Energy Savings Calculations: What Are We Heading For? Increasing Libraries of Guidelines and Handbooks or Global Harmonization and (Inter)national Standards?

Harry, H.J. Vreuls, SenterNovem, The Netherlands,
Piet, G.M. Boonekamp, ECN, The Netherlands and
Klemens Leutgöb, E-Sieben, Austria

Abstract

This paper introduces emerging European standards for energy-related topics and the role that new standards for energy savings calculations can play. The new standards allow for calculation rules from different perspectives: energy savings based on top-down indicators, energy savings based on bottom-up information (e.g., from the evaluation of actions and programs), and micro energy savings (for appliances and system components). The paper concentrates on bottom-up energy savings calculations, presenting the scope of the draft standard, discussing the applicability of measures, and describing system boundaries. In addition, the paper presents parameter definitions that will be included in the draft standard that will be presented for official comment to European Standard Organization members. The most important definitions—energy delivered, energy used and energy efficiency—are presented in the paper.

The paper also presents the initial results from a related project that the International Energy Agency (IEA) started as part of the Implementing Agreement for Demand Side Management (IEA DSM Agreement) in early 2009. This project identifies basic concepts, calculation rules and systems for energy savings calculations standards. Within this framework the relationship to greenhouse gas (GHG) emission reduction is also incorporated. The provisional basic concept will be compared with the general terms and definitions in the draft EU standard on energy savings calculations. The paper concludes by describing the potential of both projects to contribute to the general rules for calculating GHG emissions from internationally-supported energy saving projects in less developed countries.

Introduction

The number of handbooks, guidelines, instructions, etc. dealing with energy savings calculations in program evaluations continues to grow. Websites by the International Energy Program Evaluation Conference (IEPEC), the California Measurement Advisory Council (CALMAC), the Consortium for Energy Efficiency (CEE) and others contain references to several hundreds of these documents. The debate on baselines, the most appropriate reference situation (the counterfactual), net-to-gross energy savings, etc. seems to be never ending. Should we continue to put more and more efforts into evaluations that debate the details of an energy saving calculation if a specific case evaluation shows that one or more assumptions are not valid? Or should we try to summarize the main elements in the energy savings calculations and move in the direction of international standards? This paper argues for the second option.

This paper introduces the broader context for European standards for energy savings calculations from different perspectives: energy savings based on top-down indicators, energy savings based on bottom-up information (e.g., from the evaluation of actions and programs), and micro energy savings (for appliances and system components), with a more detailed focus on bottom-up energy savings calculations, discussing the scope of the draft European standard, applicable targets for measures and system boundaries. Specific definitions of energy delivered, energy used and energy efficiency are

suggested for inclusion in the standard, as well as a four-step model for calculating energy savings in a target year. In addition, we present a recently initiated project within the International Energy Agency's (IEA) Implementing Agreement for Demand Side Management (IEA DSM Agreement). This project identifies basic concepts, calculation rules and systems for energy savings calculations that should be used for future international standards. It also includes relations to greenhouse gas (GHG) emissions. The results of this IEA project could be use in measurement, reporting and verification (MRV) rules that are under discussion for the post-Kyoto GHG reduction commitments. We conclude on the potential of the EU standardization and the IEA harmonization projects to contribute to general rules for energy savings calculations and related GHG emission reductions from internationally supported energy saving projects and programs in less developed countries.

Development of harmonized European energy savings calculations

In the European Union (EU) several Directives have been adopted requiring EU Member States to improve energy efficiency. One of the most important Directives is the Energy Services Directive (ESD) 2006/32/EC. ESD, which was adopted in 2006, requires member states to target national energy savings of 9% by 2016 through implementation of end-use energy efficiency improvements and related services. Reporting on this target should be based on the general framework established in an Annex to the Directive. But harmonized measurement and verification methods for energy savings have not been developed. To address this need, a research project, Evaluation and Monitoring for the EU Directive on Energy End-Use Efficiency and Energy Services (EMEEES), was initiated in November 2006 to develop specific methods for calculating energy efficiency improvements for three areas: top-down calculations, bottom-up calculations, and calculations based on combining the previous two methods. The project is being funded by the EU and being implemented by a consortium of 21 European partners who are coordinating the effort through the Wuppertal Institute for Climate, Environment and Energy. Top-down calculations start from using existing statistical data and result in energy efficiency indicators. These can be easier to apply, particularly in areas for which many and overlapping energy efficiency improvement measures exist. Bottom-up calculations are targeted to the evaluation of single or multiple programs, services and measures, and can provide information on the effectiveness and cost-effectiveness of measures, on potential improvements, and on GHG emission reductions additional to baseline projections. The reports from the EMEEES project are available at http://www.evaluate-energy-savings.eu. The European Commission is expected to finalize additional rules for energy savings calculations this year.

The European standardization bodies CEN and CENELEC decided in 2006 to develop European standards taking into account the needs for agreed definitions and methods in the field of energy savings. Two Task Forces were initiated: one for energy management systems (TF189) and one for energy savings calculations (TF 190). The European standard(s) to be developed within TF 190 cover(s) the following topics:

- the definition of the methodology and general rules of calculation including the baseline (reference consumption) and benchmarking (how to evaluate the improvements);
- terminology and definitions;
- parameters and data, including saving lifetime, data quality and data sources.

These topics apply to both top-down and bottom-up methods, while also a more general methodology might be defined to allow combining the saving results acquired through both methods. The standard has

to rely on the results of the research project teams, particularly EMEEES and ODYSSEE[1] projects. The standard will also take into account existing EU legislation (e.g,, the promotion of cogeneration) and more specifically the Directive on the Energy Performance of Buildings (EPBD; Directive 2002/91/EC) and the Directive on the Eco-design of Energy-using Products (Eco-design; Directive 2005/32/EuP). It still has to be decided whether one, two or three separate standards will be developed. It will take at least the next two years before these standards might be accepted by CEN and even then it will be voluntary in its application in the countries that are members of CEN and CENELEC. However, it will be an obligation for National Standardization Bodies to implement the European Standard as an identical national standard and to withdraw conflicting standards. In the next section, we present the main findings from the informal version of the bottom-up standard that became available in June 2009.

Draft European standard for bottom-up energy savings calculations

Since 2007 experts from Austria, Belgium, Denmark, Finland, France, Germany, Italy, Sweden, the Netherlands and the United Kingdom, as well as from the European Commission, participated in the bottom-up Working Group to define the scope, objectives, definitions and systems approach.

General approach

The draft informal standard provides a general approach for bottom-up energy efficiency and energy savings calculations. This approach should be broadly applicable for energy savings in buildings, cars, appliances, industrial processes, etc., but at the moment it only holds specific details regarding buildings. The object of the assessment in energy saving calculations is the *end-user action*; an energy efficiency improvement action is defined as: "an achievement of technological, behavioral or economical changes providing a verifiable and measurable energy efficiency improvement." Technical actions regard a change in physical systems (often as a result of an investment decision), organizational actions regard changes in organizational processes that effect energy use, and behavioral actions regard changes in personal behavior related to daily energy use.

Three aggregation levels are presented: the overall system, the sub-system and the individual components. Examples are as follows:

- overall systems are a building, production process, road transportation of persons, an organization, a region or a service;
- subsystems are heating/cooling/ventilation, building envelope, lighting, car, communication, compressed air;
- individual components are boilers, air conditioners, appliances, internal combustion engine of a car, electric motors, etc.

Given this hierarchical relationship, energy savings can be calculated at a higher level by summing up savings at the lower levels. The choice of aggregation level in savings calculations depends on a number of issues such as: (1) data availability – in general, energy consumption data are more easily available at the overall system level than at sub-system or component level; and (2) simplicity of calculations of savings – for components, the calculation based on unitary savings and number of equipment is rather straightforward. On the other hand, the interaction between energy savings for some end-user actions can make energy savings calculations more complex. At the component and subsystem-level, interaction

[1] ODYSSEE is an EU funded project in the 27 countries in Europe plus Norway and Croatia. The project relies on a comprehensive database that contain detailed data on the energy consumption drivers by end-use and sub-sector and energy efficiency and CO_2 related indicators. The network of national teams updates the data regularly. The ODYSSEE database is managed by ENERDATA and updated twice a year.

between measures occur and double counting needs to be avoided. System-level interaction is automatically taken account of in the overall results. The demarcation of system boundaries is not yet implemented in this standard. It will be part of the standardization for specific bottom-up calculation cases.

The standard affects saving calculations for the ESD period of 2008 to 2016 and is intended to be used by the Member States when reporting the results from their National Energy Efficiency Action Plans (NEEAPs). The standard saving calculations for specific bottom-up cases (as researched in the EMEEES project) may require additional standardization work.

Definitions

The draft standard provides a set of definitions; for this paper, we focus on definitions dealing with energy use, energy efficiency improvements and energy savings. The definitions as presented in Table 1 are still open for comment. More and more end energy users are producing renewable energy production "behind the meter". Self generation influences the measured energy end use in two ways: (1) energy is used but does not shows up in the bills, or (2) energy is (partly) delivered to the energy distribution network and the net energy delivered shows up in the energy bills. Thus, the comparison of the energy delivered before and after the installation of an energy efficiency measure in these situations is no longer the correct method to calculate energy savings (unless renewable energy production is accounted for).

Table 1: Selection of definitions from draft CEN standard bottom up energy savings calculations, version June 2009

Term	**Definition**
Energy use	
Energy use	Manner or kind of application of energy
Energy end use	Energy use, not for transformation into energy carriers to be delivered to other users
Energy end user	Ultimate energy user consuming energy for final use
Energy efficiency	
Energy efficiency	The ratio between an output of performance, service, goods or energy, and an input of energy
Energy efficiency improvement	Increase in energy efficiency as a result of technological, behavioral and/or economic changes
Energy efficiency improvement action	Achievement of technological, behavioral or economical changes providing a verifiable, and measurable energy efficiency improvement
Energy efficiency improvement measure	Actions that normally lead to verifiable and measurable or estimable energy efficiency improvement
Energy Savings	
Energy savings	Reduction of energy consumption following implementation of one or more energy efficiency improvement actions
Gross energy savings bottom-up	Change of energy consumption following implementation of one or more energy efficiency improvement actions.
Saving lifetimes	Number of years for which initial savings at implementation of actions remain present
Unitary energy savings bottom-up	Energy savings per unit of analysis.

Another important element is that the energy savings are calculated **not** as a difference between two energy use periods (e.g., two energy bills), but as a difference that takes the change of the energy efficiency as a starting point: the energy reduction is measured against an efficiency baseline after applying adjustment factors. This is elaborated in the next section where we present the four steps in the bottom-up energy savings calculation.

Four steps calculation process

The bottom-up calculation of energy savings contains the following four steps:

- Step 1, unitary gross annual energy saving;
- Step 2, total gross annual energy savings;
- Step 3, total annual energy savings; and
- Step 4, total energy savings for target year.

These steps are illustrated in Figure 1. Unitary savings (from Step 1) times the number of units (participants, equipments) provides gross annual savings (Step 2). After correction for factors, annual savings result (Step 3). Step 3 comprises adjustments factors, of which not all are accounted for in the ESD target. The remaining part of these savings in the target year is determined using saving lifetimes (for the ESD, 2011 and 2016 are target years)

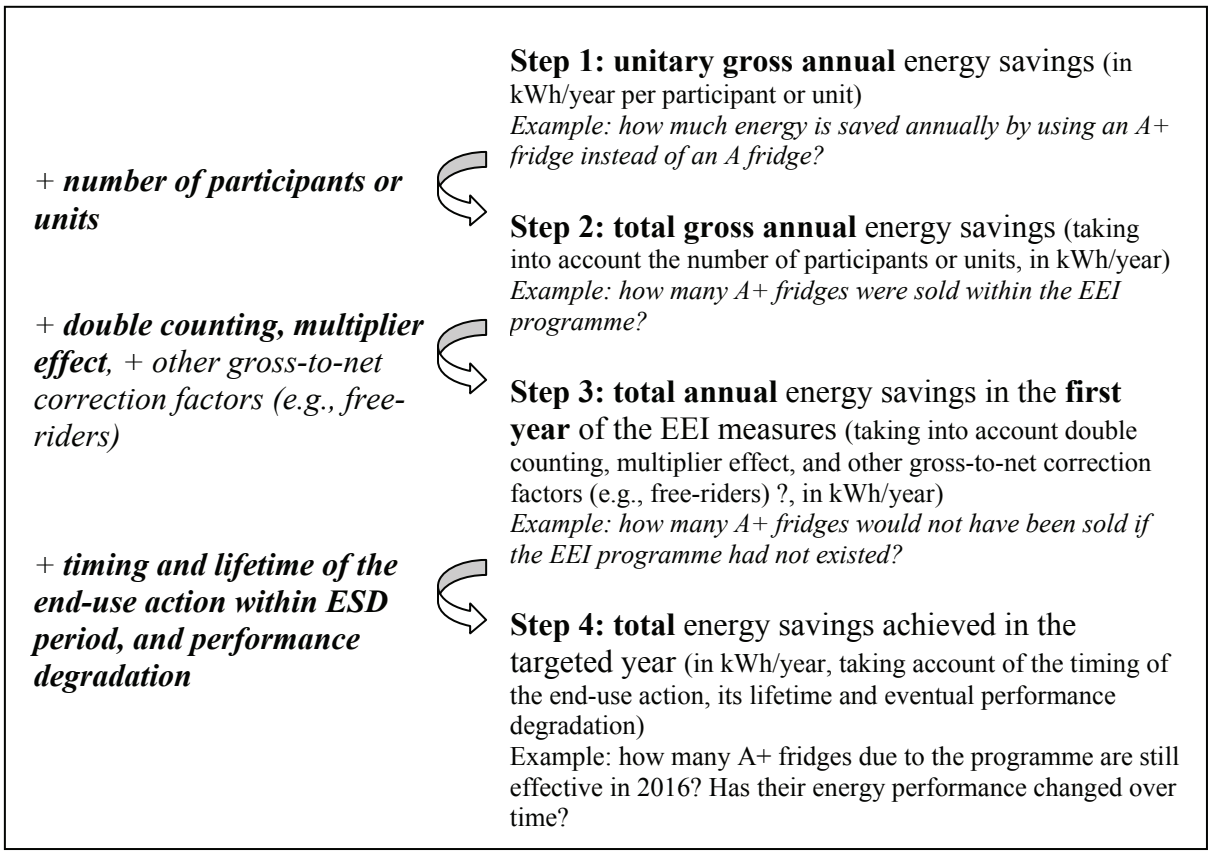

Figure 1 The four steps calculation process (source, Broc et al. 2009)

The calculation of the unitary gross annual energy savings (Step 1) seems to be a simple one, but is based on several decisions that determine the amount of energy savings. Step 1 comprises the following sub-steps:

- Step 1.a: General formula / calculation model
- Step 1.b: Baseline
- Step 1.c: Normalization factors
- Step 1.d: Calculation method and data sources
- Step 1.e: Conversion factors (when relevant)
- Step 1.f: Correction for rebound effect

We provide more detail for steps 1b and 1c. For the baseline, the draft standard clarifies the type of baseline used in order to know whether one deals with all or with additional savings (as a result of policies and measures). The baseline can be defined (in Step 1.b) in the following ways:

i. "before" annual energy consumption
ii. “before” decision, considering organizational and behavioral measures at that time
iii. "before" decision, considering equipment measures using market modeling
iv. “before" decision, considering equipment measures, using stock modeling

Baseline i. is the simplest baseline: the before situation is taken as the baseline, and only normalization factors (step 1.c) are used to make the "before" and "after" energy use comparable. In the other three baselines, the "before situation" corresponds to energy consumption with the equipment, the organizational setting or the behavior assumed to be present without the energy efficiency measure. For baseline ii, the before situation is based on energy consumption before introduction of the energy efficiency measure, leading to organizational or behavioral changes in energy use and considers their assumptions. In addition to normalization factors, corrections can be made for the rebound effect. For baseline iii on equipment measures (and buildings), the before situation is based on the market modeling of present equipment. For new equipment or buildings, no baseline is available. Thus, an alternative assessment method is needed: a reference situation has to be created. Baseline iv also regards equipment measures but uses stock modeling. The before situation is based on (average) existing equipment.

Normalization factors (Step 1.c) should ensure that the situations before and after can be compared. In this step, the energy consumption figures are normalized for external influences, such as:

- weather conditions influencing energy consumption
- occupancy levels
- opening or operation hours for non-domestic buildings
- installed equipment intensity (plant throughput)
- product mix
- plant output, level of production, volume or added value
- schedules for installation and vehicles

This step is restricted to general accepted normalization factors, while other corrections e.g., (freeriders and multipliers (or spillover) that are related to policies are explicit excluded her, but are addressed in step two.

Will a more global international standard for bottom-up energy savings calculations be possible?

IEA DSM Agreements Task on standardization of energy savings calculations

The International Energy Agency (IEA) organizes Implementing Agreements in which countries can cooperate on common work. One of these is the IEA Demand Side Management Agreement.

Information on this Agreement and its work is available at www.ieadsm.org In October 2008, it was decided to start a project (Task XXI) on standardization of energy savings calculations. This project, started with a first experts meeting in March 2009, will last until early 2011. Austria, France, Norway, South Korea, the Netherlands, Spain, Switzerland and the USA participate, and other countries might still join. The overall aim of this Task is to identify basic concepts, calculation rules and systems for energy savings calculations standards. In addition, a methodology will be developed to nominate and describe several demand response products. The work concentrates on three areas:

- Summarize and compare the current methods and standards used for determining energy use, energy demand and emissions savings related to energy efficiency actions and policies.
- Identify the organizations that could be in the near future responsible for each method and standard.
- Recommend how existing methods, standards and resources can be expanded and/or used for comparing different countries' and international efficiency policies and actions.

The actual research work will be carried out by a combination of the country experts, the project manager (Operating Agent), inputs from experts involved in standardization bodies. Also, the work from other relevant IEA DSM Tasks will be used. For example, from the Task dealing with Competitive Energy Services (Task XVI), the calculations and data from innovative energy services and financing models (as published in a series of manuals) will be an input. And from the Task on DSM and Climate Change (Task XVIII), the principles involved in methodologies for assessing the GHG emissions reductions available from specific demand-side management measures will be judged for their potential for harmonization.

Expected results from the IEA DSM Agreements Task on standardization of energy savings calculations

The project will result in several reports that will become available at the IEA DSM website from 2010 onwards. The first report will provide the basic concepts and energy savings calculation rules and will use the input from the experts for up to 15 priority technologies. This will be followed by an overview on how existing guidelines could be utilized or modified to make results from energy savings calculation - including related GHG emissions - more comparable and more harmonized in the future. A draft report will be discussed with future potential users, among these (inter)national standardization organizations. Based on this discussion, roadmaps along which energy savings calculations (ESC) standards could be further developed will be developed, taking into account the working processes of responsible standardization organizations, but giving more attention to international comparability. This report should stimulate additional work by national and international standardization organization(s) and or comparable institutions. So while this IEA work will result in commonly agreed concepts, the real implementation should be carried out through other national and international organizations.

At least one regional workshop will be organized. During this workshop, the draft reports will be discussed. In addition, during the project training material will be prepared and presented at the workshop.

Measurement, reporting and verification of greenhouse gas emissions in future commitments

The Fourth Assessment Report (2007) of the Intergovernmental Panel on Climate Change (IPCC) concludes that energy efficiency measures will play a key role in mitigating the human-induced effects of climate change across many of its scenarios, for most regions and time-scales. Future climate

change commitment (the Post-Kyoto period) will continue with the existing flexible mechanisms (Joint Implementation (JI) and the Clean Development Mechanism (CDM)) and may add some new mechanisms. From the experiences of JI and CDM project-based rules to calculate energy savings and GHG reductions, more general rules may be drafted and agreed on for use in future projects affecting energy savings programs.

The Bali Action Plan (2007) highlighted the importance of "measurable, reportable and verifiable" GHG mitigation actions and commitments for a post-2012 climate framework. This language on "measurable, reportable and verifiable" (MRV) was introduced to apply both to developed countries commitments and actions, as well as to nationally appropriate mitigation actions by developing countries in the context of sustainable development, supported and enabled by technology, financing and capacity-building. Thus, significant new guidance may be needed if post-2012 MRV provisions were to focus on GHG mitigation actions rather than GHG emission levels. There is also increasing experience with reporting sector-based emissions. However, there is no internationally-agreed guidance on how this should be done. Increased guidance on how to measure, report and verify emissions in a particular sector will be needed post-2012, particularly in order to implement some GHG mitigation actions under discussion, e.g. a sectoral no-lose target (Ellis, 2009).

The EU Council stressed in March 2009 the need, at global level, for more robust and transparent measurement, reporting and verification of mitigation and actions, for both developed and developing countries, as well as of support for mitigation efforts in developing countries through financing, technology and capacity-building. It supported the independent review processes for both developed and developing countries, building on and strengthening wherever possible the existing processes under the UNFCCC and its Kyoto Protocol and proposed that developing countries provide as soon as possible and by no later than 2011 annual emission inventories, at least for the key emitting sectors of their economies, facilitated by comprehensive capacity-building and technical and financial support.

The process for carrying out future MRV of mitigation actions can vary. Thus, countries need to agree on these issues in the coming years. For example, on measurement, countries could agree to use guidelines, rules and/or best practices when estimating the impacts of measures that mitigate GHG emissions. Agreement will also be needed on whether measurement and monitoring requirements should vary, e.g. according to type of action. Regarding reporting, an agreement needs to be reached on a common reporting format, and/or common reporting guidelines outlining how actions are reported. As far as verification is concerned, an agreement will be needed on who the verification body or bodies (national or international) is/are; what the verification process should be; how results should be reported; and how to make any required adjustments in reports of GHG mitigation. Agreement will also be needed on the consequences of problems raised at the verification stage.

Conclusions

Within the EU, consisting of 27 countries, the Directive on Energy End-use Efficiency and Energy Services (2006) pushed the harmonization of energy saving calculations, top down as well as bottom-up. It also stimulates the debate for a European standard for energy savings calculations. The European standardization bodies are now in a process that should result in standards for energy savings calculations for the top-down approach as well as for the bottom-up. The European Commission is also in a process to finalize general principles and preferred formulas to be used for reporting energy savings in the EU Member States for the period up to 2016. Although these processes will continue, it will result in more and more general accepted definitions, rules and calculations. As a result, the impact of energy policies and measures will become more and more comparable between the European countries.

The recently started work within the IEA DSM Agreement for standardization of energy savings calculations concentrates on basic concepts, calculation rules and systems for bottom-up energy savings

and options to make results from energy savings calculation - including related GHG emissions - more comparable and more harmonized. The agreement by energy experts should form the foundation that standardization and other relevant organizations can further develop. We expect that standards will be further developed by global, regional and national organizations standard organization(s) and or comparable institutions. So while this IEA work will result in common agreed concepts, the real implementation should be carried out through other international organizations. This IEA work is in line with other international developments like the International Partnership for Energy Efficiency Cooperation (IPEEC) - a partnership that the G8 countries, China, India, South Korea and the European Community decided to establish in 2008. In the IPEEC scope, one of the key topics is on methodologies of energy measurement, auditing and verification procedures, certification protocols and other tools to achieve optimal energy efficiency performance over the lifetime of building and industrial processes, relevant products, appliances and equipment.

The available knowledge from the energy community, as well from the environmental community, should be used for this future MRV. But while there are international forums for GHG emissions like the COP/MOP, SBI/SBTA and the IPCC, there are no such forums for energy savings calculationS. But as energy savings will continue to be one of the key elements in GHG reductionS, the energy experts and organizations have no time to lose and should give more attention to global harmonization of energy savings calculations. They should not continue to produce more and more national and state related evaluation guidebooks, but transpose the lessons from the long history of program evaluations into international guidance, guidelines and standards.

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