Making the results of bottom-up energy savings calculations comparable

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Abstract

The Energy Service Directive (ESD) has pushed forward the issue of energy savings calculations without clarifying the methodological basis. Therefore, in consequence of ESD the Commission has prepared "Recommendations on Measurement and Verification Methods". Furthermore, in the frame of CEN a preliminary standard on "Energy Efficiency and Savings Calculation" (prEN 16212) is under preparation. Both attempts for standardisation of energy savings calculations are confronted with considerable difficulties mainly with respect to Bottom-up (BU) calculations, because Member Countries are interested to keep the ESD methodology under control. As a result, national methodologies have emerged. Although this "fragmented" approach is in line with the ESD it leads to unsatisfying results. BU savings are calculated inside a "black box" leading to non-transparent, non-comparable results.

This background given the paper develops the idea of separating the issue of ESD verification strictly from the requirement of making results of BU energy savings calculation comparable by introducing a parallel evaluation track. The idea is analogous to the calculation of unemployment rates, where - independently from national methodologies - there exists a common European calculation routine which makes unemployment rates comparable across Europe.

Comparability is achieved by developing a standard BU calculation kernel for different EEI actions which at the same time makes transparent different calculation options in a structured way (e.g. different baseline options, different system levels, different ways of dealing with double counting, etc.). Due to the complexity and heterogeneity of BU calculations the approach requires a central database where Member States feed in input data on BU actions according to a predefined structure (e.g. XML standard), which are then processed with the standardised calculation kernel. The paper demonstrates the proposed approach including a concrete example of application.

Introduction

With growing relevance of energy efficiency policy the calculation of energy savings becomes increasingly important. There are several starting points:

- The Energy End-use Efficiency and Energy Services Directive 2006/32/EG (ESD) makes the calculation of energy savings necessary in order to verify the achievement of energy saving targets;
- Several countries have concluded voluntary agreement schemes under which different branches have to demonstrate the achievement of energy saving targets;
- Some countries (such as France, Italy and UK) have gone one step further by introducing schemes with tradable White certificates, which means that the amount of energy savings is allocated with a certain value that can be traded to other participants in the scheme;
- Furthermore there is a need for policy evaluation which is based on reliable and quantifiable data on energy saving impacts of policy programmes and other facilitating measures.

A uniform and harmonised methodological basis for energy savings calculation is missing in the ESD. There is only Annex IV that gives a general framework for this issue and a procedure for further development of methodological prescription. The Commission has presented "Recommendations on Measurement and Verification Methods" and on the level of CEN a draft standard on "Energy Efficiency and Savings Calculation" (prEN 16212) has been prepared. Both documents contain major principles and processes for the calculation of energy savings and can thus be seen as important steps towards methodological harmonisation. But they are far away from decidedly narrowing down the possible results of energy savings calculations.

This means that in practice the evaluation and verification of energy savings will be done according to national methodologies. This is true for the reporting under the ESD as well as for calculation procedures used in voluntary agreements and in white certificate schemes. National – and sometimes also regional – authorities have considerable interest to keep methodological issues under control and thus little interest to go for a further harmonisation beyond the levels achieved so far.

It seems that a comprehensive harmonisation – in the sense of *unification* – of energy savings calculation is an unrealistic goal for a longer period of time. It is, however, achievable to improve *comparability* of the results of energy savings calculation. This requires transparency with the applied calculation methodologies and the assurance that energy savings calculation results are compared only if they apply the same calculation kernel. The following paper proposes a concrete approach towards higher degree of comparability in energy savings calculation.

Need for comparability of energy savings calculations

The application of national methodologies is in line with the ESD, but leads to incomparable results due to various reasons, such as

- the complexity of the algorithms of energy savings calculations themselves;
- the difference in interpreting the term "energy savings" simply because of the fact that energy savings cannot be directly observed but always need some interpretation;
- differences in input data used, partly due to different levels of data availability.

M&V AS PART OF POLICY EVALUATION PROCESS

In each policy evaluation the monitoring and verification of the results achieved by the policies implemented is a crucial part. The same is also true for energy efficiency policy. Figure 1 illustrates the policy process initiated resp. enforced by the ESD as a sequence of design of EEI policies, of implementation of these policies and of evaluation of the success achieved. The evaluation further leads to a redesign of the policy instruments. In this sequence, the NEEAP to be delivered by the Member States to the Commission can be interpreted as valuable evaluation tool. The results of it could lead to a continuous improvement of the performance of energy efficiency policy.

The weak point in the assessment of energy efficiency policy is frequently the quantitative part. Perhaps the saying is not completely wrong that if we sum up all the energy savings reported in various kinds of studies, publications, newsletters, articles etc. we should wonder that we still use a remarkable amount of energy.

Furthermore, ESD refers to the achievement of absolute energy saving targets, whereas for policy evaluation – as for every kind of evaluation – comparability gives more valuable results than absolute values. In this context, we have to distinguish two aspects of comparability:

- The comparability between actors (such as Member States, but also different EEI programmes) in order to be able to distinguish whether EEI measure A or EEI measure B has a higher impact and thus to be able to chose priorities on this basis.
- The comparability over time, which is perhaps even more important and which can help to analyse the development of one specific EEI measure over several years.

REASONS FOR INCOMPARABLE RESULTS OF NATIONAL APPROACHES IN BU CALCULATION

To understand why the results of BU energy savings calculations lack direct comparability, we start by giving the main principle of such a calculation.

Most approaches begin with the calculation of the gross energy savings of one unit subject to the measure (e.g. one building) and then add up these unitary gross savings to obtain the total gross savings of all affected units (see e.g. Vreuls et al. (2009), Kromer (2007), and Dietsch (2007)). In following this approach the main principle of a bottom-up calculation can therefore be expressed in the formula

$$\begin{aligned}&\textit{gross energy savings}_t = \textit{baseline energy consumption}_t\\&- \textit{actual energy consumption}_t \qquad (1)\end{aligned}$$

where t refers to the period of interest. *Baseline energy consumption* is the energy consumption that would have occurred if no EEI actions had been taken to reduce energy consumption. Similarly, *actual energy consumption* is the energy consumption of the subject including the effect of the EEI action. Subscript t in formula (1) implies that baseline energy consumption and actual energy consumption are not necessarily constant from the year of the implementation of the energy efficiency measure to the last year in which the measure is effective.

Formula (1) is only the starting point of a comprehensive energy savings calculation, as the unitary gross energy savings from formula (1) of all EEI actions within the scope of one measure have to be summed up and then corrected for certain factors that might lead to biased results, such as the rebound effect, multiplier (or spillover) effect, free rider effect, etc. In most cases it is impossible to account for these factors at the unit level with a reasonable amount of effort, but previous studies or experience from the monitoring of similar measures provide evidence of the extent to which these factors affect the overall outcome of the savings calculation. Accordingly, the sum of all gross unitary energy savings achieved by the energy efficiency measure being evaluated is corrected for these factors to obtain the total net energy savings. The formula for the total net energy savings is therefore

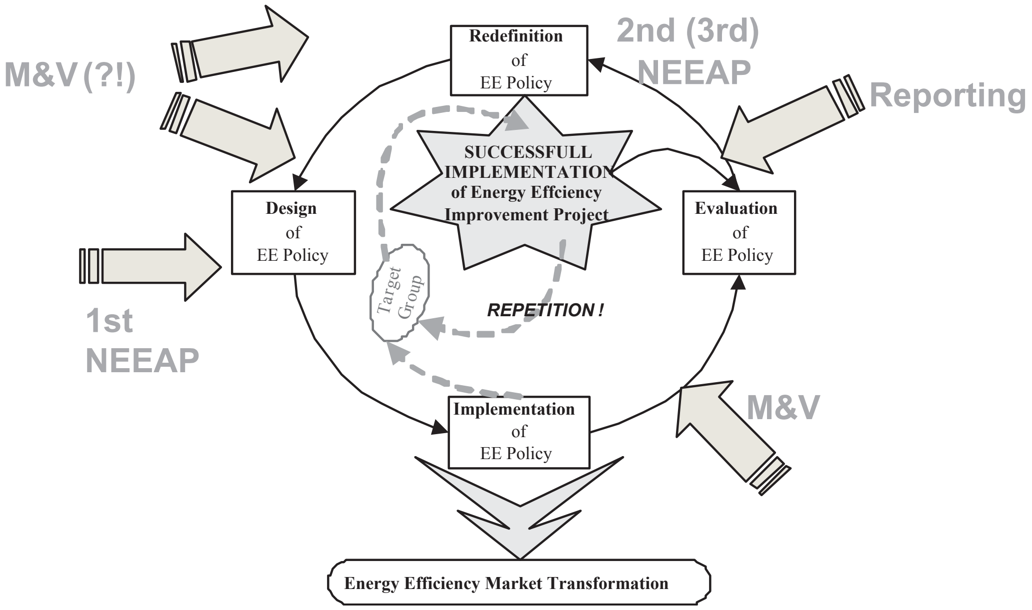

Figure 1: The role of M&V in an effective energy efficiency policy process (source: Bukarica/Leutgöb 2009).

$$\textit{total net energy savings} = \textit{total gross energy savings} - \textit{corrections}_{net} \qquad (2)$$

where $\textit{corrections}_{net}$ refers to the product of the correction factors discussed above.

Based on formula (1) and (2) we see that there are several origins of the incomparability of calculation results. Incomparability may arise from the calculation of the savings on the unit level, formula (1), or the incomparability may origin from the application of different correction factors or even from applying a correction procedure different from formula (2). We classify the reasons for incomparable results of BU energy savings calculations therefore according to the relevant stage of the calculation process; therefore we denote reasons for incomparability on the unit level as Level 1 origins, and reasons emerging from the aggregation and correction process as Level 2 origins.

For the measurement or calculation or estimation of the baseline and the actual energy consumption in formula (1), a number of procedural steps are used. These steps are outlined in Reichl and Kollmann (2011) and include decisions on and assumptions about:

- What is the baseline technology?
- What is the system boundary for which energy consumption is calculated?
- What is the lifetime of the new technology?
- Does the energy efficiency action incorporate a change in the provided energy service?
- How do we handle different circumstances (climate) between the baseline scenario and the actual scenario?
- etc.

We illustrate the importance of these questions for the comparability of BU energy savings figures by an example: The *actual energy consumption* appears most unambiguously, since it is measured, or the variables needed to calculate can be retrieved from the technical specification of the energy use system[1] intended for evaluation. Nevertheless, the measured or calculated values may not always be adequate. This would be the case for the substitution of an oil-fired boiler by the installation of a district heating in a residential building, because for this kind of EEI action the losses of the boiler are shifted to another system level.

The example shows that the **first important source for incomparability** is the decision where the **system boundaries** are drawn. The system boundaries in the context of BU energy saving calculations are defined in prEN 16212 by *physical or virtual shell around an energy using system, for which each energy transfer through this shell (in and out) is relevant in an energy efficiency and savings calculation.* The example with the exchange of an oil boiler by a connection to district heating offers two main possibilities for drawing the system boundaries. Depending on where the system boundaries are drawn we end up with very different *actual energy consumptions*, and thus with different amounts of energy savings:

- One approach would be to draw the system boundaries around the residential building. This means that every kWh that enters the building through the district heating pipeline counts to the *actual energy consumption*.
- The other possibility would be to define the district heating plant as part of the heating system, and thus draw the system boundary including the heating plant. This means that every kWh, e.g. from coal or biomass, that enters the heat production process counts to the *actual energy consumption* of the residential building from this example.

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[1] The term energy-use system is itself defined in ISO (2002): ‘part of a technical energy system converting energyware or other energy sources into energy services’. The term energyware is defined in ISO (1997) and refers to any ‘tradable commodity used mainly to produce mechanical work or heat, or to operate chemical or physical processes’.

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Both possibilities are crucially different. The *actual energy consumption* of possibility 2 incorporates all conversion losses from the primary energy to heat and the transportation losses from the heating plant to the residential building, so that the *actual energy consumption* in possibility 2 is inevitably higher than the one of possibility 1, which neglects these energy losses.

The **second important source of incomparability** at the level of unitary savings is the **definition of the baseline** case. Usually we can distinguish at least three different general baseline options (compare prEN 16212):

- The baseline can be defined using the "before"-situation, i.e. the situation before the implementation of the EEI action is interpreted as baseline case;
- The baseline can be defined using a reference situation which is based on the "market average" for a certain technology or energy use;
- Finally, the baseline can be defined by a reference situation which reflects the "stock" of a certain technology or energy use;
- In addition, we have to take into account, that baselines can be stable (unchanging) over time or they can be dynamic assuming a certain development of the reference situation without EEI action ("autonomous trend").

A **third major origin of incomparability** of energy savings calculations at the level of elementary unit of action is the **quality of input data**. In this respect we frequently find distinguished the following levels:

- Use of measured data: If measured data are used for energy saving calculations we need additional accompanying data for the necessary adjustment process (e.g. information about weather conditions, usage patterns, plant throughput etc.). Measured data can be gained either by direct measurement – which will be the case only for a very limited amount of EEI actions or by billing analysis;
- Use of calculated data which are gained by enhanced engineering estimates prevailingly using input data related to a concrete EEI action;
- Use of calculated data gained from a deemed estimate prevailingly built on default values: The default values used can be defined on the European level as well as on the national – or even regional – level, depending on the energy use or technology in question.

The choice of the input data to be used in the energy savings calculations is first of all dependent on data availability. In general, we may assume that measured data are more "realistic" than the use of default values. In turn this means that default values have to be chosen in a cautious way in order to be "at the safe side" and not to over-estimate energy savings. The principle of "conservativeness" of default values is reflected in many standards and regulations - such as in CEN standards for the calculation of the energy performance of buildings according to the EPBD or in CEN WS 27 on Saving Lifetimes. Therefore it seems advisable to apply it also for energy savings calculations in general.

There is no universally valid answer to the question which of the different calculation options derived from the approaches as presented above are most adequate, but if we want to compare the savings of similar EEI measures we need to make transparent the differences in calculation options, i.e. we need to make sure that we compare apples with apples and not with pears.

After the unitary *gross energy savings*$_t$ have been calculated, these are aggregated to the total savings according to formula (2). The **main origins for incomparability at the level of net energy savings** are therefore characterised by issues like:

- How is the issue of free riders handled?
- How is it ensured that double counting does not bias the results?
- How can we evaluate and correct for the rebound effect?
- etc.

Summing up the multiple bifurcations in the ways energy saving calculation can be done and are done we can easily conclude that it is impossible to directly compare the results of energy savings calculations - as for example presented EEAP of Member States.

Proposed approach to achieve comparability

PARALLEL EVALUATION STREAM TO ACHIEVE COMPARABILITY OF RESULTS

In order to achieve comparability of the results of energy savings calculations we need a parallel evaluation approach that is not directly linked to the national approaches related to the obligation to present evidence according to the ESD. The national approach will always be directed towards showing a compliance with the ESD targets all the more because under the ESD regime there is methodological flexibility in energy savings calculation. The M&V rules of the game under ESD are difficult to fix, therefore a separated evaluation process has to be established that works under a standardised procedure in order to assure comparability of results. In the following we use the term "energy savings calculation for comparability" (ESC-COMP) as abbreviation for the approach we propose.

There exist several analogies for the proposed parallel evaluation stream in order to achieve comparability of results:

- For the calculation of unemployment rates there exist national methodologies as well as EU-wide methodologies.
- The same is true for the calculation of state budgets, where the harmonised calculation approaches have become of major importance with respect to stability of the Euro monetary union.

Figure 2 gives an overview on the proposed approach, which is then followed by a more detailed description of the different parts of the approach.

OBJECT OF ASSESSMENT

At first it is important to clarify the object of assessment of the ESC-COMP approach. Energy savings are realised (only) by end-user actions that can be of a technical, organisational or behavioural nature. Therefore the object of assessment in the proposed approach is the elementary unit of end-user action; i.e. a certain system where an improvement of technology, or-

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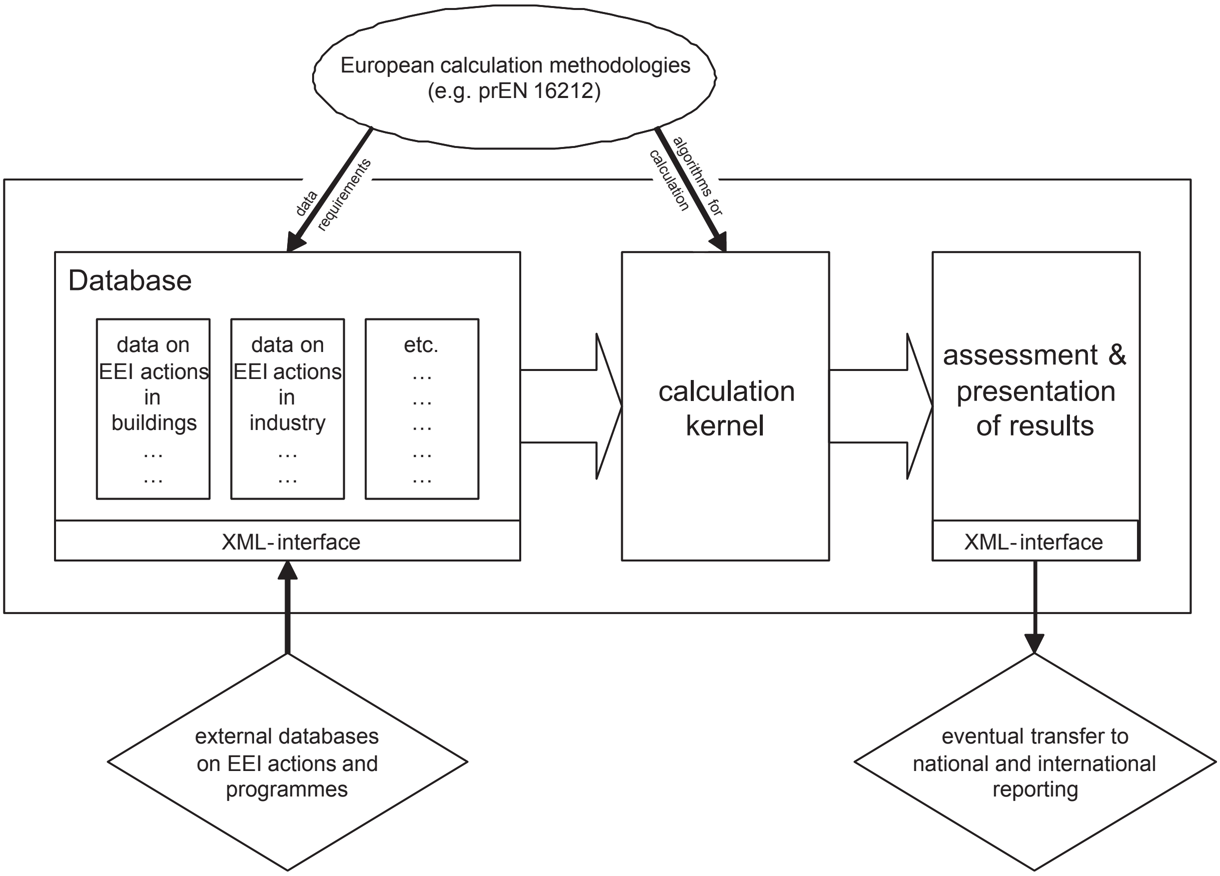

Figure 2: Overview on the ESC-COMP approach.

ganisational processes and/or user behaviour leads to verifiable and measureable energy savings. This starting point is in line with prEN 16212 which further describes that the elementary units of action can be defined at very different, hierarchically related, aggregation levels:

- the overall system, such as a building, production process, road transportation of persons, an organisation, a region or a service;
- the subsystem, such as heating/cooling/ventilation, building envelope, lighting, car, communication, compressed air;
- individual components, such as boilers, air-conditioners, appliances, internal combustion engine of a car, electric motors, etc.

EEI facilitating measures – such as energy efficiency policy programmes and other support measures – are not objects of assessment of the proposed ESC-COMP, although, of course, the approach can process data which have been generated in the frame of EEI facilitating measures. This is a major difference compared to the approach chosen by the MURE database which puts policy measures in the focus of assessment and thus has difficulties in getting verifiable and transparent information of the amount of energy savings achieved.

Figure 3 illustrates the object of assessment of the proposed ESC-COMP approach and opposes it to an approach that starts with policy instruments. Furthermore this means, that the results achieved by the proposed ESC-COMP approach cannot be *directly* used for a policy assessment but only if we have available additional information on the impact of policy instruments on EEI actions, i.e. information on the motivation behind the actual implementation of EEI actions.

STANDARDISED CALCULATION KERNEL

As we have seen before the core of each energy savings calculation is a simple comparison of the actual energy consumption resp. demand with a reference case, but details in this calculation procedure can be handled very differently. The prescriptions of prEN 16212 as well as the Commission paper with "Recommendations on Measurement and Verification Methods" deliver good guidance in fixing the algorithms. In principle it does not matter which calculation approaches are chosen at the end.

What is more important is that for all similar EEI actions the same approach is applied and that the calculation kernel needs to be able to reflect the different calculation options regarding

- Definition of the baseline
- Choice of the system boundaries and aggregation level
- Adjustment of energy consumption
- Different quality levels of input data etc.
- Application of correction factors for double counting, multiplier effect, free-rider effect etc.

There will be, however, a general difference in the calculation algorithms where energy savings are calculated on the basis of measured consumption data and those where energy savings

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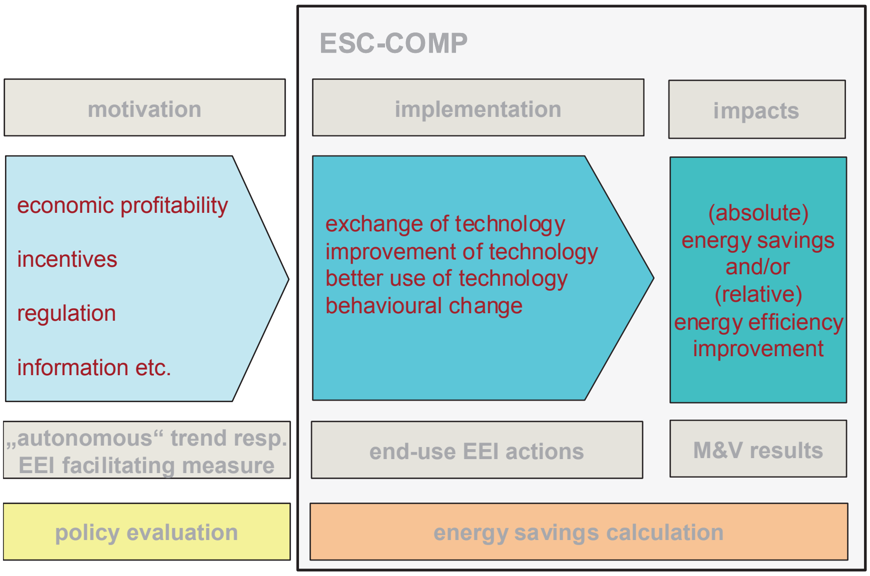

Figure 3: Object of assessment of ESC-COMP.

are derived from calculated energy demand figures. Whereas measured consumption data need adjustment for weather conditions, occupation levels, production throughput etc. - which is then reflected in respective formula for adjustment - the calculated data use standardised framework conditions which means that usually no adjustment is needed.

DATABASE FOR INPUT DATA

The calculation kernel defines the set of required input data. If the calculation kernel offers different calculation options this has to be reflected by different sets of required input data. In any case, the required input data will depend very much on the approach chosen with respect to the different levels of data quality as described above, i.e.

- Approach using measured data;
- Approach using calculated data gained by enhanced engineering estimates adapted to the conditions of single EEI actions;
- Approach using calculated data gained from deemed estimates prevailingly built on default values.

For practical operability of the ESC-COMP approach, it will be inevitable to ease the link to existing databases such as databases which have been developed by the Member States to fulfil the M&V requirements related to ESD reporting. This is usually done by defining a standardised XML file that defines the data requirements of the target database, whereas the available data in the origin database are transferred into the structure given by the XML file.

EVALUATION OF RESULTS

Since the proposed ESC-COMP approach will not produce only one single result, but a wider range of results depending on the calculation option chosen, the results of different calculation options have to be presented in a transparent way. Major features of a comprehensive evaluation supports are as follows:

- In a **first step**, only those results of energy savings calculations are compared which have been derived using the same methodology, i.e. the same combination of calculation options:
    - The comparisons of results are made between countries as well as over time (i.e. for one country resp. region but over several periods of time);
    - The comparisons are made in absolute values as well as in specific benchmarks (e.g. average amount of energy savings per m^2 of a building improved by a certain EEI measure).
- In a **second step** it is also useful in a second step to compare results for the same EEI actions derived with different methodologies (if available). By this way one can check the sensitivity of energy savings calculation results dependent on the methodological approach chosen. Furthermore one can check to which degree applied default values are really conservative.

Case study for the example of EEI measure "boiler exchange"

The following chapter demonstrates how the approach could work in practice with the help of a simplified typical example. The example consists of a set of 10 boiler exchange measures in central heating systems of multi-family residential buildings. We assume the substitution of an old outdated gas boiler by a modern gas condensing boiler including usual accompanying measures in the boiler room but no further measures related to the distribution system or the regulation of the heating system in the single flats. Also the building itself remains unchanged.

The following calculation options for this example are limited to one assessment period (assumed one year). Therefore in a first step the example excludes the additional complexity of life-time of energy savings derived from a certain EEI action (compare CEN WS 27, 2007)

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Table 1: Required input data and results for calculation option 1: Measured data based on billing analysis.

	unit	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
gross floor area	m2	850	1.560	2.011	619	770	1.233	1.756	550	1.178	912
Baseline measured											
heat consumption measured / a	MWh/a	205,3	281,7	333,6	182,0	197,3	243,4	372,4	149,0	200,4	210,7
usage indicator	%	100%	95%	90%	98%	100%	82%	89%	97%	95%	95%
yearly heating degree days		2970	3020	3400	3100	3550	2970	2970	3480	2970	2970
After boiler exchange measured											
heat consumption measured / a	MWh/a	164,2	216,9	270,2	151,0	151,9	206,9	309,1	114,7	176,3	183,3
usage indicator	%	100%	97%	92%	95%	100%	86%	85%	90%	100%	95%
yearly heating degree days		3119	3141	3570	3131	3621	3119	3119	3619	3119	3119
heat consumption total / a adjusted	MWh/a	158,0	206,4	254,9	154,1	149,5	190,7	309,9	119,0	162,0	176,3
energy savings measured & adjusted	MWh/a	47,3	75,4	78,8	27,9	47,8	52,7	62,5	30,0	38,4	34,4
					Total for all EEI actions assessed					MWh/a	**495,1**
					specific energy savings					kWh/m2	43,3

CALCULATION OPTION 1: MEASURED DATA BASED ON BILLING ANALYSIS

Calculation option 1 is based on measured data mostly gained from energy bills. Although for many cases it will be difficult to collect measured data there exit several data sources which could be used in this context, such as data from energy bookkeeping systems, data related to the evaluation of energy performance contracting projects etc.

The approach is characterised by the following features:

- Using the energy bills as basic information source implies that the system boundary used for the energy savings calculation is the building as a whole.
- The baseline is defined by the energy consumption gained from the bills for the baseline period. The actual consumption is read from the bills for the assessment period as well.
- The calculation kernel is based on a simple comparison of the actual consumption compared to the baseline consumption where the actual consumption is adjusted to the side conditions observable in the baseline period. The formula for the adjustment is as follows:

$$EC_{m,t,n} = EC_{m,t,} \cdot [(1\text{-}f_u) + f_u \cdot (UI_b \,/\, UI_t)] \cdot [(1\text{-}f_w) + f_w \cdot (WI_b \,/\, WI_t)] \qquad (3)$$

with

$EC_{m,t,n}$ *energy consumption metered in the observed period t normalised to the external conditions in the baseline period*

$EC_{m,t}$ *energy consumption metered in the observed period t*

f_u *usage factor; share of the energy consumption which is dependent on the building use; with* $0 \le f_u \le 1$

UI_b *indicator for usage conditions in the baseline period*

UI_t *indicator for usage conditions in the observed period t*

f_w *usage factor; share of the energy consumption which is dependent on weather conditions; with* $0 \le f_w \le 1$

WI_b *indicator for weather conditions in the baseline period*

WI_t *indicator for weather conditions in the observed period t*

- The necessary input data for calculation option 1 are as follows: energy consumption (information from the energy bill); heat degree days (as a proxy for weather conditions) and information about the degree of tenancy. All information has to be available in a comparable way for the baseline period as well as for the assessment period. In practice this might be already a problem for the energy consumption, since meter-reading periods vary from year to year. For larger deviations an extra adjustment has to be made.

Table 1 summarises input data and results of calculation option 1 for our simplified boiler exchange example.

CALCULATION OPTION 2: ENHANCED ESTIMATE FOR EACH SINGLE EEI ACTION

Calculation option 2 uses enhanced engineering estimate which is applied separately to each of the single EEI actions. Instead of using metered data energy consumption values are calculated. In this case the Austrian standards for the calculation of energy performance of buildings according to the EPBD have been used. Calculation option 2 features the following characteristics:

- The approach uses the building as system boundaries since the energy consumption of the whole building is calculated (not only the losses related to the heating system).
- The baseline energy consumption is calculated by using the technical characteristics of a given building as input data to a detailed calculation of energy performance of the building.
- The energy consumption of the assessment period is calculated by reflecting the EEI action in the technical characteristics of the calculated building. This means that the baseline calculation is just adapted by substituting the old boiler by a new condensing boiler.
- Energy saving are then only the result of subtracting the energy consumption of the assessment period from the baseline energy consumption. No further adjustment with respect to weather conditions and/or usage patterns are necessary under the condition that the input parameters used for these impact factors on energy consumption are close to reality.
- In order to be able to conduct an enhanced engineering estimate, a wider range of input parameter is needed. On a first sight, it seems hard to implement this in an energy saving calculation for a larger number of EEI actions. There are however several possibilities for simplification, which hardly influence the accurateness of the result: Thermal

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Table 2: Required input data and results for calculation option 2: Enhanced estimate for single EEI actions.

	unit	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
gross floor area	m2	850	1.560	2.011	619	770	1.233	1.756	550	1.178	912
Baseline calculated											
net heat demand calculated	kWh/m2a	115,0	86,2	95,4	140,0	122,0	94,9	101,3	129,0	103,0	110,0
hot water demand default	kWh/m2a	15,0	15,0	15,0	15,0	15,0	15,0	15,0	15,0	15,0	15,0
losses of heating system calculated	kWh/m2a	103,0	102,2	93,0	96,6	105,0	99,8	95,7	103,0	99,6	100,2
heat demand calculated /m2a	kWh/m2a	233,0	203,4	203,4	251,6	242,0	209,7	212,0	247,0	217,6	225,2
heat consumption total / a	MWh/a	198,1	317,3	409,0	155,7	186,3	258,6	372,3	135,9	256,3	205,4
After boiler exchange calculated											
net heat demand calculated	kWh/m2a	115,0	86,2	95,4	140,0	122,0	94,9	101,3	129,0	103,0	110,0
hot water demand default	kWh/m2a	15,0	15,0	15,0	15,0	15,0	15,0	15,0	15,0	15,0	15,0
losses of heating system calculated	kWh/m2a	65,9	55,0	57,3	63,9	50,1	52,3	49,7	60,0	55,6	44,0
heat demand calculated /m2a	kWh/m2a	195,9	156,2	167,7	218,9	187,1	162,2	166,0	204,0	173,6	169,0
heat consumption total / a	MWh/a	166,5	243,7	337,2	135,5	144,1	200,0	291,5	112,2	204,5	154,1
deemed energy savings measured	MWh/a	31,5	73,6	71,8	20,2	42,3	58,6	80,8	23,7	51,8	51,3
					Total for all EEI action assessed					MWh/a	**505,6**
					specific energy savings					kWh/m2	44,2

losses of usual buildings can be quite accurately estimated by using information on the gross floor area, the surface-volume-ratio of the building, the share of window area in the building envelope and typical data on heat transmission factors (e.g. according to the standards in force in the given building period). The losses of the heating systems can be estimated according to reference equipment which is typical for the building period. All these data are usually available on the energy certificates. In addition, if energy certificate data are available in databases – as this is the case for some regions in Austria where energy certificate data are centrally administered[2] – an automatic transfer of the required data to the ESC-COMP tool could be organised.

Table 2 gives a summary of the main results of calculation option 2 for the assumed example of boiler exchange actions.

CALCULATION OPTION 3: DEEMED ESTIMATE USING STANDARDISED DEFAULT VALUES

Calculation option 3 can be interpreted as a maximum simplification of calculation option 2. The following characteristics are crucial:

- The calculation kernel is comparable to the one used for option 2, but input data are largely simplified. There is only one figure used for the energy demand to be served by the heating system and one figure expressing the efficiency of the heating system itself.
- Furthermore the default values do not differentiate between the single buildings and EEI actions. This means that if the default values are once fixed the only information which is needed for an energy savings estimate is the number of m^2 which are supplied by the new condensing boiler.
- In principle the default values could be fixed at different levels. There can be applied regional default values as well as national or European default values. For the case of energy savings related to buildings, regional default values should be a minimum requirement simply because of the considerable climatic difference across countries. Default values could be further adapted to the specific EEI action e.g. by introducing a differentiation according to building type, construction year of the building, construction year of the baseline heating system etc. A further differentiation of default values leading to a more accurate mapping of the real starting conditions of the EEI actions transforms calculation option 3 stepwise into calculation option 2. In practice there are many possible intermediate levels between these two options.
- "On paper" calculation option 3 uses the whole building as system boundary, too. In reality, however - if the use of unifying default values prevails over the reflection of specific conditions for each EE action - technical interaction are not taken into account accordingly.

Table 3 summarises input data and the main results of calculation option 3 for the boiler exchange example.

Since this calculation option seems to be frequently used in the M&V practice according ESD we add some further remarks:

- The results of this calculation option are very (!) sensitive to the default values used. Only slight changes in the default values for heat demand or – even more sensitive – the value for the performance of the heating system either on the baseline side or on the side after EEI implementation lead to remarkable changes in the result.
- It is questionable if default values applied in national energy savings calculation approaches applying deemed estimates are really conservative. For example this is not the case for the deemed estimate described for boiler exchange actions in the Austrian guidebook for M&V according to the ESD (see Energieeffizienz-Monitoringstelle, 2010).

CALCULATION OPTION 4: DEEMED ESTIMATE WITH A MARKET AVERAGE BASELINE

Calculation option 4 is based on calculation option 3 and demonstrates the additional impact of a different choice in baseline definition. If we choose the market average instead of the before-situation as baseline this has major impact on the results of energy savings. And there is good reason to choose a market average baseline in our example if the exchanged boilers are old and thus anyhow subject to replacement sooner or later. The main questions in defining a market average baseline are as follows:

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[2] see for example www.energieausweise.net which is a portal for the administration of energy certificates in the region of Salzburg.

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Table 3: Required input data and results for calculation option 3: Deemed estimate using default values.

	unit	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
gross floor area	m2	850	1.560	2.011	619	770	1.233	1.756	550	1.178	912
Baseline default											
net heat demand default	kWh/m2a	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
hot water demand default	kWh/m2a	15,0	15,0	15,0	15,0	15,0	15,0	15,0	15,0	15,0	15,0
performance ratio of heating system		1,90	1,90	1,90	1,90	1,90	1,90	1,90	1,90	1,90	1,90
heat demand default /m2a	kWh/m2a	218,5	218,5	218,5	218,5	218,5	218,5	218,5	218,5	218,5	218,5
heat consumption total / a	MWh/a	185,7	340,9	439,4	135,3	168,2	269,4	383,7	120,2	257,4	199,3
After boiler exchange default											
net heat demand default	kWh/m2a	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
hot water demand default	kWh/m2a	15,0	15,0	15,0	15,0	15,0	15,0	15,0	15,0	15,0	15,0
performance ratio of heating system		1,55	1,55	1,55	1,55	1,55	1,55	1,55	1,55	1,55	1,55
heat consumption default /m2a	kWh/m2a	178,3	178,3	178,3	178,3	178,3	178,3	178,3	178,3	178,3	178,3
heat consumption total / a	MWh/a	151,5	278,1	358,5	110,3	137,3	219,8	313,0	98,0	210,0	162,6
deemed energy savings measured	MWh/a	34,2	62,8	80,9	24,9	31,0	49,6	70,7	22,1	47,4	36,7
					Total for all EEI action assessed					MWh/a	**460,4**
					specific energy savings					kWh/m2	40,3

Table 4: Required input data and results for calculation option 4: Deemed estimate with a market average baseline.

	unit	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
gross floor area	m2	850	1.560	2.011	619	770	1.233	1.756	550	1.178	912
Baseline default market average											
net heat demand default	kWh/m2a	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
hot water demand default	kWh/m2a	15,0	15,0	15,0	15,0	15,0	15,0	15,0	15,0	15,0	15,0
performance ratio of heating system		1,70	1,70	1,70	1,70	1,70	1,70	1,70	1,70	1,70	1,7
heat demand default /m2a	kWh/m2a	195,5	195,5	195,5	195,5	195,5	195,5	195,5	195,5	195,5	195,5
heat consumption total / a	MWh/a	166,2	305,0	393,2	121,0	150,5	241,1	343,3	107,5	230,3	178,3
After boiler exchange default											
net heat demand default	kWh/m2a	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
hot water demand default	kWh/m2a	15,0	15,0	15,0	15,0	15,0	15,0	15,0	15,0	15,0	15,0
performance ratio of heating system		1,55	1,55	1,55	1,55	1,55	1,55	1,55	1,55	1,55	1,55
heat consumption default /m2a	kWh/m2a	178,3	178,3	178,3	178,3	178,3	178,3	178,3	178,3	178,3	178,3
heat consumption total / a	MWh/a	151,5	278,1	358,5	110,3	137,3	219,8	313,0	98,0	210,0	162,6
deemed energy savings measured	MWh/a	14,7	26,9	34,7	10,7	13,3	21,3	30,3	9,5	20,3	15,7
					Total for all EEI action assessed					MWh/a	**197,3**
					specific energy savings					kWh/m2	17,3

- What is the market average? In our case we would need a survey on the actual market for boiler exchange (i.e. excluding boiler installation in new construction), but very often this kind of market data is lacking;
- At which point in time we have to assume a market average situation as baseline case? Probably this would not be the first year after the EEI action has been implemented, but also the assumption of an unchanged before-baseline over the whole life-time of the EEI action is highly questionable. In our example this would mean that we would assume that the old boiler would survive another 15-20 years which is impossible from the technical point of view.

Once again there are no commonly acknowledged answers to these questions available. The ESC-COMP approach, however, can make transparent the differences in results coming from different answers to these questions. Table 4 summarises the main input data and results for a deemed estimate with market average baseline for our simplified boiler exchange example, where the default value of the performance ratio of the heating system has been improved for the baseline situation (assumption that the old boiler is exchanged by a market average boiler instead of a highly efficient one). The example also demonstrates how very sensitively the results of deemed estimates react to adaptations of the default values.

Conclusions

The paper demonstrated from the theoretical point of view as well as for a simplified practical example that comparability of the national ESD calculation results cannot be expected without introducing a parallel evaluation stream that is not directed towards attesting ESD target achievement but towards achieving comparability in energy savings calculations.

We propose the ESC-COMP ("energy savings calculation for comparability") approach aiming at making transparent different calculation options regarding the definition of the baseline, the choice of the system boundaries and aggregation level, the application of adjustment and correction factors, the different quality levels of input data etc.

In practical terms, the ESC-COMP approach requires a professional IT tool best combined with a web database for easy data handling and a calculation engine that allows the calculation of different methodological scenarios. We see the ESC-COMP approach as a highly beneficial supplement to the existing MURE database and the ODDYSEE approach. Whereas MURE delivers a comprehensive overview on different kinds of energy efficiency programmes and facilitating measures around Europe and whereas ODYSSEE has implemented a standard approach for the calculation of Top-down savings, ESC-COMP would contribute traceable information on the quantitative impact of various Bottom-up measures. This would clearly add

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to a more reliable evaluation of energy efficiency policy and to a better chance to learn for the future from the successes and mistakes of the past.

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