level of requirements the different EMEEES proposals correspond to. We hereafter distinguish supporting resources, reporting check-list and general principles, as described in table 1.

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 (2005/32/EC).

As these resources are not mandatory, they do not require a decision (validation) from the ESD Committee.

The **reporting check-list** 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 check-list is a quality assurance (on data, sources, etc.) that would enable the Commission to well compare data provided by the Member States on their achieved energy savings. An example of such a check-list can be found in (Vine and Sathaye, 1999). The check-list specific to ESD proposed by the EMEEES project will have to be validated by the European Commission and is included in the final bottom-up summary report of EMEEES (Vreuls et al. 2009: Appendix 6 of that report).

The checklist does not require Member States to apply a given method nor 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 check-list will also facilitate the collection and analysis of experience to share between Member States.

General principles correspond to the major and priority issues, for which harmonisation is required in order to achieve a harmonised evaluation system for all Member States. 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 Working Groups (or ESD Sub-Committee) [3]. The EMEEES work provided analysis about possible options that might be considered in these decisions.

Debates in the ESD Committee and Sub-Committees' meetings highlighted how difficult it is to get a consensus among the 27 Member States on harmonised evaluation rules. Indeed, sometimes lively discussions are needed so that national representatives let own experiences, standpoints or habits aside in order to agree on common proposals. Member States will always better accept them when they are in line with the rules they are used to. The EMEEES proposal to distinguish several levels of requirements is then very useful, as it focuses the debates on the highest level (i.e. general principles) and therefore limits the discussions on the main issues. At the same time, national representatives are reassured to see that for lower requirement levels they retain freedom on how to manage ESD implementation in their country.

3. To facilitate the decisions of the ESD Committee, two sub-committees were created to examine the most important issues respectively related to bottom-up and top-down evaluation approaches.

The importance of measurement for the effectiveness of the ESD

The primary objective of the ESD is to achieve at least 9% of annual energy savings[4] across the EU by inducing energy efficiency improvement measures and stimulating the energy services markets. Member States need to measure and prove the savings they achieved. But how much energy savings will these 9% really be? Will they contribute to the 'objective of saving 20% of the EU's energy consumption compared to projections by 2020' as stated by the European Council on 8/9 March 2007? The ESD does not explicitly mention that the energy efficiency improvement measures and the resulting energy savings shall be ***additional*** to the so-called autonomous savings[5] that energy consumers, investors, or other market actors would have done by themselves anyway. However, the ESD energy savings will need to be additional to autonomous savings, if the EU is to attain the objective of saving 20% of the EU's energy consumption compared to projections – hence, additional savings – by 2020. This is the case, although the two targets are not directly comparable, since the ESD target is on final energy savings and for each Member State, and the 20% target is on primary energy savings (hence, includes savings in power and district heat generation and transmission, and oil refineries) and for the EU as a whole. Final energy savings directly translate into primary energy savings. And the 20% target is so high that all Member States will at least have to come close to 9% ***additional*** energy savings for the Union to meet the 20% target[6].

Furthermore, the ESD states that ***'early action'*** can be counted towards the national energy savings target, albeit subject to guidelines by the European Commission. However, the ESD text can be interpreted in two ways: 'early action' could mean energy savings from technical or organisational action taken by market actors between 2008 and 2016 but facilitated by measures created before 2008 by Member States to achieve energy efficiency improvements (e.g., a building code revised in 2005 with tightened requirements) (we shall call this interpretation *'early measures'*), or it could mean energy savings achieved between 1995 and 2008 due to energy efficiency improvement measures (we shall call this *'early energy savings'*). A number of Member States have claimed early energy savings in their first national energy efficiency action plans (NEEAPs) filed in 2007. Up to 45 % of the 9 % target would be achieved through early energy savings by these Member States.

An analysis of these two issues has led to the following conclusions:

- If **all energy savings**, including those due to autonomous changes are allowed to count towards the ESD target, in the extreme case that all autonomous change is due to energy end-use efficiency and the Commission's estimate of 0.85% per year of autonomous improvement (EC, 2006) is correct for energy end-use efficiency improvements in the end-use sectors covered by the ESD as well, only ca. 0.15% additional annual energy savings each year (or 1.35% in 9 years) would be needed to achieve the target (cf. figure 1).
- If **'early energy savings'** from action taken between 1995 and 2007 are allowed, if their average saving lifetime according to CWA (2007) is 15 years, and if they reach 0.6% per year in each year from 2002 to 2007, only ca. 0.6% new annual energy savings would be required in each year from 2008 to 2016 (or 5.4% in these 9 years together; cf. figure 1).
- If **both** energy savings due to autonomous changes and 'early energy savings' from action taken between 1995 and 2007 are allowed, no additional energy savings at all may be needed between 2008 and 2016. The energy savings due to autonomous changes could be higher than those that remain to be made, after 'early energy savings' from action taken between 2002 and 2007 are counted towards the target of 9% (cf. figure 1). **This would render the ESD meaningless.**

What does this mean for a harmonised model of methods to evaluate energy savings for the ESD? If the ESD is to make a significant contribution to achieving the EU's target of 20% additional energy savings by 2020, as the 2006 EU Action Plan for Energy Efficiency assumed, the following **political conclusions** will need to be drawn for the implementation of the ESD:

1. **Not all energy savings** from all end-use actions to improve energy efficiency **should be allowed** to count for the ESD energy savings target **but only energy savings additional to autonomous changes** of energy efficiency. Member States should, under this condition, try with the highest appropriate effort to exclude energy savings due to autonomous changes from the calculation of ESD energy savings. The next section will present how to make bottom-up and top-down calculations of additional energy savings consistent with each other.
2. The best solution regarding 'early action' would be **not to allow 'early energy savings' to count towards the ESD target.** This will not put forerunners at a disadvantage, since they already have good experiences and have many – early – measures in place, which will create new energy savings during the 2008 to 2016 period.

However, it is not up to the EMEEES project to decide on the interpretation of the ESD. We therefore decided that our methods and case applications should enable Member States to **both** calculate **all** energy savings and the **additional** energy savings that are an impact of energy efficiency improvement measures. Furthermore, the methods and case applications need to enable Member States to assess whether early energy savings achieved before 2008 still exist in 2016.

4. ESD implementation covers 9 years (2008-2016). The national targets were calculated in 2007, and consist for each Member-State of 9% (or above) of its annual average energy consumption (in absolute terms (GWh)), based on a reference period (the most recent five-year period previous to 2008, for which data were available). The energy consumption taken into account in the ESD does not include that covered by the European Emission Trading Scheme (see Directive 2003/87/EC).

5. "brought about by natural replacement, energy price changes, etc." as stated in the EU Action Plan (EC, 2006)

6. See also the analysis in Boonekamp, 2009

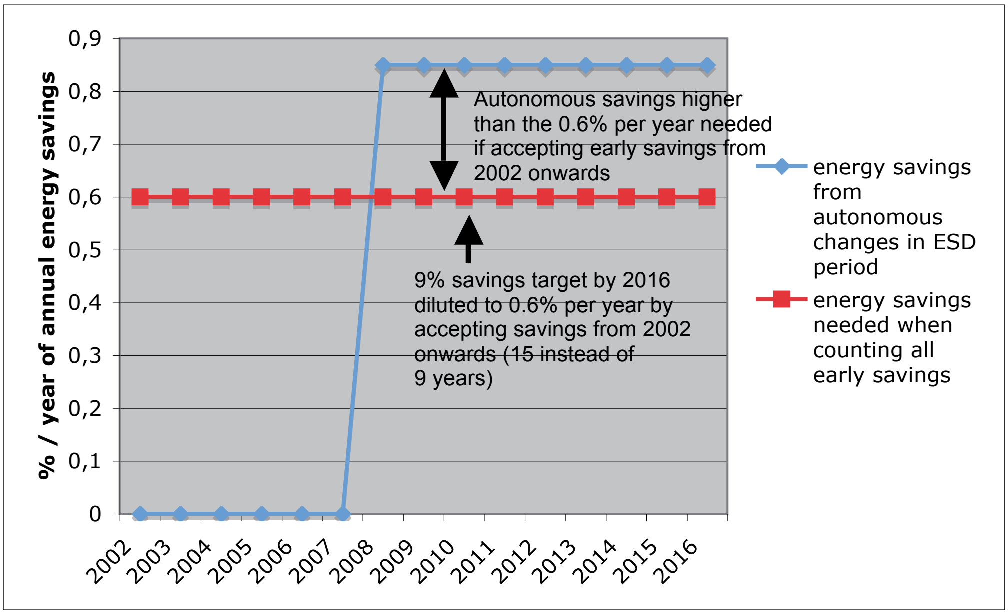

Figure 1: The potential effects of counting energy savings due to autonomous changes and 'early energy savings' (example)

Main elements of calculation needed to ensure consistent results between bottom-up and top-down methods

Following the considerations in the preceding section, the EMEEES project has developed methods and case applications that would allow the calculation of both additional or all energy savings.

- Additional energy savings[7] are understood as those that are additional to autonomous energy savings (i.e., to savings that would occur without energy efficiency programmes, energy services, and other energy efficiency policies such as building codes or energy efficiency mechanisms). These additional energy savings include additional energy savings due to existing policies, programmes, and services that are ongoing or have a lasting effect.
- By contrast, all energy savings are those resulting from all technical, organisational, or behavioural actions taken at the end-use level to improve energy efficiency, whatever their driving factor (or cause) (energy services, policies, or market forces and autonomous technical progress).

The ESD monitoring system can include bottom-up or top-down methods for monitoring and evaluation, or combinations of both (cf. ESD Annex IV for the definition of bottom-up and top-down methods and footnote above).

In order for it to be a harmonised system, the results of either bottom-up or top-down calculation must be consistent and comparable with each other. This requires that the elements of calculation need to be chosen in a consistent manner for both, and for the two evaluation targets introduced above: additional and all energy savings.

Bottom-up methods start from calculating annual energy savings for one final consumer or one piece of equipment. These so-called unitary energy savings can normally not be directly measured but need to be calculated from the difference between the energy-efficient situation after an energy efficiency improvement measure and a hypothetical baseline. For example, the savings for a specific dwelling are the calculated or measured gas use after a thermal insulation measure compared to the calculated or measured gas use before, normalising measured values for fluctuation in heating degree days. In some cases, the choice of the baseline is decisive for whether all or additional savings will be calculated, as table 2 presents. Then these so-called unitary energy savings per consumer or equipment are added together for all consumers or equipment affected by an energy efficiency improvement measure. However, the resulting total gross annual energy savings need to be corrected by some factors. The ESD requires avoidance of double counting but accounting for multiplier effects. It does not explicitly require correction for free-rider effects, i.e., savings by consumers who would have taken action without energy efficiency programmes, energy services, and other energy efficiency policies. Correcting for free-rider effects or not is, therefore, another element in the calculation of all or additional energy savings (cf. table 2 and paper 3176, Vreuls et al., 2009, for details on bottom-up calculations, baselines, and correction factors).

As for top-down methods, the overall energy savings are calculated from the difference in the current value of a particular statistical indicator used in a certain year, and the hypothetical value that is calculated for that year from a reference trend assumed. The simplest form of a reference trend is to take the value of the indicator in a base year as the reference. E.g., if the amount of gas use per dwelling decreases with respect to a base year, the difference is taken as energy savings. The resulting energy savings have been called 'total' savings ('total apparent' savings would be a better name), and the assumption is easily made that these are equivalent to 'all' energy savings. However, this intuitive calculation is only meaningful for indicators that have the 'right' trend over the years, a trend towards higher

7. For general discussions about additionality and baseline, see also (Vine 2008).

Table 2. Elements of calculation for the evaluation of additional or all energy savings that will ensure consistency between bottom-up and top-down methods

Evaluation target	**Elements of bottom-up calculation**	**Elements of top-down calculation**
Additional energy savings	Case 1: replacement of existing equipment Baseline = Without measure situation (market baseline) Case 2: add-on energy efficiency investment without replacement of existing equipment or building Baseline = Before action situation Case 3: new building or appliance: the before situation does not exist and a reference has to be created. Baseline = A reference situation° (e.g., (2) the existing market) Apart from avoiding double-counting and taking multiplier effects* into account, also free-rider effects* should be analysed in principle	Case a): for specific energy consumption indicators related to an end-use equipment (e.g., cars, refrigerators): Reference trend = EU default value (based on a regression analysis for all countries with data available, and on the average of the three countries with the slowest trend found in the analysis) Case b): for other types of indicators (unit energy consumption of sectors, diffusion indicators): b1) if possible, Reference trend for one country = extrapolation of historical trend before measures (from regression analysis for each country) b2) otherwise, the only option that appears consistent, however, feasibility was NOT tested within EMEEES: Reference trend = result of direct (bottom-up) modelling calculation or of correction of the indicator for structural effects, using (bottom-up) modelling In all cases: correction of reference trend for energy market price increase, using a default value for the short-term price elasticity of 0.1 or 0.2
All energy savings	Case 1: replacement of existing equipment Baseline = Before action situation (stock baseline if aggregated units are used) Case 2: add-on energy efficiency investment without replacement of existing equipment or building Baseline = Before action situation Case 3: new building or appliance: the before situation does not exist and a reference has to be created. Baseline = A reference situation° (e.g., (1) the existing stock) Apart from avoiding double-counting, only multiplier effects* have to be analysed in principle	The option that appears most consistent; however, feasibility was NOT tested within EMEEES: Reference trend = result of (bottom-up) modelling calculation of the development of the indicator without any technical, organisational, or behavioural end-use actions taken to improve energy efficiency. *In particular, zero change of the indicator between years would only be a correct reference trend, if all structural effects influencing the indicator value were removed**.* This may be feasible for specific energy consumption indicators related to an end-use equipment (e.g., cars, refrigerators). In these cases: Reference trend = base year (2007) value of the indicator

* In practice, this is often difficult, and so it is recommended to only assess multiplier and free-rider effects for EEI measures exceeding a threshold of annual energy savings of, e.g., 40 million kWh of electricity or 100 million kWh of other fuels. According to experience, the additional costs for evaluating these effects would still be below 1% of the overall costs of measures above this threshold.

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

** Despite the efforts of ODYSSEE to remove structural effects, the "total apparent" energy savings calculated by taking zero change of the indicator between years as the reference trend are, for most ODYSSEE indicators, **not consistent with calculating all energy savings**, and anyway feasible only for about 60% of all ODYSSEE indicators/countries analysed in EMEEES case studies. Taking these "total apparent" energy savings for proving the ESD energy savings would be **like a lottery** for the Member States.

Notwithstanding these principles, the actual EMEEES methods and case applications have looked for a pragmatic solution and often propose to drop some of these effects from the calculation, if there is no way, or it is too expensive to evaluate them.

Contents Keywords Authors

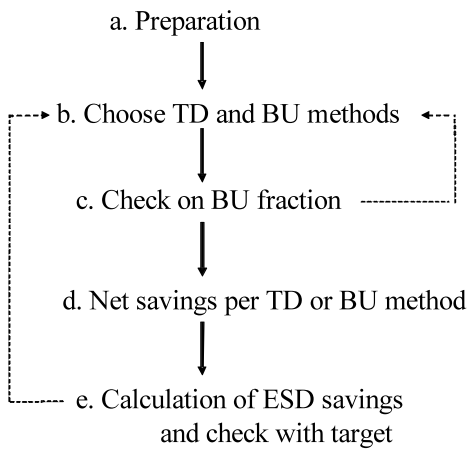

Figure 2: Process of evaluating ESD energy savings

energy efficiency. But that is only the case for about 60% of all the 14 indicators and countries analysed in EMEEES. This is because there are structural effects that also lead to changes in the indicator value but have nothing to do with energy efficiency. Therefore, these structural effects need to be corrected before calculating, if possible with reasonable effort. Such correction could be done by bottom-up modelling of some of the effects to correct them. With all structural effects removed, 'total' energy savings should be equal to 'all' energy savings. It may, however, be difficult to judge from the results whether all structural effects have been removed, and it may be costly to do the correction. An equivalent way, in principle, could therefore be to calculate the reference trend for 'all' energy savings from bottom-up modelling of the energy consumption underlying the indicator, with zero energy efficiency changes in the model. However, the feasibility of this approach was not tested in EMEEES.

For calculating additional energy savings, the approach taken in EMEEES is a regression analysis of past trends of an indicator that would reflect the autonomous changes. This was conclusive in some cases but not in others. In those latter cases, again, bottom-up modelling of the energy consumption underlying the indicator and the structural changes may provide a way forward, but EMEEES was not able to test it (cf. table 2 and paper 3270, Bosseboeuf, 2009, for details on top-down calculations and correction factors).

This section presents the **elements that would ensure consistency in principle**, see **Table 2**. It **must be noted** that only the elements of bottom-up and top-down calculations in either of the two rows of the table: additional energy savings and all energy savings, respectively, are consistent with each other. Using the elements of bottom-up calculation from one and those of top-down from the other row of the table would be highly inconsistent.

Applicability of the methods developed by EMEEES to prove attainment of the Member States' ESD targets

In the EMEEES project, 20 bottom-up (BU) and 14 top-down (TD) case applications have been chosen to calculate energy efficiency improvement in various end-use sectors. The choice of case applications was based on targeted energy use, where relatively large energy savings were expected. But available experience with evaluation methods has played a role as well in the choices.

EU countries can choose from these case applications when fulfilling the demands of the ESD:

- proving that the 9% or higher savings target has been met for 2016 (or the intermediate target for 2011)
- showing that BU case applications cover at least 20-30% of the energy use covered by the ESD
- taking account of overlap in the scope of TD and BU case applications focusing on the same targeted energy use, in order to avoid double counting of energy savings.

Figure 2 shows how, in an interactive process, countries can choose a set of case applications that meets the ESD demands. In step c the check on coverage takes place, in step d the correction for overlap ("net" instead of gross savings) and in step e the check on the 9% target.

The question arose whether the chosen set of TD and BU case applications fits to the needs and circumstances of the different EU countries. Therefore, a check was made how the countries could prove the 9% energy savings and meet the 20-30% BU coverage. To this end, for all countries an analysis was made of the applied energy efficiency improvement measures in their national energy efficiency action plan (NEEAP), and which TD and BU case applications could be used to calculate the savings of these measures. The results are given in Table 3**.**

The upper part of table 3 shows which BU methods can be used to calculate the ESD energy savings[8] of the measures specified in the NEEAPs. Another prerequisite for applying BU methods is availability of data. As no inventory on data was available, it was looked upon how countries quantified the savings of the energy efficiency improvement measures in the NEEAP. A distinction was made between applicable BU-methods in case of described-only measures ("Y") or quantified measures ("Q").

The results for households show many possibilities for the case application on new dwellings, slightly less on building envelope and heating, and substantially less on appliances and solar. For services application, possibilities are lower over the whole range due to fewer measures found in the NEEAPs. The same is true for all three case applications in transport. For industry (not being part of emission trading) there are hardly any opportunities for the four technology-specific case applications. General BU methods, like energy audits, white certificate systems and voluntary agreements, can be applied in a limited number of countries only. However, due to the large scope of

8. No results for Greece are presented due to the absence of an English version of the NEEAP. For Belgium both the results for Flanders and Wallonia are shown

Table 3: Overview of BU (upper part) and TD (lower part) case applications suitable for EU countries

	Countries																									
BU-methods	at	be	bg	cy	cz	dk	ee	fi	fr	de	hu	ie	it	lv	lt	lu	mt	nl	pl	pt	ro	sk	si	es	se	uk
H - New dwellings	Y	Q/Y		Q		Y		Q	Y	Q		Q	Y	Q	Y	Q		Q	Y	Q		Y	Q	Q	Y	Q
H - Building envelope	Y	Q/Y	Y	Q	Y				Y	Q	Q	Q	Q	Q	Y			Q	Y	Q	Q	Y	Q	Q	Y	Q
H - Heating systems	Y		Y	Q	Y			Q	Y	Q								Q	Y		Y	Y	Q	Q	Y	Q
H - Condensing boilers	Y	Q/Y	Y	Q	Y	Y					Q	Q						Q								
H - White goods	Y		Y		Y					Q			Q				Q	Q	Y	Q	Y	Y	Q	Q/Y	Y	
H - Solar, HP, etc	Y	Q/Y		Q	Y					Q			Q			Q	Q			Q	Y		Q		Y	
S - New buildings	Y	Q/Y		Q		Y		Q	Y	Q		Q	Y		Y	Q		Q		Q		Y	Q			Q
S - Heating systems	Y	Q/Y	Y	Q	Y				Y		Q	Q			Y				Y			Y	Q	?		
S - Lighting	Y	Q/Y	Y		Y					Q			Q	Q	Y					Q			Q	Q/Y		
S - VAC	Y			Q								Q	Q										Q	Q/Y		
S - Office appliances	Y									Q		Q		Q					Y	Q		Y		Q/Y		
I - Lighting-Industry		Q/Y																					Q			
I - VAC - Industry																										
I - Electric motors		./Y	Y										Q			Q							Q			
I - Variable speed			Y																				Q			
T - Eff.car-bus-truck	Y	Q/Y		Q	Y			Q	Y	Q	Q	Q	Y	Y		Y		Q	Y	Y		Y	Q	Y		
T - Eco-driving	Y							Q	Y	Q		Q	Q				Y	Q	Y	Q		Y		Q	Y	Y
T - Modal shift bus/bike	Y	Q/Y		Q	Y		Y					Q		Q	Y		Y		Y	Y		Y	Q	Q		Y
Energy audits		./Y	Y		Y			Q	Y					Q					Y			Y	Q	Q		
Energy Perf.Contracting	Y				Y?	Y				?	Q		?								?					
Vol.Agreement-sector		./Y						Q		Q		Y						Q	Y		Y			Q		Y/Q
Vol.Agreement-indiv.																										
TD-methods																										
H - Space heating	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y	Y	Y	Y	Y
H - Main appliances	Y		Y		Y			Y	Y	Y		Y	Y				Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
H - Solar Boiler	Y	Y	Y	Y						Y		Y	Y			Y	Y		Y	Y	Y		Y		Y	
T - New cars	Y	Y	x	Y	Y	x	Y	Y	Y	y		Y	Y	Y	x	Y	x	Y	Y	Y	x	Y	Y	Y	Y	Y
T - Vehicle stock			?	x		x	?	Y	Y	Y	Y	Y		Y	x		x	Y	Y	Y	x	Y	Y	Y	Y	Y
Tax on energy								Q		Y		Y		Y	Y								Y		Y	Y

these measures, they can compensate for few possibilities for the specific case applications.

The lower part of table 3 shows a selection of TD methods that are thought to be applicable in principle to prove both all savings, which can for these indicators be assumed to be close to apparent 'total' savings, as well as additional savings. Contrary to BU, no distinction is made between a case with described-only measures and quantified measures, because the selection of TD case applications already implies availability of data, as known from the ODYSSEE project on energy indicators.

The three applicable TD case applications for households resemble those of BU: many possibilities for space heating, fewer for appliances and fewest for solar boilers. The two cases on transport show moderate possibilities but the application is very limited for the TD case "taxes", which has the broadest scope.

Given the applicable TD and BU cases for the measures in each country's NEEAP, and an estimate of coverage per BU case and provable savings per TD or BU case, the following conclusions emerge from the analysis:

- In case all BU case applications can be applied, they can achieve more than 90% coverage of the energy use
- All countries except 3 can prove minimum coverage of 20-30% for BU methods
- Large contributions are from: space heating in dwellings and passenger transport
- Horizontal measures are important for coverage, as their scope is large
- One-third of Member States could have problems proving the 9% savings target, due to very different reasons: no transport measures in the NEEAP, no space heating (Malta), no ECS measure, few measures in general, etc.

Finally it showed up that some case applications are lacking, e.g. on CHP, street lighting, and mobility management. Generally, the set of case applications is sufficient but countries may have problems if they have few BU methods for targeted energy use, no horizontal measures, and only 6 to 8 out of 14 TD case applications are to be applied.

First results from the field tests

In co-operation with Member State governments, energy companies, and other organizations offering energy efficiency improvement measures, the EMEEES methods are being tested in six pilot tests. These will each evaluate ex post the energy savings from energy efficiency improvement measures implemented in various countries for a selected sector and end use, by making use of the methods and case applications tested.

The table 4 below reports the list of case applications being tested, whereas table 5 indicates which energy efficiency improvement measures are being evaluated. All the case applications tested are bottom-up excepting the last one in the list below, which is top-down.

Preliminary results are available from the field tests performed in Italy and France. In general the tests performed so far indicate that it is quite difficult to find a good compromise between accuracy and applicability of the methods being developed. Hereunder it is briefly discussed how this aspect emerged for some of the case applications presently under test.

Table 4: List of case applications being tested

EMEEES case applications	Sector	Italy	France	Denmark	Sweden
Building envelope improvement	Residential		X		
Energy-efficient white goods	Residential	X		X	
Biomass boilers in the residential sector	Residential		X		
Condensing Boilers	Residential	X	X		
Improvement of lighting system	Tertiary (industry)				X
High efficiency electric motors	Industry	X			
Variable speed drives	Industry	X			
Energy audit programmes (or as commercial energy efficiency service)	Tertiary and industry end uses			X	
Energy performance contracting	Tertiary and industry				X
Building shell and heating systems (Top-down case application)	Residential		X		

Table 5: energy efficiency improvement measures evaluated ex-post

Country	Subject	Sector(s) addressed
France	ADEME subsidies for renewable energies, VAT reduction on dwellings renovation works, tax credit for energy efficient equipments and renewable energies and French White Certificates.	Residential
Italy	Schemes under the Italian White Certificates system	Residential, tertiary, industry
Sweden	Energy Efficiency Investment Programme for Public Buildings (2005-2008)	Public non-residential buildings
Denmark	Energy audits performed in Denmark between2006 and 2008; Rebate programme by the Energy Saving Trust	Residential, tertiary

Concerning the EMEEES bottom-up case application related to the installation of condensing boilers in the domestic sector, the field tests have suggested that this case application should be simplified in some points. In particular, field test outcomes indicated that providing EU default values for energy efficiency improvements related to parts of the heating system like heat emitters, heat control systems and heating distribution systems might not be appropriate. It appears better to provide a single default value to only allow the evaluation of the energy efficiency improvement due to condensing boiler installation and ensuring that the case application is applied in case simple and effective operation standards are fulfilled (e.g. only in case condensing boilers with modulated burners are installed in heating systems where the water temperature does not exceed 60°C) than attempting to capture effects that are too difficult to estimate. This approach would ensure that real savings are generated and would make the method application simpler. On the other hand the field tests indicated also that the case application proposed should not neglect the energy savings due to domestic hot water production by condensing boilers, as the amount of such savings is generally considerable.

Concerning the EMEEES case application related to the installation of energy efficient motors in the industrial sector, the field tests performed showed that the EU default values provided for the motor load factors in case of different application types may make the EMEEES evaluation case application more reliable than the corresponding method used under the Italian white certificate scheme. On the other hand, default values provided for the number of motor operating hours appear too rough and may make EMEEES estimates not conservative. In general, it might be more appropriate and simpler to provide just the energy saving EU default values for various motor application types and motor power ranges rather than providing default values for load factors, operating hours and motor efficiency that are supposed to be used in an energy saving calculation formula by the evaluator.

In the case of the EMEEES case application related to the installation of variable speed drives (VSDs), the field tests showed that this case application aims at covering a range of VSD technological applications that is probably too wide. This would cause that this case application would disadvantage e.g. Italy with respect to other EU countries. In Italy, a highly specific method for VSDs used for water pumping systems has been developed under the white certificate scheme and results in less energy savings with respect to the energy savings estimated through the EU default values provided by the EMEEES case application. Therefore, other EU countries using the EMEEES method for the same VSD application would be rewarded with more energy savings despite that Italy has developed and applied a more accurate evaluation method. The tests of this case application seems to confirm the general principle that is better to propose a sufficiently accurate calculation method for a *specific* application than aiming at covering very different applications by too rough energy saving estimates.

Although the above-mentioned examples only refer to the verification of the appropriateness of the EU default values and the calculation formulas provided by the EMEEES methods, several other aspects are presently being tested and verified. Among the other aspects being tested we just would like to quote EMEEES method transparency (are all the assumptions and hypotheses made in the case applications clearly justified and understandable?), usability (is key information easily accessible? Can the method be easily applied to the specific context considered?), efficiency (which are the costs implied by the application of the method being tested?), equity (are there energy efficient technologies and solutions that might be penalized with respect to others by the evaluation?), adaptability (can the method being tested be easily adapted to possible evaluation methodologies already existing in a given country or vice versa?).

Test outcomes will be taken into account for the production of the final versions of the case applications and the underlying methods.

Conclusions and Outlook

How much energy saving is 1% per year? As we have seen, this largely depends on the interpretation that the European Commission and the Member States will take on some of the issues that are not really clearly defined in the ESD. The most important of these issues are the additionality or not of energy savings, and the 'early energy savings' that we analysed in this paper. We hope to have made the choices clearer with our analysis, and provided the ground on which the European Commission and the ESD Committee can decide.

Whatever the decision on these two issues will be, the recommendation we conclude from our analysis is as follows:

- Use top-down calculation methods for electric appliances and vehicles, for which there is a well-defined indicator of the sales-weighted specific annual energy consumption per unit of appliance or per vehicle, and for solar water heaters. In these cases, the indicator is well-suited to capture the effects of the whole package of measures, including multiplier (market transformation) effects. An EU harmonised reference trend can and should be defined for these indicators to calculate additional energy savings, and the base year value may be assumed to be a proxy for the correct reference trend for calculating all energy savings. Neither of these two reference trends are usually possible for the other types of top-down indicators: neither for indicators measuring the energy consumption of a sector per unit of production or per employee, nor for indicators measuring the diffusion of energy-efficient transport modes or combined heat and power in industry. For these indicators, some countries may see 'apparent total' savings, while others not, so the question remains what is the reason for this, and whether it would be fair between Member States, or rather a lottery, to use these results as such.
- Also use top-down methods to calculate the effects of energy taxation and add them to the effects of bottom-up calculations for a sector, but only if these bottom-up calculations exclude free-rider effects. The energy savings due to taxation must not be added to results of top-down calculations on sectors or end-use equipment, if the latter already include an analysis of price elasticities to separate the effects of energy taxation.
- Use bottom-up calculation methods for all other end-use sectors, end-uses, and energy efficiency improvement measures. This is particularly the case for buildings, for the industry and tertiary sectors with their larger final consumers that are easier to monitor, and for modal shifts and eco-driving in transport. In these areas, structural effects can often not be corrected for in top-down indicators, or it will need costly bottom-up modelling and gathering the necessary data for that modelling to do the required corrections. This will disable the use of top-down methods in such cases. By contrast, bottom-up calculations are usually feasible.

These recommendations are based on our analysis of case applications for bottom-up and top-down methods, as well as on practical experience in many countries and our pilot tests. They are based on the general trend of findings from these sources. For example, we estimate that with our total set of BU case applications, more than 90% coverage of the energy use subject to the ESD can achieved (see above). Bottom-up calculation needs specific monitoring but can provide information on the effectiveness and cost-effectiveness of measures, on potential improvements, and on greenhouse gas emission reductions additional to baseline projections. However, calculation of multiplier and free-rider effects can be costly, particularly for appliances and vehicles, for which the multiplier effects are particularly important. Top-down calculation starts from using existing statistical data and can be easier to apply, particularly in areas, for which many and overlapping energy efficiency improvement measures exist. However, it is often difficult to define the reference trend, or the indicator is not showing energy savings at all without costly corrections. Therefore, the quality of data available in a country will finally determine which bottom-up or top-down methods is best to apply for evaluating the energy savings for the ESD from a sector, an energy end use, an end-use action, or a measure.

There are, however, further open issues that are still not solved, e.g., how to deal with biomass, how to define the part of the energy consumption subject to the EU emissions trading scheme, or whether energy savings from short-lived measures may still be counted at least partly in 2016 due to multiplier effects over time. More analysis and/or decisions will be needed to clarify all these issues.

More analysis and field-testing of methods to calculate ESD energy savings will also be needed to learn more about the magnitude of uncertainty and methods for quantifying it. Total gross annual energy savings from all participants of an energy efficiency improvement measure can be calculated bottom up with reasonable accuracy. The accuracy will increase while going from level 1 to level 3 calculations, however, at an increasing cost as well. The baselines are also usually quite easily and accurately defined. However, bottom-up methods usually need a significant effort to estimate free-rider and multiplier effects, using surveys of participants, non-participants and other market actors. EMEEES therefore thinks that this effort could be spared for groups of measures that save less than, say, 40 million kWh of electricity or 100 million kWh of other fuels per year and provide less than 5% of a Member State's ESD target. Double counting can be avoided by evaluating the energy savings from the whole package of measures targeting a group of final consumers, an end use, or an end-use action, but this may require extensive databases of single end-use actions vs. measures.

Top-down methods, in turn, will automatically deal with multiplier effects and double counting, and also free riders if the autonomous trend is taken as the reference. However, what is the reference trend, i.e., the counterfactual that would have been without the energy efficiency improvement measures? The uncertainties around this counterfactual reference trend are potentially very large, as we have discussed above, and need more analysis and testing, too. This is true, no matter whether the aim is to calculate all or additional energy savings.

It will often be possible to gather the necessary data at quite limited costs, if the monitoring is planned before implementing an energy efficiency improvement (EEI) measure. In addition, it will only be necessary to evaluate the influence of the whole package of EEI measures targeting a specific end use or end-use action. For the ESD, there is no need to distinguish, e.g., the energy-saving effects of an information campaign on energy-efficient lighting in tertiary buildings from the effects of an audit programme and/or a financial incentive programme targeting the same subject. It is, therefore, a task for the Member States to find a solution for monitoring that is a good compromise between evaluation cost and accuracy.

While the solutions may be inexpensive, it is important that methods on the same type of EEI measure be consistent between Member States: this is the objective of 'harmonisation'. Here, the concept of the three levels of evaluation efforts and accuracy will be crucial. Member States with little experience can start by using parameters that were defined as conservative EU level default values. The conservativeness provides an incentive to perform evaluations at national or even lower level. Such Member State-specific evaluations will need to use harmonised methods, i.e., methods that allow for consideration of the differences between Member States, but make the results comparable between Member States and do not favour one Member State over another. A specific issue for harmonisation is also how to evaluate the energy savings from 'early action' between 1995 and 2007, as far as allowed for the ESD.

The cost that evaluation entails is another reason for EMEEES to propose for bottom-up evaluations 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 particularly 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.

With the EMEEES project, we tried our best to contribute to clarification of the question for this paper from the ESD perspective: How much energy saving is 1% per year in the framework of the 9% targets set by the Member States under the ESD? What will be the calculated as the result of the energy efficiency improvement programmes, energy services, and other energy efficiency improvement measures that the Member States create or stimulate in order to fulfil their target?

It is clear that doing research and development of a normally technical issue such as measurement and calculation methods for energy savings under such lack of clarity of the basics is far from easy. It was further complicated by the highly political environment with its diverging interests. These were sometimes also present within the EMEEES consortium.

On the other hand, the many open issues and the need to develop a harmonised measurement system for a new purpose also presented an intellectual challenge, and an opportunity to give the implementation of the ESD and its process a clearer shape.

The results of our work were discussed with the Member States and with the expert public in a series of workshops and conferences, and are available as soon as they are publishable at www.evaluate-energy-savings.eu. These various dissemination activities made it possible to get rich feedback from concerned stakeholders. Some of the proposals (e.g. evaluating additional savings) were the subject of lively debates. But most of the comments were constructive, and despite some disagreements, all stakeholders welcome the results from EMEEES as valuable inputs, both for the ESD Committee discussions and for the ESD implementation in each country. The efforts to build a common language were also appreciated, as this is very helpful in avoiding misunderstandings. Finally, the discussions about the EMEEES project were a good starting point in many Member States to put evaluation issues on the agenda and launch a learning process, especially in the new Member States.

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Project partner	Country
Wuppertal Institute for Climate, Environment, 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
Enerdata sas	FR
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
Swedish Energy Agency (STEM)	SE
Association pour la Recherche et le Développement des Méthodes et Processus Industriels (ARMINES)	FR
Electricité de France (EdF)	FR
Enova SF	NO
Motiva Oy	FI
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