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Energy Efficiency and Savings Calculation, Top-down and Bottom-up Methods

Energieeffizienz und -einsparberechnung - Top-Down- und Bottom-Up-Methoden

Efficacité énergétique et calcul d'économies - Méthodes top-down (descendante) et bottom-up (ascendante)

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Energy Efficiency and Savings Calculation, Top-down and Bottom-up Methods

Efficacité énergétique et calcul d'économies - Méthodes top-down (descendante) et bottom-up (ascendante)

Energieeffizienz und -einsparberechnung - Top-Down- und Bottom-Up-Methoden

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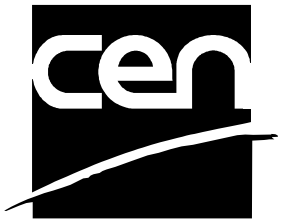

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Foreword

This document (EN 16212:2012) has been prepared by Technical Committee CEN/CLC/TC JWG 4 “Energy Efficiency and Energy Savings Calculation”, the secretariat of which is held by NEN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by February 2013, and conflicting national standards shall be withdrawn at the latest by February 2013.

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Introduction

Due to uncertainties of energy supply and the need to limit the greenhouse effect, European countries have adopted policies to increase the energy efficiency and to develop the use of renewable energy sources. The amount of energy to be saved in each state separately, and overall for the European Union (EU), has been notified in international agreements. In recent years the EU has adopted several Directives as part of the efforts at EU level to improve energy efficiency. An example is the Directive 2006/32/EC on energy end-use efficiency and energy services (ESD). The ESD establishes for 2016 a national indicative energy savings target, equal to 9 % of final energy consumption in five years before 2007.This target is to be reached through energy services and other energy efficiency improvement measures.

The formulation of policies and targets has led to the need for harmonised monitoring and evaluation methods on energy savings at international level and at European level. In addition many countries that get involved in the monitoring of the energy savings achieved, or the impact of implemented policies and measures, need these calculation methods as well.

This European Standard covers the following topics:

— the methodology and general rules of calculation;

— terminology and definitions;

— parameters and data, including data quality and data sources.

This European Standard covers both top-down and bottom-up calculation methods. The top-down method is based on energy indicators (e.g. mean gas consumption per dwelling) which are often calculated from statistical data. The bottom-up method considers end-user actions and facilitating measures to enhance energy efficiency. For top-down the standard uses the results of earlier indicator work in the Odyssee project and in the framework of the ESD. For bottom-up the standard builds on the results of the EMEEES project, initially done in the framework of the ESD implementation. These results are the starting point for this standard which is general in nature and applicable to a larger category of purposes and users than the EU-driven ESD.

NOTE 1 The ODYSSEE project develops and updates energy efficiency indicators that can be used to calculate top-down energy savings for the 27 EU countries plus Norway and Croatia.

NOTE 2 The EMEEES project dealt with the definition of top-down and bottom-up calculation methods to monitor the ESD savings.

The top-down and bottom-up calculation methods are presented as two separate calculation methods. Using a combination of top-down and bottom-up methods is not part of this standard. However, the differences and application of both methods will be highlighted.

This European Standard provides a general framework for calculating energy savings. For top-down, examples of specific calculations per indicator are presented separately. For bottom-up, one specific application case, on building energy use, is presented as example.

After normative references (Clause 2) and terms and definitions (Clause 3) the characteristics of the top-down and bottom-up methods are presented in Clause 4. The top-down calculation method is described in Clause 5 and the bottom-up calculation methods in Clause 6. Annex A provides some example indicators that may be used in top-down calculations. Annex B deals with the level of detail at which bottom-up methods can be applied. Annex C describes the bottom-up example case for buildings.

1 Scope

This European Standard provides a general approach for energy efficiency and energy savings calculations with top-down and bottom-up methods. The general approach is applicable for energy savings in buildings, cars, appliances, industrial processes, etc.

This European Standard covers energy consumption in all end-use sectors. The standard does not cover energy supply, e.g. in power stations, as it considers only final energy consumption.

This European Standard deals with savings on energy supplied to end-users. Some forms of renewable energy “behind-the-meter” (e.g. from solar water heating panels) reduce supplied energy and therefore can be part of the calculated energy savings. Users of the standard should be aware that this renewable energy behind the meter can also be claimed as energy generated.

The standard is meant to be used for ex-post evaluations of realised savings as well as ex-ante evaluations of expected savings.

This European Standard provides saving calculations for any period chosen. However, short data series may limit the possible periods over which savings can be calculated.

The standard is not intended to be used for calculating energy savings of individual households, companies or other end-users.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

CWA 15693:2007, *Saving Lifetimes of Energy Efficiency Improvement Measures in bottom-up calculations*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply:

3.1
adjustment factor
quantifiable parameter affecting energy consumption

[SOURCE: CEN/CLC/TR 16103:2010]

Note 1 to entry: Adjustment factors are mainly used in the bottom-up method.

EXAMPLE Weather conditions, behaviour related parameters (indoor temperature, light level) working hours, production throughput.

3.2
baseline
energy consumption calculated or measured, possibly normalised, in the situation without an end-use action

Note 1 to entry: The baseline provides a reference against which measurements can be taken or compared.

Note 2 to entry: The baseline can contain other actions but not the action under consideration.

3.3
bottom-up savings
energy savings calculated with bottom-up methods

3.4
bottom-up method
determination of energy savings from end-user actions using unitary savings and elementary units of actions

3.5
diffusion indicator
indicator showing the penetration of energy saving systems (e.g. efficient equipment or efficient mode of transport) with given savings per system

EXAMPLE Number of solar water heaters, efficient lamps or electrical appliances with a label A+ or A++, percentage of passenger transport by public modes or transport of goods by rail and water.

3.6
double counting
claiming energy savings more than once for two or more facilitating measures that focus on the same end-user action

Note 1 to entry: In most cases, the savings due to the combined effect of two facilitating measures will be lower than the sum of the savings from the separate effects.

Note 2 to entry: Double counting can be the result of overlap.

3.7
driver
quantity that is assumed to define the change in energy use under consideration in top-down methods

Note 1 to entry: A driver can be an activity (e.g. production) but also a state of a system (e.g. floor space).

3.8
elementary unit of action
entity for which unitary energy savings can be defined and summed up

Note 1 to entry: Generally it relates to an energy using system or a participant in an energy savings programme.

3.9
end-use action
energy efficiency improvement measure implemented on the site of an end-user

3.10
energy carrier
substance or phenomenon that can be used to produce mechanical work or heat or to operate chemical or physical processes

[SOURCE: ISO 13600:1997]

Note 1 to entry: The energy content of energy carriers is given by their gross (=higher) calorific value.

EXAMPLE Coke, petrol, gas, district heat and electricity.

3.11
energy consumption
amount of energy used

[SOURCE: CEN/CLC/TR 16103:2010]

Note 1 to entry: Although technically incorrect, energy consumption is a widely used term.

Note 2 to entry: The unit of energy consumption can be expressed related to the involved energy carrier but also in the standard unit for energy, Joule.

Note 3 to entry: The manner or kind of application of energy is expressed as "energy use".

3.12
energy efficiency
ratio between an output of performance, service, goods or energy, and an input of energy

[SOURCE: CEN/CLC/TR 16103:2010]

Note 1 to entry: It is essential that both input and output be accurately defined in quantity and quality, and be measurable.

Note 2 to entry: Energy efficiency is commonly used to mean the whole process of ensuring that energy is used in a more efficient manner, or in the most efficient manner that is economically cost-effective. This standard will only use the term in its narrower more technical sense.

Note 3 to entry: Commonly used meaning of energy efficiency is doing at least the same with less energy.

3.13
energy efficiency improvement (EEI)
increase in energy efficiency as a result of technological, behavioural and/or economic changes

[SOURCE: CEN/CLC/TR 16103:2010]

3.14
energy efficiency improvement measure
action normally leading to a verifiable, measurable or estimable energy efficiency improvement

[SOURCE: CEN/CLC/TR 16103:2010]

Note 1 to entry: In the ESD the term comprises both end-use actions and facilitating measures which are defined here separately.

3.15
energy efficiency indicator
value indicative of the energy efficiency

[SOURCE: CEN/CLC/TR 16103:2010]

Note 1 to entry: Mainly used as a metric in policy evaluation and in macroeconomic studies of energy efficiency.

3.16
energy end-user
entity consuming final energy

[SOURCE: CEN/CLC/TR 16103:2010]

Note 1 to entry: The energy end-user may differ from the customer who might purchase the energy but does not necessarily use it.

Note 2 to entry: Energy end-use can be grouped using the European statistical NACE code system or a national industrial classification conforming to NACE.

3.17
energy saving
reduction of energy consumption following implementation of end-use action(s)

Note 1 to entry: The reduction is obtained by comparison against the baseline taking into account all adjustment factors.

Note 2 to entry: Energy savings can be potential following an assessment or actual after implementing action(s).

Note 3 to entry: If an intended end-use action leads to an increase in energy consumption, then the energy savings calculated will be negative.

3.18
energy use
manner or kind of application of energy

[SOURCE: CEN/CLC/TR 16103:2010]

EXAMPLE Lighting, ventilation, heating, processes, production lines.

Note 1 to entry: The quantity of the energy applied is expressed as energy consumption.

3.19
energy using system
physically defined energy using item with boundaries, energy input and output

[SOURCE: CEN/CLC/TR 16103:2010]

Note 1 to entry: An energy using system can be a building, a vehicle or a plant but also a part of it, such as equipment, a machine, a product, etc.

Note 2 to entry: Output can be energy, service, product.

3.20
estimation
process of judging one or more values that can be attributed to a quantity

[SOURCE: CEN/CLC/TR 16103:2010]

Note 1 to entry: Estimation by a suitable experienced professional can provide data of a reasonable accuracy.

3.21
facilitating measure
energy efficiency service or an improvement programme offered to an energy end-user

[SOURCE: CEN/CLC/TR 16103:2010]

Note 1 to entry: A facilitating measure is offered by a third party that is not the energy end-user.

3.22
final energy
energy as received by an energy using system

[SOURCE: CEN/CLC/TR 16103:2010]

3.23
free rider effect
energy savings related to a facilitating measure that would have been realised also without the measure

EXAMPLE Free riders make use of subsidy schemes but would have implemented the subsidised end-user action anyway.

3.24
gross energy saving
energy savings before correction

Note 1 to entry: Examples of corrections are technical interaction, double counting, multiplier effect and free-rider effect.

3.25
measurement
process of obtaining one or more values that can be attributed to a quantity

Note 1 to entry: Measurement implies counting and comparison of quantities.

3.26
monitoring
recording and checking of metered and other data over a period of time

[SOURCE: CEN/CLC/TR 16103:2010]

3.27
multiplier effect
ongoing effect of a facilitating measure after the measure has ended

EXAMPLE Temporary promotion of efficient devices changes the market for these devices in such a way that further penetration occurs after the end of the promotion activity.

3.28
normalisation
adjustment of energy consumption over a period for influences that are not to be accounted for in the calculation of energy savings

Note 1 to entry: The correction is done using an adjustment factor that can be smaller or larger than unity.

3.29
rebound effect
change in energy using behaviour that yields an increased level of service and that occurs as a result of taking an end-use action

3.30
renewable energy
energy from a source that is not depleted by extraction

Note 1 to entry: In ISO 13602-1:2002, renewable resource is defined as "natural resource for which the ratio of the creation of the natural resource to the output of that resource from nature to the techno sphere is equal to or greater than one".

EXAMPLE Solar energy (thermal and photovoltaic), wind energy, water power and biomass that is replanted after harvesting.

3.31
saving lifetimes
number of years for which initial savings at implementation of end-user actions remain present

Note 1 to entry: See specified lifetimes in CWA 15693.

3.32
specific energy consumption
energy consumption per physical unit of output

[SOURCE: CEN/CLC/TR 16103:2010]

Note 1 to entry: Specific energy consumption can be defined at subsector level and relates the annual energy consumption to an annual physical production.

Note 2 to entry: In this standard it can also be defined for energy using systems and relates total energy consumption to the number of systems: it is then equivalent to mean yearly energy consumption per system.

EXAMPLE Gigajoule (GJ) per ton of steel, kWh per m^2 of dwelling, kWh per refrigerator, litre/100km for vehicles.

3.33
system boundary
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

3.34
technical interaction
relation of the elementary unit of action to the surrounding technical system or to other elementary units of actions which influence the unitary energy savings

Note 1 to entry: In case of technical interaction between elementary units of action, the energy savings related to different action may not be simply summed up. For example the combining of thermal insulation and a new efficient boiler in a single property leads to combined savings smaller than the sum of the savings for each measure apart.

3.35
top-down savings
energy savings calculated with top-down methods

3.36
top-down method
determination of energy savings from the variation for energy consumption indicators over a period, starting with aggregate statistics at national or sector level

EXAMPLE For industry, a decrease in energy consumption per Euro of output is not only due to energy savings but also due to changes in the structure of industrial production. Therefore separate indicators are calculated for cement production, steel production, etc. The savings per targeted energy use taken together provide energy savings of industry.

3.37
unitary energy savings
calculated energy savings per elementary unit of action

Note 1 to entry: Also called “unitary gross annual energy savings bottom-up”. The word "gross" means that corrections can be made and "bottom-up" highlights its use in bottom-up calculations only.

4 Characteristics of top-down and bottom-up methods

4.1 Characteristics

This European Standard provides separate top-down and bottom-up calculation methods. Currently no attempt is made to combine the top-down and bottom-up methods into one integrated calculation system.

However, in practice there will be a need to understand how top-down and bottom-up results relate to each other. Therefore, this clause describes the (different) characteristics of both methods with regard to:

- type of EEI measure (4.2);
- type of savings found (4.3);
- type of input data used (4.4);

— system boundaries (4.5).

An overview of the characteristics is presented in Table 1.

4.2 Energy efficiency improvement measure

An Energy Efficiency Improvement (EEI) measure can be a physical, organisational or behavioural action taken at an end-user's site (or building, equipment, etc.) that improves the energy efficiency of that end-user's facilities or equipment, and thereby saves energy. But it can also be an energy service sold to, or an energy efficiency improvement programme offered to this end-user, by an actor (such as the government or a company) distinct from an end-user, with the aim of supporting the end-user in implementing a specific physical, organisational or behavioural action.

In this European Standard, a clear distinction is made between the following two meanings of EEI measure:

— end-user action;

— facilitating measure.

End-user actions are energy efficiency improvement measures implemented by an end-user. Facilitating measures, such as regulation, subsidy schemes or voluntary agreements, stimulate end-user actions.

Facilitating measures do not by themselves result (directly) in energy savings. Instead, they are targeted to the implementation of end-user actions that would not have taken place without the facilitating measure. The saving effect of facilitating measures becomes visible in the form of end-user actions and their effect on energy consumption. Therefore, end-user actions are the first focus of the calculation of energy savings. These end-user actions may be of a physical, organisational or behavioural nature.

Top-down methods use energy efficiency indicators such as the mean gas consumption per dwelling to calculate energy savings. These indicators relate energy consumption at a (sub)sectoral level to a "driver" that is statistically representative. For example, energy consumption for space heating is related to the number of dwellings. The change in the indicator value is used to calculate the savings (in the example a lower mean gas use per dwelling). These savings are the result of all end-user actions that focus on the energy use covered by the indicator (in the example this could include roof/cavity wall insulation, double glazing and a high efficiency boiler among other possible measures).

End-user actions can be the result of facilitating measures but they can also be caused by other factors like high energy costs, autonomous progress, market forces or non-energy government policy. The energy indicator values incorporate both the effect of facilitating measures and other factors. Normally, the indicators cannot show separately the effect of facilitating measures.

Some top-down indicators regard energy use at a (very) low aggregation level, e.g. electricity consumption of refrigerators. In that case there could be a direct relation with a specific end-user action (buying a high efficiency refrigerator) and a facilitating measure (a labelling scheme for efficient refrigerators).

Bottom-up methods focus on the saving effect of EEI measures to enhance energy efficiency. The methods can focus on the effect of a facilitating measure, e.g. the energy savings due to an audit scheme. The methods can also calculate the saving effect of an end-user action, e.g. roof insulation for existing dwellings.

In case of facilitating measures, the saving effect will be derived from the effect of the end-user actions stimulated (e.g. for audits the end-user actions recommended by the audit). In case of end-user actions, the saving effect can be directly calculated, and may or may not be linked to one or more facilitating measures.

In practice, some bottom-up methods focus on aggregated end-user actions as a result of one or more facilitating measures. For example, the overall savings calculated for new dwellings may result from insulation, high efficiency boilers, heat recovery and solar water heaters, due to energy performance standards, subsidies for solar heaters and voluntary agreements with construction companies. Other bottom-up methods

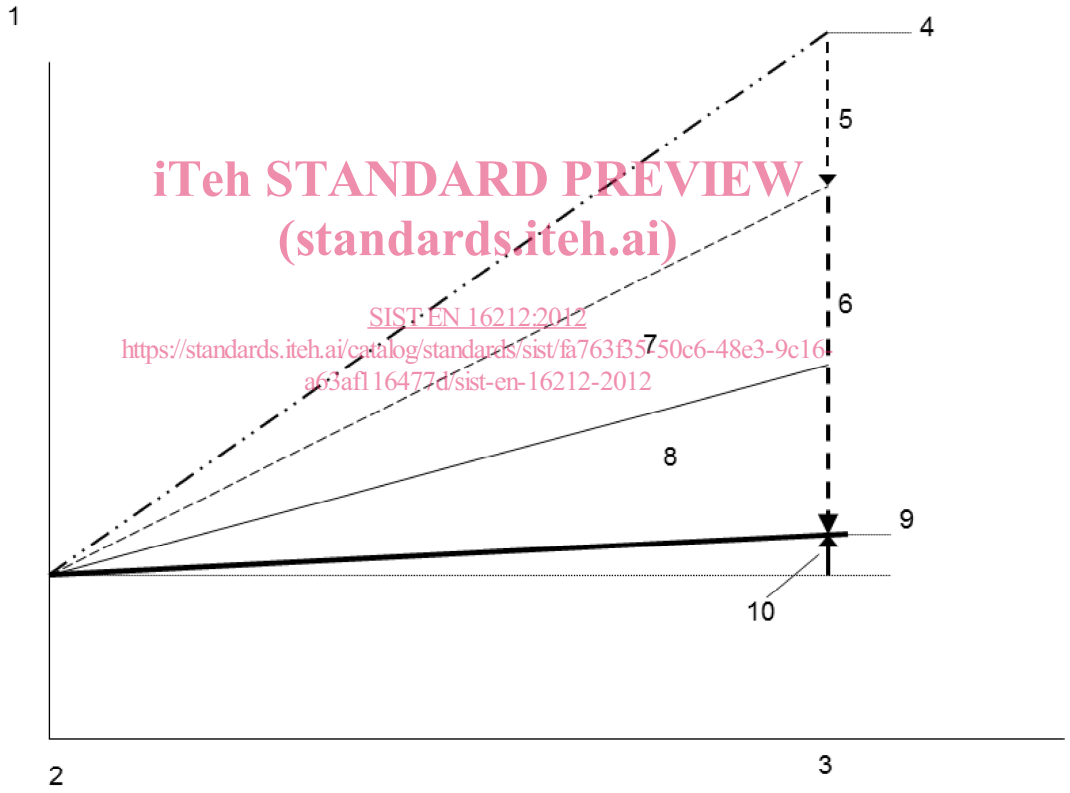
focus on very specific facilitating measures aiming at one end-user action, e.g. a light bulb replacement programme.

4.3 Type of energy savings

4.3.1 Total, autonomous and policy induced savings

Evaluations of energy savings can focus on total savings or policy induced savings. Total savings are important because they determine how actual energy use has changed and may develop. This is shown in Figure 1 where the upper line represents the final energy trend due to the growth in activities, number of energy using devices, etc. between a base year and a target year. Changes in the type of activities can limit the growth in energy use (see structural effect in Figure 1). However, structural effects can also stimulate energy use, e.g. longer opening hours in shops or public buildings. Total savings reduce the growth in energy use, which results in an actual energy use trend. The change in actual energy use can be upwards (see Figure 1), but with greater overall savings it could also be downwards.

A proportion of the total savings can be policy-induced savings which is important from the viewpoint of policy effectiveness, as it shows what policy has actually accomplished.



Key

1 energy use
2 base year
3 target year
4 final energy trend due to growth
5 structural effect
6 total savings
7 autonomous savings
8 policy-induced savings
9 actual final energy trend
10 change in final energy use

Figure 1 — Autonomous, policy induced and total energy savings

The difference between total and policy induced savings is known as autonomous savings (see Figure 1). Autonomous savings occur without a deliberate effort to save energy, from either the users themselves or by other actors. These savings can originate from technological progress, e.g. diesel instead of steam engines