Using prEN 16212 for improving the comparability of results of bottom-up energy savings

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ABSTRACT

Bottom-up (BU) energy saving calculations still lack a clear methodological basis. As a consequence BU savings are frequently calculated inside a "black box" leading to non-transparent, non-comparable results.

In the frame of CEN a preliminary standard on "Energy Efficiency and Savings Calculation" (prEN 16212) has been developed. It offers a precise structure which makes it possible to make transparent the assumptions behind energy savings calculations by addressing the most important "sources for incomparability" in a well-structured way, such as

- At the level of unit savings: the decision about the system boundaries, the definition of the baseline case, the quality of input data;
- At the level of net energy savings: Handling of free-rider effect and rebound effects; different approaches to address the issue of double counting;
- Concerning the sustainability of energy savings over time: Lifetime of energy efficiency improvement (EEI) actions.

This background given the paper develops the idea of a standardised prEN-16212-based BU calculation tool, which can process different EEI actions in a flexible way, so that different calculation options can be chosen (e.g. different baseline options, different system levels, different ways of handling double counting, etc.). The proposed approach can be called "energy savings calculation for comparability" (ESC-COMP) and needs to be based on a data-base tool which is capable to process raw data. When comparing similar EEI actions in different settings the ESC-COMP tool may contribute to a better comparability of results by ensuring that the same calculation options are applied. The paper demonstrates the proposed approach for concrete examples of EEI actions.

Introduction

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

- There is a general need for policy evaluation which is based on reliable and quantifiable data on energy saving impacts of policy programmes and other facilitating measures.
- For EU member countries 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. It might be assumed that other countries will follow this approach in the light of the new Energy Efficiency Directive.

As refers to BU energy saving calculations in today's practice there are used quite different methodological approaches. 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 thgerefore 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 CEN draft standard on "Energy Efficiency and Savings Calculation" (prEN 16212) contains major principles and processes for the calculation of energy savings and can thus be seen as an important step towards methodological harmonisation. Although it is far away from decidedly narrowing down the possible results of energy savings calculations it can set the basis for a well-structured comparison of energy saving calculations. The following paper proposes a concrete approach towards higher degree of comparability in energy savings calculation transforming the principles and structure of prEN 16212 into a tool for practice.

Starting point: Need for comparability of energy savings calculations

Different methodologies applied for the BU calculation of energy savings lead 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.

Therefore the weak point in the assessment of energy efficiency policy is frequently the quantitative part. The weakness, however, does not refer to the absolute results of energy saving calculations as such, but to a lack of transparency on how these results have been achieved. Generally we may say that the absolute amount of energy saving is less important for policy evaluation purposes than aspects of comparability, such as

- The comparability between actors (such as different EEI programmes, different Member States etc.) 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 different BU calculation approaches

Starting from the structural elements of prEN 16212[1] we can derive the main reasons for incomparable results of different BU calculation approaches. prEN 16212 begins with the calculation of the gross energy savings of one unit subject to the measure (e.g. one building) and then adds up these unitary gross savings to obtain the total gross savings of all affected units.

This can be expressed in the following two simple formulas:

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

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

[1] CEN (2012), *Energy Efficiency and Savings Calculation, Top-down and Bottom-up Methods* – prEN 16212. European Committee for Standardisation

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.

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

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

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, i.e. 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). 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.

At the unit level 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*. For example, 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.

Both options lead to different results. 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, which are also described in prEN 16212[2]:

- 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;

[2] compare Reichl J. and Kollmann A., (2011). *The baseline in bottom-up energy efficiency and saving calculations – A concept for its formalisation and a discussion of relevant options.* Applied Energy, 88(2): 422-431

- 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[3]:

- 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?

Summing up the multiple choices 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 but we need a tool that supports us in increasing their transparency and comparability.

Proposal for an ESC-COMP tool for increased comparability

In order to achieve comparability of the results of energy savings calculations we need a tool that allows for a "parallel evaluation approach" independent of the evaluation that is done according to the specific calculation rules applied for the purpose of white certificate schemes, voluntary agreements or the obligations under the ESD. In the following the term "energy savings calculation for comparability" (ESC-COMP) is used as abbreviation for the proposed approach.

Figure 1 gives an overview on the proposed approach, which is then followed by a more detailed description of the different parts of the approach.

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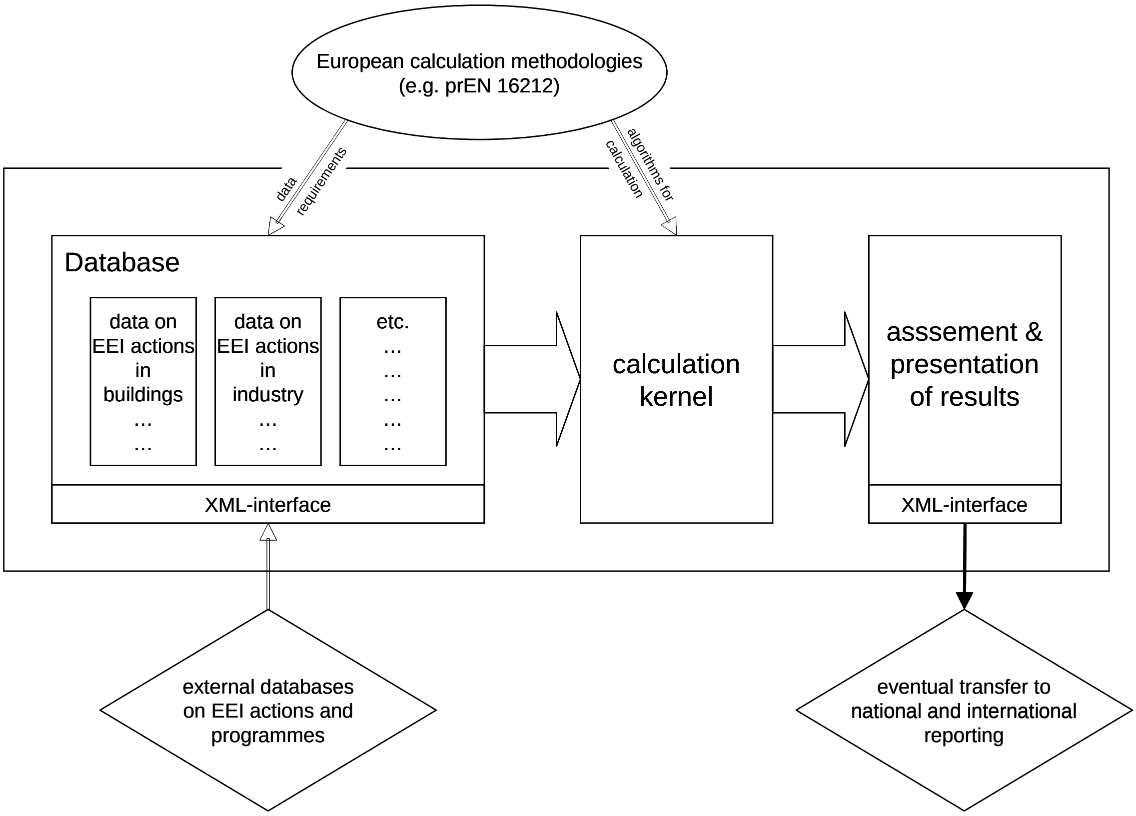
[3] compare Vreuls H, Thomas S, and Broc J-S., (2009). *General bottom-up data collection, monitoring and calculation methods.* Technical report. EMEEES Project

Figure 1: Overview on the ESC-COMP approach



Object of assessment

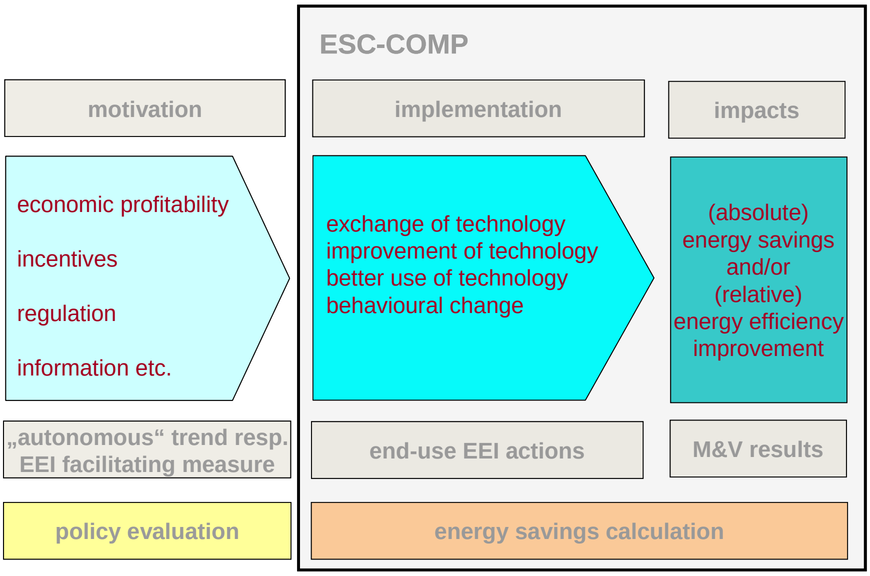
At first it is important to clarify the object of assessment of the ESC-COMP approach. ESC-COMP covers only the ”quantitative part” of the assessment of energy savings. Therefore the object of assessment is the elementary unit of end-user action; i.e. a certain system where an improvement of technology, organisational 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 on the amount of energy savings achieved.

Figure 2 illustrates the object of assessment of the proposed ESC-COMP approach and opposes it to an approach that refers to the assessment of 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.

Figure 2 Object of assessment of ESC-COMP



Standardised calculation kernel

Under the term "calculation kernel" we understand a set of algorithms, usually put together in a software tool. 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 deliver good guidance in fixing the algorithms. In principle it does not matter which calculation approaches are chosen at the end, because the approach does not intend to unify calculation algorithms but to ensure comparability.
What is thus more important is that the tool delivers the opportunity to compare similar EEI actions with the same methodological approach and to make changes in the applied methodological approach in an easy way. Therefore 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 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 m2 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: The example of EEI measure "boiler exchange"

The following chapter demonstrates how the ESC-COMP approach could work in practice with the help of a simplified example for the EEI measure "boiler exchange". We present a theoretical example which consists of a set of 10 boiler exchange measures in central heating systems of multi-family residential buildings. We assume the substitution of old outdated gas boilers by modern gas condensing boilers including 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. In a first step the calculation example is limited to one assessment period (assumed one year), thus excluding the additional complexity of life-time of energy savings derived from a certain EEI action[4]

Tables 1-4 show the different energy saving results which can be explained by the application of different calculation options, in detail as follows:

Calculation option 1 – Measured data based on billing analysis: This 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.

[4] compare CEN WS 27 (2007), Saving Lifetimes of Energy Efficiency Improvement Measures in Bottom-up Calculations, Final CWA Draft (CEN WS 27)

- The baseline is defined by the energy consumption gained from the bills for the baseline period. We assume that the baseline corresponds with the measured consumption before the implementation of the EEI action.
- 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 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 (as a proxy for the usage indicator). 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.

Calculation option 2 – Enhanced estimate for each single EEI action: Instead of using metered data this calculation option uses energy consumption values from energy performance of buildings standards. Calculation option 2 features the following characteristics:

- The choice of the specific indicator in the energy performance calculation defines the choice of system boundary. In our case we choose the indicator of final energy consumption thus selecting the building as system boundary. In this case the energy consumption of the whole building is calculated (not only the losses related to the heating system). In Table 3 this is expressed by a final energy consumption which includes the losses through the building envelope (net heat demand) as well as the demand for hot water and the losses of the heating and water installations.
- 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 calculation done for the baseline case is just adapted by substituting the old boiler by a new condensing boiler.
- No further adjustment with respect to weather conditions and/or usage patterns are necessary because these input parameters are already normalised in energy performance calculations.
- 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: Practically all required 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[5] - an automatic transfer of the required data to the ESC-COMP tool could be organised.

Calculation option 3 – Deemed estimate using standardised default values: This calculation option which is frequently used in the context of policy assessments (e.g. with respect to the reporting obligations under the ESD) 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 default value used for the energy demand to be served by the heating system – mainly due to the fact that in practice this value is not known for many boiler exchange projects – and one figure expressing the efficiency of the heating system itself.

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

- Furthermore the default values do not differentiate between the single buildings and EEI actions. This means that if the default values are once fixed – either on regional, national or even European level – the only information which is needed for an energy savings estimate is the number of sqm which are supplied by the new condensing boiler.
- "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 interactions are not taken into account accordingly.
- As a result the calculation option is 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. This is the reason why default values need to be fixed in a conservative way.

Calculation option 4: Deemed estimate with a market average baseline: This 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, since we assume that the old boiler is exchanged by a market average boiler instead of a highly efficient one. 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 in the near future.

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

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

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

Improvement of comparability through ESC-COMP in the case study

The ESC-COMP approach is not intended to decide upon the "right" way how to calculate energy savings, but it should give the possibility to switch easily between different calculations options and thus to evaluate similar EEI actions from the perspective of comparability. With regard to the case study presented above, the ESC-COMP approach could help for the following purposes:

- Comparing the EEI action presented above to other similar EEI actions in other countries and regions while ensuring that the same calculation option is applied;
- Making plausibility checks on reported energy savings for certain EEI actions;
- Making comparisons over time, i.e. "accompanying" longer-term EEI actions by monitoring activities which are based on the same methodological approach;
- Testing the impact of different calculation options on the final result of energy savings;
- Testing the impact of different default values and baseline definitions;
- Summing up the impact of different EEI actions by applying the same calculation option.

The major precondition is that for each "object of assessment" – i.e. for each elementary unit of end-user action – the required input data are collected. If the ESC-COMP database contains the sufficient information at the level of input data, calculation of energy savings can be easily repeated and shifted between different calculation options.

Conclusions

The paper demonstrated from the theoretical point of view as well as for a simplified practical example that comparability of energy saving calculations can be achieved by introducing a parallel evaluation stream. The proposed ESC-COMP ("energy savings calculation for comparability") approach aims at making different calculation options more transparent. Transparency in this context refers to 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 for the easy 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 put forward a standard approach for the calculation of Top-down energy savings, ESC-COMP would contribute traceable information on the quantitative impact of various BU measures. This would clearly add to a more reliable evaluation of energy efficiency policy and to a better chance to draw lessons learned from the successes and mistakes of the past.

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References

CEN (2012), *Energy Efficiency and Savings Calculation, Top-down and Bottom-up Methods* – prEN 16212. European Committee for Standardisation

CEN WS 27 (2007), Saving Lifetimes of Energy Efficiency Improvement Measures in Bottom-up Calculations, Final CWA Draft (CEN WS 27)

ISO (1997), *Technical energy systems – basic concepts;* ISO 13600:1997. International Organization for Standardization – International Standard

ISO (2002), *Technical energy systems – methods for analysis;* part 1: general – ISO 13602:1. International Organization for Standardization – International Standard

Kromer JS., (2007). *International performance measurement and verification protocol – concepts and options for determining energy and water savings.* Technical report. vol. 1. Efficiency Valuation Organization

Leutgöb K., Reichl J. and Kollmann A., (2011). Making the results of bottom-up energy savings calculations comparable, ECEEE 2011 Summer Study

Reichl J. and Kollmann A., (2011). *The baseline in bottom-up energy efficiency and saving calculations – A concept for its formalisation and a discussion of relevant options.* Applied Energy, 88(2): 422-431

Vreuls H, Thomas S, and Broc J-S., (2009). *General bottom-up data collection, monitoring and calculation methods.* Technical report. EMEEES Project