How to measure the overall energy savings linked to policies and energy services at the national level?

Dr. Stefan Thomas, Wuppertal Institute for Climate, Environment and Energy, Wuppertal, Germany
Dr. Piet Boonekamp, ECN, Petten, the Netherlands
Harry Vreuls, SenterNovem, Sittard, the Netherlands
Dr. Jean-Sébastien Broc, École des Mines de Nantes, France
Didier Bosseboeuf, ADEME, Paris, France
Dr. Bruno Lapillonne, Enerdata, Grenoble, France
Nicola Labanca, eERG/Politecnico di Milano, Milano, Italy

ABSTRACT

From 2006 to 2009, the European project EMEEES, with 21 partners and co-ordinated by the Wuppertal Institute, has worked out an integrated system of bottom-up and top-down methods for the measurement of energy savings. This is to support the implementation of Energy End-use Efficiency and Energy Services Directive of the European Union. The Directive required the development of harmonised calculation methods to be used by Member States to prove that they attain the overall target of 9 % annual energy savings by 2016.

The paper presents the overview of the final results on the methods developed by the EMEEES project. The proposals, inter alia, include 20 bottom-up and 14 top-down case applications of general evaluation methods. They enable more than 90 % of the potential energy savings to be measured and reported and were used as a starting point by the European Commission to develop the final methods to be used by Member States – a still ongoing process.

Furthermore, the paper briefly discusses the importance of the quantity to be measured – all or additional energy savings – and the effect of past measures ('early action'), and what this meant for the methods to be developed. It compares the main elements of calculation needed to ensure consistent results between bottom-up and top-down methods at the overall national level.

Finally, general conclusions are drawn from the findings of EMEEES about what could be the next steps in developing an evaluation system that enables a high degree of comparability of results between different countries.

Introduction

From 2006 to 2009, the European project "Evaluation and Monitoring for the EU Directive on Energy End-Use Efficiency and Energy Services" (EMEEES), with 21 partners and co-ordinated by the Wuppertal Institute, has worked out an integrated system of bottom-up and top-down methods for the measurement of energy savings induced by energy services and other energy efficiency improvement (EEI) measures. This work had the aim to support the implementation of Energy End-use Efficiency and Energy Services Directive (ESD) of the European Union (EU). The Directive required the development of harmonised calculation methods to be used by Member States to prove that they attain the overall target of 9 % energy savings by 2016. The constitution of a regulatory Committee of the Member States (hereafter named ESD Committee) has therefore been included in the Directive to assist the European Commission, i.a., 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 and provided funding to the EMEEES project. The EMEEES 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.

The unique feature of this project's task was the focus on the measurement of overall energy savings at the national level due to the complete portfolio of national, sub-national, but also EU-wide policies and measures, and even commercial energy services. In addition, the evaluation results need to be comparable between the EU Member States, so the methods need to be harmonised.

This paper presents the overview of the final results on the methods developed by the EMEEES project, including the most important principles and one example of a case application for both bottom-up and top-down calculation. The project developed proposals that were used as a starting point by the European Commission to develop the final methods to be used by Member States. The proposals, inter alia, include a set of 20 bottom-up and 14 top-down evaluation case applications of general evaluation methods. These include harmonised default values for most of the bottom-up methods. The methods and case applications developed by EMEEES are thus harmonised between Member States to the extent possible and enable more than 90 % of the potential energy savings to be measured and reported.

Furthermore, the paper briefly discusses the importance of the quantity to be measured – all or additional energy savings – and the effect of past measures ('early action'), and what this meant for the methods to be developed. It compares the main elements of calculation needed to ensure consistent results between bottom-up and top-down methods at the overall national level and present the applicability of the methods developed by EMEEES in the EU Member States. It also includes results from one of the field tests of the methods.

Finally, general conclusions are drawn from the findings of EMEEES about what could be the next steps in developing an evaluation system that enables a high degree of comparability of results between different countries.

Overview of Bottom-up and Top-down Methodology

Bottom-up methods

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 (Broc et al. 2009) and are used in each case application.

Bottom-up methods start from calculating annual energy savings for one final consumer or one piece of equipment. These so-called **unitary gross annual 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 (cf. discussion and table 2 below).

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[1]. Avoiding double-counting is an important issue when trying to evaluate overall energy savings for one country or region from multiple enery efficiency policies and measures with bottom-up methods. The ESD, in contrast, does not mention correction for free-rider effects, i.e., savings by consumers who would have taken the 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 below for details on bottom-up calculations, baselines, and correction factors).

All of these correction factors will add uncertainty to the results and need careful evaluation.

[1] 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".

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

+ ***summing up across 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. discussion below. This effect is not mentioned in the ESD.
Note: EEI = energy efficiency improvement

Figure 1: A four steps calculation process.

Two general formulas can be derived from this four-step process for the **total ESD annual energy savings** in the first year; they are classic bottom-up evaluation formulas (cf., e.g., also SRCI et al. 2001, p. 65):

1. If average unitary gross annual energy savings for a unit of end-use action can be defined, the formula will be:

total ESD annual energy savings
= average unitary gross annual energy savings per equipment (or participant)
* number of equipment (or participants)
* (1 - *free-rider fraction*° + multiplier fraction)
* (1- double-counting factor/fraction)

° only if additional energy savings are calculated **Equation 1a**

2. If individual unitary gross annual energy savings for one (usually larger) final consumer benefitting from an energy efficiency improvement measure (called a participant) have to be used, the formula will be:

total ESD annual energy savings
= sum of individual unitary gross annual energy savings per participant
* (1 - double-counting factor/fraction (average or individual))
* (1 - *free-rider fraction*° + multiplier fraction)

° only if additional energy savings are calculated **Equation 1b**

In both cases of the formula:

- the free-rider fraction is the share of free-riders, between 0 and 1
- the multiplier fraction is equivalent to spill-over effect and is ≥ 0
- the double counting factor/fraction is a coefficient or fraction between 0 and 1

Top-down methods

top-down methods rely on **energy efficiency indicators** calculated from national statistics (also called ‚top-down indicators', e.g., ODYSSEE indicators). There are several types of indicators:

- Specific energy consumption indicators for a well-defined type of new appliance, equipment, or vehicle, measuring the average energy consumption of the sold equipment or the equipment stock in energy/appliance/year or energy/km
- Unit energy consumption indicators of a sub-sector or sector, e.g., electricity/employee/year in the tertiary sector, process fuels per ton of cement, heating energy/m^2 of dwelling/year
- Indicators on the diffusion of energy-saving technologies, such as m^2 of solar thermal collectors, or energy-efficient transport modes, such as the share of trains and ships in goods transport.

Furthermore, a special econometric method based on the analysis of price elasticities can be used to evaluate the effects of energy taxation from any indicator.

The analysis of top-down methods done by EMEEES is presented in a summary report (Lapillonne, Bosseboeuf&Thomas 2009) with a separate Annex presenting the ODYSSEE indicators in more detail, and a second summary report on the top-down cases analysed in EMEEES (Lapillonne&Desbrosses 2009).

With 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. For example, if the average 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 (however, 'apparent total' savings would be a better name), and the assumption is easily made that these are equivalent to *all* energy savings.

However, this intuitive assumption is only meaningful for indicators that have the 'right' trend over the years, a trend towards higher energy efficiency. But that is only the case for about 60 % of all the 14 ODYSSEE indicators and countries analysed in EMEEES. For some indicators, there are all cases of countries with a decreasing, increasing, or stable trend. 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 energy savings, if possible with a reasonable effort. Such correction could be done by bottom-up modelling of some of the effects to correct them. With all structural effects removed, 'apparent 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 using top-down methods, 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 below for details on top-down calculations and correction factors).

Using such regression analysis in principle allows to evaluate energy savings compared to an autonomous trend, even if the trend of the underlying indicator does not allow to calculate 'apparent total' energy savings. However, there is significant potential uncertainty in the autonomous trend.

Simple econometric methods were used to quantify the impact of energy market prices and trends, on purpose, taking into account several criteria:

- the need for transparency and of harmonisation among countries,
- the easiness of implementation and of their understanding, as such methods would ultimately need to be applied by the countries;
- finally, the data limitations, in particular for additional explanatory variables (e.g., price/tax on cars, cost of equipment) and the uncertainty of the data handled.

The typical regression equation considered was follows:

$$\ln ES = a + b\,T + c \ln P + d \ln A + K$$

with : ln : logarithm; ES: energy saving indicator; a: a constant; b: trend; T: time; P : energy price; c : price elasticity[2] ; A: macro economic variable (e.g. GDP) to capture the impact of business cycles; d : elasticity to GDP; K: constant coefficient

Equation 2

The estimate of the regression coefficient is made over a period ending before the period on which the effects of facilitating measures will have to be assessed (e.g., before 1995). Then using the coefficient, the impact of the different effects can be modelled, using driver data, to obtain the reference trend over the period on which the ESD savings will be calculated (i.e. 2008-2016) (Figure 2). The price effect can be separated into two components, ex-tax energy price (market component) and an energy tax if that exists (policy component), using the same price elasticity .

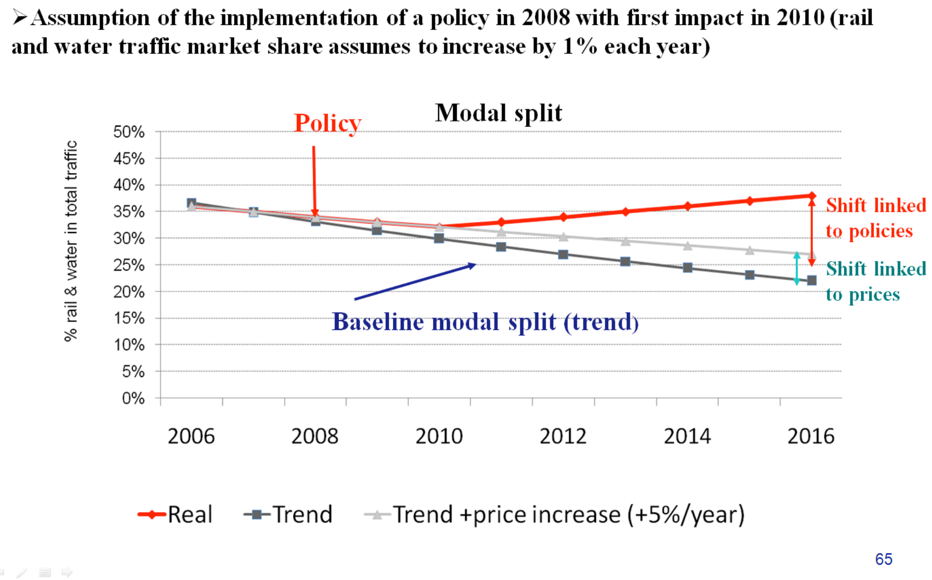

Figure 2: An example of the calculation of changes in an indicator vs. the reference trend determined through regression analysis (indicator on modal shares in goods transport)

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.

2 Price elasticity may be differentiated between upward and downward price elasticity.

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. EMEEES has proposed a number of such default values in bottom-up case applications, available at www.evaluate-energy-savings.eu. 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 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, TecMarket 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 and 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 the table below.

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*

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 & 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 report of EMEEES (Wuppertal Institute 2009: Appendices 2 and 3 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.

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

[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.

[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)

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 3).
- 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 3).
- 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 3). **This would render the ESD meaningless.**

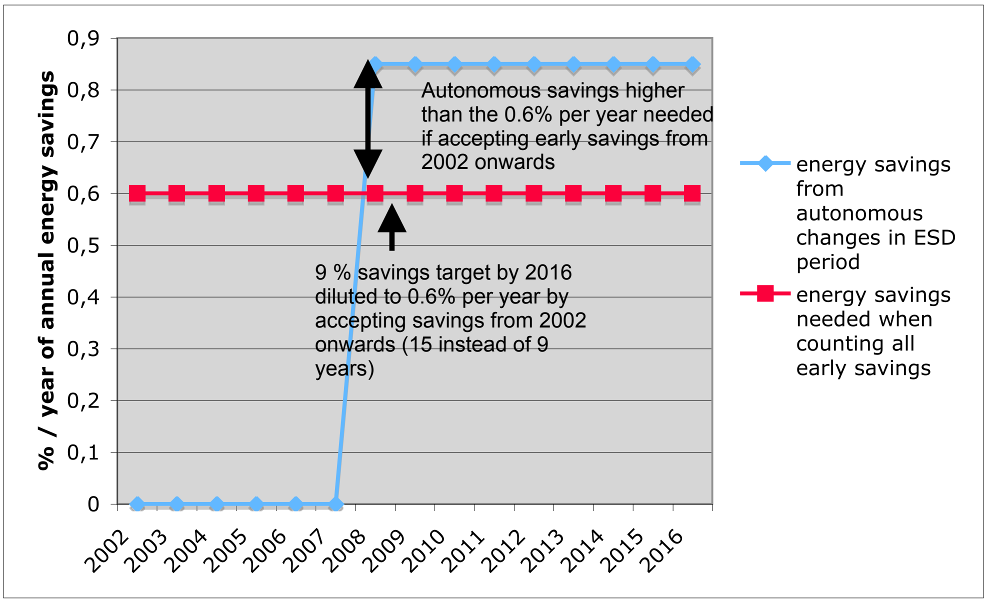

Figure 3: The potential effects of counting energy savings due to autonomous changes and 'early energy savings' (example)

[6] See also the analysis in Boonekamp 2010

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.

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.

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.

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, i.e., 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.

[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; *e.g., for refrigerators, the average annual energy consumption of the not energy-efficient models sold*) Case 2: add-on energy efficiency investment without replacement of existing equipment or building (*e.g., thermal insulation*) Baseline = Before action situation (*in the example, energy consumption of the building before thermal insulation*) 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, *e.g., stock of refrigerators*) 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) and for the stock of solar water heaters. 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.

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 choice.

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.

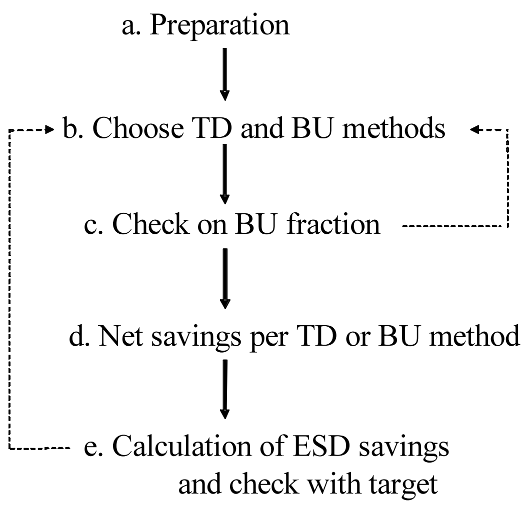

Figure 2: Process of evaluating ESD energy savings

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 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 with the EMEEES set of case applications, 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 and no horizontal measures, since only 6 to 8 out of 14 TD case applications can usually be applied.

Example 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 were tested in six pilot tests. These each evaluated 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 3 below reports the list of case applications being tested, which are all bottom-up.

Table 3: List of case applications being tested

EMEEES case application	Sector	Italy	France	Denmark	Sweden
Building envelope improvement	Residential		X		
Energy-efficient white goods	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 audits	Tertiary and industry			X	
Energy performance contracting	Tertiary and industry				X

Out of the results, we would like to present some from the field tests performed in France. The pilot tests performed under the **French** White Certificate (FWC) scheme focused on end-use actions addressing space heating in the residential sector, as most of the white certificates have been issued for such actions so far. In general, pilot test outcomes suggest the necessity to keep flexibility for each Member State in order to use the methods best adapted to its context, provided the global bottom-up methodology of 4 steps and 3 levels remains harmonised at the EU level. During the pilot tests, energy saving amounts estimated resulted to largely depend on parameters describing the 'before measure' situation (baseline). The adopted estimates must hence be explicitly sourced and the assumptions used should be transparent.

In the case of building insulation end-use actions, the savings estimated from the FWC scheme and the EMEEES case application[8] appear to be similar when using the same main parameters. However, significant differences are observed in the calculated energy savings in the tested building, mainly due to differences in the values used for the initial thermal transmission. In fact, EPC results using actual values

[8] Engineering estimates obtained from building energy performance certificates (EPC) have been considered according to the EMEEES case application.

of the building are lower than FWC values based on deemed values of baseline parameters (e.g., U-values before refurbishment). This highlights how important the baseline choice is.

In the case of end-use actions addressing condensing boiler installation, there is a significant gap between level 1 (European default values) and level 2 (national average) results. This highlights that either the proposed level 1 default values may be too conservative even when calculating **all** energy savings, or the FWC values overestimate the savings (for condensing boilers), especially due to the low boiler efficiency used in the FWC baseline. Although it is possible at a national level to use a particular baseline to encourage a given action, for the ESD reporting, this should be justified or not allowed, for harmonisation purpose. In this case, at least, the low level 1 default value provides a clear incentive to proceed towards level 2 or 3 evaluation.

Test outcomes were 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 for **calculating overall energy savings on the national level**, as required for the ESD, is as follows:

- **Top-down** calculation methods can be used for **electric appliances and vehicles**, for which there is a well-defined statistical indicator of the average specific annual energy consumption per unit of appliance or per vehicle, and for **solar water heaters**. In these cases, the top-down indicator is well-suited to capture the effects of the whole package of measures, including multiplier (market transformation) effects. **Bottom-up** calculations are possible for appliances and vehicles, too, but it is often difficult to calculate multiplier (and free-rider) effects with them.
- **Top-down** methods are the way 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 to calculate the effects of energy taxation.
- It is the best and often the only possible way to 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.

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.

However, the **quality of data available in a country** will finally determine which bottom-up or top-down methods are 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. It is, therefore, important that the accessibility, quality, and availability of data be considered when policies and measures are formulated and implemented in the ESD context. If evaluation methods and data collection are planned from the very beginning, this will improve data and evaluation results and often reduce the evaluation costs at the same time. Still, uncertainty will remain an issue in calculation of energy savings, since they can only be calculated in relation to a counterfactual (which we call 'baseline' in bottom-up and 'reference trend' in top-down calculations but which also includes some correction factors), and there will remain a trade-off between precision of results and evaluation effort.

The ESD has, therefore, required the European Commission to propose a **harmonised calculation model** of bottom-up and top-down calculation methods for ESD energy savings. Some thoughts were presented above about what harmonisation could mean in practice. As insiders report, the European Commission has based its proposals for the calculation model at least in part on the methods developed by the EMEEES project, however, the ESD Committee has not yet achieved an agreement. Debates seem to continue on the issues of simplicity vs. precision and which factors to include or not, the effort needed, and in which areas to use bottom-up vs. top-down calculations. This also appears to based on traditions that some Member States have in using methods, or their level of policy ambition.

Certainly, the Commission and the Member States could decide to use as many **default values** as possible. EMEEES has developed some proposals in this area, too. They will calculate rather low levels of energy savings to encourage Member States to perform national evaluation efforts.

On the other hand, the precision of results will deliberately be higher if national level 2 and 3 calculations (bottom-up) and national reference trends (top-down) are used, but with **harmonised rules for** a) definition of formulas, parameters, monitoring, and calculation procedures, particularly for the counterfactual, and b) **harmonised reporting of results**. This is certainly an area, in which more experience needs to be collected in the next round of NEEAPs in 2011. These NEEAPs will include the first ex-post calculations of energy savings. And we again very **strongly recommend to require harmonised reporting** using at least a format such as the reporting checklists we have developed and present in Appendices 2 and 3 of the final report. This will then allow the Commission to better judge the plausibility and comparability of savings (and hence efforts) between Member States and in many cases also a verification of the reported energy savings, using models such as the adapted MURE assessment tool developed by EMEEES.

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- Bottom-up methodological report (Broc et al. 2009)
- 20 bottom-up case applications papers
- Compilation report on 14 top-down case studies (Lapillonne&Desbrosses 2009)
- A report on consistency and the integration of the savings from bottom-up and top-down methods (Boonekamp&Thomas 2009)
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