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Specific guidance on evaluating Financial incentives on energy efficiency in Industry using the Unit consumption method

This guide can be applied to evaluate the savings due to grants or subsidies for saving actions in the sector industry using the method of unit consumption. It includes guidance and explanations specific to this combination of types of policy measure, sector and method, as well as links to general guidance and explanations that can also apply to this combination.

CONTENT

1 | USE OF THE GUIDE – AUDIENCE, OBJECTIVES AND FOCUS

The primary **audience** for this specific guide concerns energy efficiency programme designers, implementers or supervisors, and evaluators looking for guidance on the evaluation process of energy savings in the scope of this guide.

Although the application of the guide will generally concern the (sub)national level, account will be taken of issues at EU level when relevant (e.g. the specific format of saving figures for the EED).

This guide is not about the preceding step in the evaluation process, the choice of the method. About this previous step in the evaluation process, see the guidance provided here. However, after presenting the capabilities and limitations of the guide at hand, the user will be offered alternatives for the method within this guide (see section 6).

The **objective** of this guide is to provide:

- Information on the scope of the guide that enables the user to decide whether this guide is suited to his/her needs, and whether complementary or additional method(s) could be needed or useful (section 2);
- Guidance about specifying the evaluation objectives and requirements (section 3);
- Guidance about key methodological choices to calculate energy savings (section 4);
- Guidance about the inputs (data requirements) and outputs of the method (energy savings metrics) (section 5)**;**
- Possible alternative methods (with pros and cons) (section 6)
- Background about evaluation results other than energy savings (section 7);
- Relevant examples, case studies and/or good practices (section 8);
- Relevant references for further reading (section 9).

The guide is intended for assessing realised (ex-post) energy savings. However, account is taken of earlier (ex-ante) evaluations of expected savings, if available (see section 4).

The **focus** of the guide is on *impact evaluation*, i.e. determining the energy savings, but not on how this has been reached through a step by step process with intermediate results (process evaluation).

Readers looking for the basic and general principles of energy efficiency evaluation may find the following link useful.

2 | SCOPE OF THE GUIDE – POLICY, SECTOR and METHOD

2.1 About financial incentive policy

More information and examples on the different subtypes residing under the main type Grants & Subsidies (GS) can be found here and here.

Financial incentive policy is restricted to grants of subsidies concerning specific energy using systems, which should make it more attractive to invest in the most efficient version.

More detailed information on the evaluation of grants and subsidies can be found here.

2.2 Evaluation for a combination of policy measure types

When the subsidy scheme is combined with other policy measures types (e.g. a voluntary agreement on savings) it is assumed that the overall savings are mainly resulting from the policy measure at hand. However, in this case the evaluation concerns the combined savings effect of both policy measures.

The guide may not be capable of attributing part of the (overall) calculated savings to each of the policy measures (see also Double counting in section 4 on Gross to Net savings).

2.3 Evaluation when combined with energy taxes

The calculated savings effect for a subsidy scheme can overlap with that of the energy tax. The guide is not capable of attributing part of the (overall) calculated savings to either the policy measures at hand or the energy tax. For dealing with this overlap see section 4 on Calculating Gross and Net savings.

2.4 About the industry (sub) sector

Information on (sub)sectors defined in the Toolbox can be found here, chapter 2, p.17

The sector industry is characterized by production and use of material goods, applying a high degree of automation and mechanization. The industry is divided in different sectors (usually defined by the national statistics office), like food & beverage industry, chemical and pharmaceutical industry, paper industry, rubber and plastic industry electro-technical industry. Although the guide is meant to cover all sectors in industry, it will mostly be applied to sectors with specific systems using a considerable amount of energy, for which the unit consumption method can be applied.

2.5 Evaluation for cross-sector saving actions

Specific energy using systems, like electric drive of pumps, can be present in other sectors as well. The guide is also applicable to these cross-sector saving actions (see next section).

2.6 About the unit consumption method

Information about the various evaluation methods can be found here, table 1 and 2. This source also covers the combination of the method at hand with other methods, which will be dealt with below.

The unit consumption method concerns the calculation of unitary savings for energy using systems, like appliances or equipment. The equipment considered is very much linked to the subsector.

In industry, it might be the energy required for a naphtha cracker of a particular size (in terms of tonnes/day of ethylene, or the energy consumption of an electric drive for a pump. The unit consumption method uses an indicator on energy consumption per unit of physical output. For example, the energy required to produce one tonne of ethylene in a naphtha cracker. The indicator approach is closely related to the concept of unitary savings applied in most evaluation methods (see chapter 4).

2.7 Complementary methods to determine total savings

Complementary methods are methods that are required, in addition to the primary selected method, to calculate energy savings.

The method at hand is meant to calculate unitary savings for one particular piece of equipment or appliance. These unitary savings should than be multiplied by the number of saving actions (e.g. number of electric drives for pumps in the Netherlands) in order to have the calculated total savings. The number of actions (equipment per type) can be obtained in various ways. See this link, table 2 and 3. The number of actions is sometimes directly available from the monitoring of policy measures, such as in case of a subsidy scheme.

2.8 Additional methods to increase reliability of the results

An additional method can be applied on top of the unit consumption method for this Specific Guidance to improve the reliability of the evaluation results and/or the cost-effectiveness of the evaluation approach. Measurement of energy consumption of the equipment (direct measurement) for a sample group of the saving actions can also be an additional method to check the results of the unit consumption method. The combination can increase the reliability of the savings figures and is more cost-effective than measurement for all equipment.

A second additional method is the engineering estimates method, which is very suitable for calculating the savings for a complex energy using system like specific industrial processes. The change in unit consumption does not show where and how the savings will be (ex-ante) or have been (ex-post) realized. Moreover, the unit consumption does not show the part of total savings that is due to policy (i.e. the subsidy). Engineering calculations can include factors that create uncertainties in the results. With the engineering estimate method the savings can be analysed in more detail, thus providing more insight in the saving actions and the role of subsidies. Engineering estimates as additional method are more costly than the unit consumption method but is affordable due to the larger scale of energy consumption.

It can also be useful to combine the engineering estimates with measurement as additional method. The combination can increase the reliability of the savings figures in a cost-effective way.

For possible combinations with an additional method see chapter 6 in this link.

3 | EVALUATION OBJECTIVES and REQUIREMENTS

3.1 Meeting evaluation goals and ambition

The table shows whether this guide can be used to report on general evaluation goals or criteria. See also this document.

General types of evaluation goals or criteria	Level of ambition	Remarks
Calculation of realized energy savings from saving actions	Fair	For reasonably uniform saving actions
Calculation of energy savings attributed to the policy measure(s)	Low	Additional method (engineering estimate or direct measurement)
Cost-effectiveness of saving action (for end-users)	Fair	Good housekeeping of data
Cost-effectiveness of policy (government spending)	Low	Due to free rider effect
CO_2-emission reduction from saving actions	Fair	Direct link with energy savings
CO_2-emission reduction attributed to the policy measure(s)	Low	Due to free rider effect

For more information on verification of actual energy savings and attribution/baseline/corrections, see section 4, and for cost-effectiveness and emission reduction see section 7.

3.2 Reporting expectations

- Gross and Net savings, these are the savings that are calculated by the method of unit consumption (gross) or the adjusted savings attributed to the policy measure. See further in section 4 under the heading of Calculating Gross and Net savings.
- Yearly or cumulative savings, these energy savings can be ranked as cumulative over a specific period or on a yearly basis.

3.3 Time frame for evaluation

The length of the period under evaluation is dependent on the active period of the policy measure, the need to monitor developments before the implementation of savings actions (in case of methods based on before/after saving actions), and the time needed to present (reliable enough) results or impacts that fit into the decision making process. In some cases, the periodicity of evaluation can be set by law. This measure, and thus the associated monitoring, is typically executed in a period of a few years (2-5).

The planning of evaluation activities concerns regular monitoring of energy consumption and factors that define consumption, intermediate check of (ex-ante) estimated (unitary) savings through engineering estimates, actual measuring or surveys, intermediate evaluations to improve the policy implementation and the final evaluation and reporting, see also planning of evaluation in the link here.

3.4 Expertise needed for chosen method

For this evaluation method knowledge on the subsector and the associated equipment or production processes is vital.

3.5 Boundaries for the evaluation

Typical boundaries for this evaluation concern the defined subsector or the demarcation of the energy using system as part of overall process.

4 | KEY METHODOLOGICAL CHOICES FOR CALCULATION OF ENERGY SAVINGS

This section deals with key methodological choices to be considered when calculating energy savings: consistency between ex-ante and ex-post evaluation, baseline, normalization and adjustment factors. These choices are important to document when reporting energy savings, to ensure the transparency of the results.

General principles of calculating realized savings using different methods can be found here and here.

The unit consumption method calculates the energy saved per type of industrial equipment. To estimate the effect of the policy, it also needs to take into account which part of the savings is due to the subsidies.

4.1 Matching method with earlier ex-ante evaluation

From the viewpoint of methodological consistency and data availability, using the same method in ex-ante evaluation and in this guide on ex-post evaluation, might be an obvious choice. However, the unit consumption method is not applicable for an ex-ante evaluation, unless very detailed scenario data are available (see next reference below).

The ex-post method unit consumption can be combined with a different method used for the ex-ante evaluation, depending on the evaluation objectives, timeframe and data available for the situation after implementing the actions. Available ex-ante methods are deemed savings, engineering estimate and stock modeling. However, the last one is not practical where it concerns limited numbers of specific equipment in industry. For possible combinations of methods applied ex-ante and ex-post, see chapter 7, calculation approaches in in this document.

4.2 Calculation baselines

Energy savings are defined in general as the difference between the actual situation and a reference situation without the saving actions (and without the policy measures that influence these saving actions). In case of saving actions, the reference situation can be defined using various calculation baselines: Before/after, With/without, Trend, Target/control group and Minimum efficiency standards (see further here).

Total savings are found by multiplying the unitary savings per action by the number of actions. The chosen baseline can define the total savings through the unitary savings, but also through the number of actions.

The applicable baseline Before/After, which compares the situation prior to the introduction of the subsidy scheme with the situation after (usually after some years), is considered most appropriate.

An alternative is the baseline option “Target/control group” where non-subsidized comparable equipment acts as the control group. The difference in unit consumption for target and control group can be used to calculate the savings. This baseline enables to correct for (almost) all other influences. However, this only works for comparable equipment and for a sufficiently high number of equipment in the absence of dedicated information. The choice between baseline options will be dependent on the requirements formulated in chapter 3.

See further information in this document.

4.3 Normalization factors

The calculation with the Before/After baseline considered above provides a change in energy consumption that should be corrected for influences on energy consumption other than the saving actions. These so-called normalization factors can be weather (with effect on consumption), the **rebound** effect and changes in energy using **activities**, such as production (industry), occupation rate (buildings) or car usage (transport). All normalization factors affect total savings through the unitary savings.

For the industry sector changes in energy using activities are most relevant in terms of normalization, see table 1 here.

For each type of equipment concerned energy consumption can be corrected for differences in production volume/utilization rate for the baseline situation and the situation after the saving action.

The rebound effect can be ignored as it generally concerns space heating in dwellings or fuel use in cars. For industrial equipment correcting energy consumption for weather is normally not needed.

4.4 Adjustment factors

Adjustment factors define which part of the calculated energy savings can be attributed to a policy measure or meets the definition of savings specified in the evaluation objectives or reporting requirements (see next section on "Calculating Gross and net savings).

Adjustment factors can concern the Free rider effect, the Spill-over/multiplier effect, Additionality and Non-compliance, see table 1 here.

Additionality and non-compliance are connected to unitary savings, while free riders and spill-over work through the number of actions.

Double counting might be relevant in case of another policy measure focusing on the same saving actions, but can only be accounted for at a higher level than an individual Specific Guidance. See section on Calculating Gross and Net savings in this link; also here and in this link.

The adjustment factors to consider in priority are the **free rider** effect and **non-compliance**. For free riders a distinction must be made between saving actions due to the policy measure and actions which would have been taken anyway.

The unit consumption method does not provide this information directly, thus other ways must be found, such as a survey among participants to the policy measure about their motivation, or application of Randomized Controlled Trial (RCT) or Quasi-experimental design, see further in this topical case study.

In order to correct for non-compliance due to inappropriate implementation of saving actions, data should be available of sample-wise checks on the implementation.

See also link to note "Saving calculation methods and their application in the EPATEE Toolbox".

4.5 Calculating Gross and Net energy savings

Gross savings concern the calculated savings from saving actions using a chosen baseline and normalization factors. Net savings concern the savings attributed to policy measures or to a stakeholder (e.g. an energy company with an obligation to realise savings at their customers).

When calculating savings a distinction must be made to the **unitary savings** and **number of actions**, see further in this link.

The gross unitary savings can be calculated using the before/after baseline. Per piece of equipment or per production system the unitary savings follow from the change in unit consumption per tonne of product, which is corrected for changes in activity levels (see also section on Normalization factors). The number of actions is the number of subsidized more efficient equipment.

Net unitary savings can be calculated from gross unitary savings by applying the adjustment factor non-compliance (see section on adjustment factors). The net number of actions follows from the gross number, corrected for the adjustment factor free rider). See here and here and here.

In case of using the baseline Target/control or comparison group the net savings can be evaluated directly, thus without applying gross-to-net adjustment factors.

In case applicable, the energy savings should be corrected for the double counting effect, i.e. the overlap between the savings due to the financial incentive measure and savings due to other policy measures. The overlap in the calculated savings of both policy measures cannot be processed at the level of a specific guidance, but must be corrected at the level of savings due to overall policy portfolios. For addressing double counting see here or here.

See also chapter 8 on concrete examples.

5 | INPUT AND OUTPUT

5.1 Main data requirements, sources and collection techniques

Data requirements specified in the table below correspond to the calculation of energy savings, when using the baseline option Before/After.

Calculation subject	Data requirements	Possible data sources and collection techniques
Energy consumption per equipment type before and after saving actions	Energy consumption ion before/after subsidy for on saving actions	Data from equipment providers or from submitted saving plan to get subsidies
Normalization factor: change in production volume (throughput)	Production level before/after subsidized saving actions	Monitoring program: Plant data (in case of continuous production), equipment data (e.g. energy use as function of capacity or throughput)
Primary energy factors applied (from final to primary savings)	Fuel input and electricity output of power production	Statistics on electricity conversion
Number of saving actions	Number of equipment (per type) with saving actions	National statistics
Adjustment factor free riders	Fraction of actions without need for subsidies	Survey on reason to invest in more efficient equipment

Data issues when evaluating net energy savings

The main good practice to ensure the feasibility and reliability of the evaluation of net energy savings is to think about the method to be used when designing (or revising) the financial incentive measure with the unit consumption method. Before the introduction of the policy measure, the data collection method for the selected industrial equipment items or appliances has to be assessed and confirmed.

Determining the free rider effect asks for a separate survey among receivers of subsidies.

For more details about the evaluation of net energy savings, see this topical case study.

Data issues with the additional method

For possible other methods with different data demands see the section 6 on alternatives for the chosen method.

5.2 Energy savings in final terms or in primary terms

Energy savings can be expressed in final terms or in primary terms. See definitions about primary and final energy here.

The unit consumption method can calculate savings in final terms. It can also calculate savings in primary terms if savings at end-users are calculated for each energy carrier apart, and primary factors are available to convert the savings in final terms to savings in primary terms.

5.3 Energy savings over time

Implemented saving actions in a year lead to savings over a number of consecutive years. E.g. a more efficient boiler can save gas over its lifetime of about 15 years, insulation over up to 60 years and more efficient computers up to 5 years.

Energy savings can be calculated in different metrics in terms of time reference, for example: year-to-year, annual, cumulated annual, cumulative. See the definitions here.

The calculated yearly savings concern the savings of all new saving actions in that year. In this approach, only data for the savings in the chosen year are needed.

Adding up the yearly savings over a period, provided that earlier saving actions are still delivering savings, leads to cumulative savings. For the cumulative savings, data are needed for the whole period.

Another cumulative approach, to be applied for the EE directive, is to multiply the (new) savings in a year with the number of years up to a target year and sum this result with that for all other years up to the target year. This cumulative approach stimulates early saving actions, as these count more times to the target than later actions.

Finally, savings from a saving action can be discounted and summed up over the lifetime of the action See link here.

The unit consumption method in the guide can provide yearly savings of new saving actions in that year. It can also provide cumulative savings provided that data are available over a period.

In case compliance with EU policy evaluation requirements is required, cumulative savings according to the Energy Efficiency Directive can be provided when the lifetimes of savings actions are known. Finally, the guide can provide discounted cumulative savings when discount factors have been defined for yearly savings over time.

6 | ALTERNATIVE FOR CHOSEN METHOD

6.1 Alternatives for the chosen method

Often other savings calculation methods can be applied as well, although they will all have pros and cons regarding various aspects dealt with in preceding sections.

The table below presents the pros and cons of the method for evaluating financial incentives in industry, and for commonly used alternative methods for the same combination of policy measure and sector.

Type of method	Pros	Cons
Unit consumption method	Relatively simple when data are available	May be inaccurate due to complexity of system. No insight in factors behind change in unit consumption
Engineering estimate	Accurate description of complex systems and contribution of different saving actions	More time consuming, needs special expertise on equipment level

7 | ADDITIONAL EVALUATION RESULTS

7.1 Calculating avoided CO_2 emissions

Avoided CO_2 emissions can be evaluated from the energy savings by applying emission factors. Four key aspects are to be taken into account when choosing the emission factor(s):

1) Emission factors vary according to the **energy type**, so the data about energy savings need to be available per energy type
2) Emission factors for a given type of energy **can vary over time** (especially for **electricity**).
3) Emission factors can take into account:
   a. **Direct emission factors** that take into account the emissions generated when producing the energy used;
   b. **Lifecycle emission factors** which take into account all the emissions generated from the extraction of the energy resources up to the dismantling of the energy plant.

Due to the differences that the choice of emission factor(s) can induce, it is important to document what emission factor(s) has(have) been used. The emission factor(s) have to be defined per equipment item of appliance.

The direct reduction in CO_2-emissions can only be calculated when savings are calculated per relevant energy carrier and a specific emission factor is available for each energy carrier.

If the savings concern electricity only (e.g. appliances) the reduction in CO_2-emissions can be calculated from the savings with an emission factor for electricity that takes into account the different inputs of power production. The actual factor to be applied can vary, depending on saving action(s) and sector, year of implementation, policy considerations and etcetera.

The avoided emission of **other greenhouse gases** due to energy savings are not taken into account here, as emission reductions are generally negligible compared to that of CO_2.

IPCC (Intergovernmental Panel on Climate Change) provides a **detailed database of peer-reviewed emission factors.**

7.2 Calculating cost-effectiveness

Cost-effectiveness is the ratio between costs to achieve energy savings and the amount of savings and possibly other benefits.

A distinction can be made according to the point of view adopted to assess cost-effectiveness:

- Cost-effectiveness for the end-user or participant
- Cost-effectiveness for society at large
- Cost-effectiveness for the party that takes responsibility for saving targets (government or actor with an Energy Efficiency Obligation)

See further here.

The calculation of cost-effectiveness for end-users demands, apart from the savings:

- data on investments made, subsidies on investments, interest rates, lifetimes of the saving actions per type of unit or equipment
- energy prices (including taxes) and discount factors per type of end-use.

The calculation proceeds as by calculating the energy savings in monetary units per year over a period of time (the lifetime of equipment) and comparing that with the investment done at the used discount factor in %. This will generate the Payback time, Internal return of Investment (IRR) and the Net Present Value (NPV). In a simple spreadsheet calculation these figures can be obtained.

7.3 Calculating other co-benefits

Possible co-benefits from saving energy concern:

- Extra employment
- Reduction of energy poverty
- Other emission reductions (NO_x, SO_2, fine particles, etc.)
- Better indoor climate
- Reduced dependency on (insecure) energy import

The above issues may be calculated, but do depend on the equipment items of appliances selected for this guide. When applicable, these co-benefits should be included at the implementation of the policy measure, as the related data collection can then be formulated.

7.4 Other aspects of importance

The competitive position market players or companies involved.

8 | CONCRETE EXAMPLES

N. v.d. Velden (LEI), Energiemonitor van de Nederlandse Glastuinbouw 2009 (Agricultural monitor) (in Dutch), available at http://edepot.wur.nl/15538

9 | FURTHER READING

About the Unit consumption method

There is a wide variety of information on the internet; a very practical tool is listed here:

- https://www.rapidtables.com/calc/electric/energy-consumption-calculator.html

About subsidies and free riders

- https://corporatefinanceinstitute.com/resources/knowledge/economics/free-rider/

Relevant case studies

The case study on the EE agreement for Industries in Finland. This study does not use the unit consumption method, yet the case study describes nicely the setting up of a program on energy Efficiency with stakeholders.

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