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EPATEE

# Evaluating taxation for energy efficiency in end-use sectors using regression analysis

This guide can be applied to evaluate the savings due to energy taxes in various end-use sectors using the method regression analysis. 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 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 energy taxes

Taxation for the purpose of energy efficiency improvements mainly aims at addressing market failures caused by energy consumption, by charging a tax or levy on certain type of energy sources or energy usage. The objective of the measure is to make consumers and producers pay social cost of the good (including the cost that pollution poses to society in the form of carbon emissions and green house effects). In practice direct and indirect measures are typically used. Direct measures include charges related directly to the externality. This type of measures implicitly assumes that the market failure is observable and quantifiable. An example would be taxes on carbon emissions. Indirect measures are taxes related to the consumable generating the externality (for example, the fuels generating carbon emissions) or consumables related to it (e.g. the cars which use such fuels).

The energy taxes measure is a subtype of the main policy measure type Fiscal/Tariffs. More information and examples on the different subtypes residing under the main type Fiscal/Tariffs can be found here and in the Knowledge Base of EPATEE .The focus of this guide can be enlarged to taxes based on the CO2-emission, provided that this tax can be converted to a levy per unit of energy consumption.

Many other policy measures focus on specific saving actions, but taxes influence all saving actions, not only of a technical nature, but also behavioral, where the increase of the energy costs plays a role.

Where variations in tax rates exist, separate analyses should be carried out for each group and energy type.

The impact on end consumer prices should be expressed as the percentage change relative to the price including the tax.

In case of taxes for intermediate actors (e.g. energy companies) it is important know the extent to which the tax is passed on to end consumers, and any exemptions or variations in rates for particular groups of end consumers or energy type, also taking account of any offsetting allowances or subsidies. In the case that an allowance is foreseen for low income households for alleviating the impacts from an increased tax, the weighted increase of the tax that is passed on to end consumers should be estimated.

More detailed information on the evaluation of energy taxes can be found in this link.

## 2.2 Evaluation for a combination of policy measure types

In practice, energy taxes are implemented in parallel to all types of policy measures (from financial to standards and from information to voluntary agreements). When this guide is applied it is assumed that the overall savings are mainly due to energy taxes. However, the evaluation concerns the combined savings effect of this policy measure and other policy measures focusing on the same energy users. For dealing with this overlap see section on Gross to Net savings.

## 2.3 About end-use sectors

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

The guide is capable of covering the effect of taxes for all end-use sectors, but it can also be applied to specific parts of end-use under taxation. Often the tax level is differentiated as to sector, e.g. lower for industry because of international competition. Sometimes the tax is restricted to part of the sector, e.g. below or above a certain amount of consumption, or the tax does not target all energy carriers.

Also, distinctions can be made for end-users in a sector, in order to have an appropriate regression analysis. In the residential sector, for example, a distinction can be made as income groups, floor area, individual dwellings or apartment buildings.

## 2.4 About the regression analysis method

More information and examples on the different subtypes residing under the main type **(financial incentives)** can be found here and 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.

In regression analysis the (change in) a dependent variable, here energy consumption, is assumed to be a function of (the change for) a number of explaining variables. These variables may be level of energy using activities, energy prices or any quantity that Is regarded as influencing energy consumption. Time series should be available for all explaining and dependent variables.

In the regression formula a factor is attached to each explaining variable. The energy consumption is calculated accordingly and compared with the observed energy consumption. The value of the factors is determined, using the least square algorithm, such that calculated yearly energy consumption fits best to observed energy consumption. The values found for each factor show the relative influence of each explaining variable on the (change in) energy consumption.

In case of introducing a tax the energy price for end-users will rise and observed energy consumption should decrease. The value of the regression factor from the regression analysis times the amount of taxes provides the effect of the tax on energy consumption (see also chapter 9 on Further reading).

If different tax rates apply to different end-user groups or fuel types, the regression analysis should be applied for each group apart, and the counterfactual energy consumption should be separately calculated for each consumer group and fuel type.

The regression formula can be formulated in many ways, e.g. with lagged yearly values for some explaining variables, such as energy prices. The influence of weather conditions can be taken account of by introducing Heating Degree Days as explaining variable in the regression formula.

The analysis can also be performed at a lower aggregation level, e.g. with the number of implemented saving actions as dependent variable, where the effect of the tax is expressed in extra saving actions.

Regression analysis on taxes can even take into account the effect of other policy measures, e.g. a comprehensive scheme on energy saving audits to avoid higher energy costs due to the tax. The introduction of such a scheme is accounted for in the regression formula as a deterministic variable with a factor 0 or 1 (before respectively after introduction year).

The analysis can be performed for distinctive parts of end-use sectors, e.g. for households with different dwelling types or income levels

Finally, regression analysis is connected to elasticity analysis (see also the guide on Elasticity analysis in the Toolbox). The price-elasticities applied in the method elasticity analysis can be calculated with the method regression analysis.

## 2.5 Complementary methods to determine total savings

Complementary methods are required, in addition to the primary selected method, to calculate number of actions or unitary savings as part of calculating total energy savings.

However, the method regression analysis provides directly the total savings, thus does not concern complementary methods.

## 2.6 Additional methods to increase reliability of the results

An additional method can be applied on top of the already chosen method to improve the reliability of the evaluation results and/or the cost-effectiveness of the evaluation approach.

In regression analysis the combined effect of a set of explaining variables is analysed. This implies that leaving out, or adding, an explaining variable may change the values of regression factors for all other explaining variables. Moreover, the results are dependent on the quality of the yearly data for all variables applied.

In practice this can lead to “wrong” sign for factors, e.g. a positive factor for the energy price, suggesting that higher price does not lead to lower energy consumption. However, also with the “right” sign for explaining variables the results have to be checked. For energy prices the results can be checked with the results obtained with the guide on Elasticity analysis from the Toolbox. The impact on energy consumption of individual actions undertaken during the taxation can be calculated from, elasticities of demand and the observed energy consumption in order to estimate the counterfactual, which depicts the energy consumption without the imposed energy or CO2 tax. Compared with the resulting observed energy consumption this provides an estimate of the reduction in energy consumption thanks to the taxation measure each year. This process can be an element of the regression analysis to provide more robust data on the price reactions.

Regression analysis, focusing on aggregated energy consumption in a top-down “black box” approach, can also be checked with bottom-up approaches focusing on the different saving actions influenced by energy taxes. These concern the methods deemed savings, engineering estimates, unit consumption or (sample-wise) measurement.

For possible combinations with an additional method see chapter 6 of the document here.

# 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 or this link.

| General types of evaluation goals or criteria | Level of ambition | Remarks |
|---|---|---|
| Calculation of realized energy savings from saving actions | Limited | Regression analysis does not focus on specific saving actions, but can focus on specific parts of end-use |
| Calculation of energy savings attributed to the policy measure(s) | Good | Can provide savings due to taxes accounting for all other influencing quantities |
| Cost-effectiveness of saving action (for end-users) | No | Method does not focus on individual actions with costs and benefits |
| Cost-effectiveness of policy (government spending) | Not relevant | No government spending |
| $CO_2$-emission reduction from saving actions | Limited | See realized savings |
| $CO_2$-emission reduction attributed to the policy measure(s) | Good | For distinction between tax per energy carrier (with own emission factor) |

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

Possible reporting options:

- Net savings (no Gross savings, see section 4)
- Yearly savings (no cumulative savings because no specific saving actions, with life times, are regarded, see section 5)
- Effect of other variables than energy taxes, e.g. energy using activities or another policy measure (see section 2).

## 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 introduction/major increase of the energy tax and the time needed to present reliable results that fit into the decision making process.

For regression analysis the time series should be as long as possible, covering changes in most of the explaining variables and/or energy consumption. Preferably the length of the period before the energy tax should be as long as that of the active period of the energy tax (without major changes in this period).

The effect of prices as explaining variable will vary over time. In the short-run it will be smaller. This reflects the limited options (such as indicatively behavioural measures or fuel substitution decisions) facing consumers as they adapt to the change in prices. Over time, it will become larger as more and more consumers make investment decisions based on the higher energy prices, which offer better returns to investments in more efficient goods and services. Given full replacement over decades the time frame should be at least 10 years to show the longer term effects of taxes.

In case of already existing taxation measures, the impacts of energy efficiency individual actions should be isolated from the impacts of individual actions undertaken in earlier periods. Specifically, the investment decisions based on the higher energy prices due to the imposition of a tax, which were initiated in the medium run period, should be deducted during claiming the energy savings in the entire evaluation period. Before the introduction of the energy tax the monitoring of the saving effects must be set up, including data availability for earlier year, such as (mean) energy prices for each group of end-users and energy consumption. See also planning of evaluation in the link here.

## 3.4 Expertise needed for chosen method

The actual estimation and interpretation requires expertise in econometric and statistical analysis (theory and practice) including the testing of statistical parameters to assure quality and robustness of the results.

In order to set up a reliable regression analysis expertise is needed on the possibilities and limitations: the choice of relevant influencing variables, possible regression formulas (including lagged variables or deterministic variables) and the availability/quality of time series for all variables.

## 3.5 Boundaries for the evaluation

Because energy taxes are often introduced at national level or at least at sector level, the method will normally be applied at that aggregated level. This is also true for EU wide taxes that become part of national policies.

If taxes differ per sector, or even inside sectors, the analysis should preferably be executed separately for each (sub) sector.

# 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.

General principles of calculating realized savings using different methods can be found in

For the application of the regression analysis method the following issues has to be taken into account.

If the tax differs per group of end-users separate calculations must be made for each category. In case of a flat tax on all end-users the analysis can be done at end-user level.

Price and tax levels, as well as the reaction (amount of energy savings), often differ for fuels and electricity; therefore separate calculations must be executed for fuels and electricity.

Contrary to most other methods used in the guides of the Toolbox the method does not show the composition of the savings, e.g. amount of insulation actions times the unitary savings per action, including the investments made, etcetera.  But given an application per sub-sector or category, insight in the contribution per group of end-users can be provided.

The method provides by nature the net savings due to the energy tax, thus no corrections of gross savings are needed. However, if other policy measures focus on the group of end-users with a tax , a correction should be made for Double counting (the contribution of other policy measures, see section on Gross to Net savings).

Interaction of energy taxes with other policies is a major issue. In order to cope with this interaction, especially over longer periods, it is recommended to either (a) only use short-run elasticities when calculating the impacts of taxation measures; or (b) use both short- and long-run elasticities to calculate the impacts of taxation measures, but not claim energy savings for any other policy measure (i.e. treating the taxation measure as the main policy measure in a bundle of policies).

## 4.1 Matching method with earlier ex-ante evaluation

From the viewpoint of methodological consistency and data availability using the same method in the ex-ante evaluation (expected savings) and in this guide on ex-post evaluation (realized savings) might be an obvious choice. However, regression analysis builds on an extensive set of observed values over a considerable period. Using regression analysis for the ex-ante evaluation is only possible if information is available from comprehensive energy scenarios. But generally regression analysis is no option for an ex-ante evaluation.

Ex-post regression analysis could be matched with other ex-ante methods such as deemed savings, engineering estimate or elasticity analysis (see chapter 7, calculation approaches in this link)**.**

The methods deemed savings and engineering estimate concern the ex-ante calculation of unitary savings. A complementary method providing number is actions (see section 2) is needed to calculate the total savings, that can be compared with the regression results.  However, given long enough time series (at least 15 to 20 years, used for calculating long-term elasticities) deemed savings or engineering estimates should be calculated over a long time. Moreover, account should be taken of the effect of a large set of non-tax policies in this period, to ensure that the ex-ante savings can be compared with the ex-post savings calculated with this guide. For the short-term ex-post effects over 2-3 years, due to behavioural change, a comparison with ex-ante deemed savings or engineering estimates is not possible because these are based on investment decisions.

The method elasticity analysis provides directly ex-ante total savings (see guide on Elasticity analysis in the Toolbox), which can be compared with ex-post regression results. Given an evaluation using ex-ante elasticity analysis, the ex-post regression analysis can be seen as a more elaborate evaluation version (see section 2). Regression analysis provides the opportunity to calculate the effect of the tax while accounting for the effect of other drivers and policy measures.

## 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, for further background see further here.

Here no baseline is applicable because the calculated savings from saving actions due to energy taxes are a direct result of the regression analysis, where the introduction of the energy tax is one of the explaining variables. The introduction of the tax in a year resembles a “Before/after” baseline but because of an analysis over the whole period and for all other explaining variables no separate results before and after the introduction moment are supplied.

However, for the part of the energy tax to be taken into account, a baseline can be present, e.g. on the grounds of the mandatory requirements of the EU legislation. In the Energy tax directive minimum national energy tax levels have been defined and according to the Energy Efficiency Directive and Ecodesign directive only eligible saving effects results from national taxes above the minimum level prescribed by the tax directive.

## 4.3 Normalization factors

The calculation with the previously chosen baseline 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).

The rebound effect is already accounted for in observed energy consumption and the change in activity is processed in the time series for activity as explaining variable. The only normalization factor Weather can be processed through correction of energy consumption data for yearly deviations from long term weather (mean outdoor temperature during the heating season or mean number of hot summer days for cooling). But this correction can also be made part of the regression analysis, using time series for weather as explaining variables.

## 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, Non-compliance and Double counting, see further here.

Double counting might be relevant, in case of another policy focusing on the same saving actions as evaluated with the advanced guidance at hand. However, double counting can only be accounted for at a higher level than individual advanced guidances, see the links here, here and here.

The only applicable adjustment factor is Double counting (see section on Gross and Net savings). The other factors are connected to either the unitary savings or the number of actions, but these quantities are not covered in the regression analysis method.

## 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).

The gross savings follow directly from the regression analysis. They are equal to the (increase in) tax level (Euro/energy unit) times the regression factor for the price/tax variable and times the energy consumption (normalized for weather). When the tax differs per sector, the analysis should be executed per sector.

For net savings the gross savings should only be corrected for the Double counting effect, i.e. the overlap between the savings due to energy taxation and savings due to other policy measures. One option is to incorporate other policies in the regression analysis as explaining variables (see section "About the regression analysis" in chapter 2). Another way is to include the savings from other policies in the savings from taxes (see introductory part of this chapter). Without these options the overlap in the calculated savings of both taxes and other policy measures cannot be processed at the level of this guide but must be corrected at the level of savings due to overall policy portfolios.

For addressing double counting See this link and here.

# 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 With/Without.

| Calculation subject | Data requirements | Possible data sources and collection technics |
|---|---|---|
| Energy consumption (end-use or group of end-users) | Yearly values per type of energy carrier, corrected for variations in heating degree days | EU and national statistics |
| Energy price per group of end-users and tax (per group of end-users) | Mean prices and tax levels per type of energy carrier delivered to end-users (including tax details) | EU and national statistics |
| Relevant activity levels as to energy consumption | Yearly activity level | EU and national statistics or other sources |
| Other discrete variables (e.g. other policy measures) | Introduction year of policy measure (value 0 > 1) | Policy measure overview |

Where insufficient data is available to produce robust estimates of elasticities, the results of similar modelling exercises with the targeted end consumer groups or fuel types could be used to produce proxies for the relevant price elasticities. As a final option and only in the documented absence of the options above, results from one sector could be applied to other sectors.

## 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.

With the regression analysis method savings in final terms can be calculated. The method can also calculate savings in primary terms provided that primary energy consumption data for end-users are available. To this end final energy consumption per energy carrier should be known and converted to primary values using primary factors per energy carrier.

## 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.

Regression analysis cannot provide cumulative savings because it does not provide the savings for separate saving actions (each with their own life time).

For the same reason cumulative savings according to the Energy Efficiency Directive cannot be provided, nor discounted cumulative savings (where 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.

For the method applied ~~for~~ in this guide, the only alternative is Elasticity analysis (see Specific Guidance 22).

The table below presents the pros and cons of the method at hand and for a commonly used alternative method for the same combination of policy measure and sector.

| Type of method | Pros | Cons |
|---|---|---|
| Regression analysis | Price/tax effect separated from all other effects. Only aggregated data needed. Possibility to integrate effect of other policy measures. | All relevant explaining variables to be defined. Data needed on all quantities used in regression analysis, over period before and after introduction of tax |
| Elasticity analysis (based on literature) | Simple approach: only elasticity values, prices/tax levels and energy consumption needed (thus no data on all explaining variables). Only monitoring for the active period of the tax. | Elasticity values sensitive to other influences than price/tax, therefore values from literature have a large margin |

# 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** that 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 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 CO2-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 (given varying emissions factors over day and season), year of implementation, policy considerations, 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 $CO_2$.

When needed, **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

For more details about the different perspectives, see for example (Breitschopf et al., 2018).

For the policy measure covered in this guide no cost-effectiveness can be calculated because it concerns a top-down approach without data on saving actions with their (cost) savings, investments, etc.

## 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

For the same reasons as mentioned for cost-effectiveness most of the other co-benefits cannot be calculated. Only reduced import dependency can be determined from the savings, provided that the effect of taxation is calculated per energy carrier type.

## 7.4 Other aspects of importance

One possible aspect of energy taxes to be analysed is the effect on income distribution.

# 8 | CONCRETE EXAMPLES

For the method of ***regression analysis*** the following references are useful. However, they are not focusing on the effect of energy taxes.

**CRC Energy Efficiency Scheme Evaluation - Final synthesis report**, see https://www.gov.uk/government/publications/evaluation-of-the-crc-energy-efficiency-scheme
This study concerns a DinD regression analysis on CO2-emissions of non-energy intensive companies /organizations. The Difference in Difference approach analysis both the differences before/after or with/without the implementation of a policy measure as well as the differences between a target group and a control group. The econometric research did not attempt to quantify the relative impact of energy prices or other factors compared to CRC influence. Instead, it removed these other factors by looking at differences in behavior between CRC participants and non-participants.

**Free-riding on tax credits for home insulation: An econometric assessment using panel data**, see DOI 10.1016/j.enco.2014.08.11
This study concerns calculation of the effect of the CIDD program with tax credits through regression analysis on all factors as to implementing saving actions on dwellings. The amount of free-riders as to the tax credits was also calculated per type of saving action.

For the policy measure ***energy taxes*** the following reference is useful. However, it concerns price elasticities based on regression analysis, but not the regression analysis itself (with all other factors taken into account). This summary concentrates on the part on taxes.

**Evaluation of fiscal measures in the NEEAPs for article 7 of the EED**, see https://ec.europa.eu/energy/sites/ener/files/documents/final_report_on_fiscal_measures_used_under_article_7_eed_0.pdf

*Chapter 2: Effectiveness of Fiscal Measures*
The policy measure Energy taxation leads to less administrative costs for implementation of saving actions than other policies, such as standards or subsidies
Financing other policy measures (e.g. subsidy schemes) from the tax receipts lowers the burden on energy users and strengthen the incentives to save energy i
The weakness of taxes as incentive to implement saving actions is that it does not provide information on the saving options and their costs. Subsidy schemes do provide both the incentive and the information how to save energy.
Taxes are more effective than a subsidy, with the same incentive to invest into saving actions, because profitable subsidized action lead to a rebound effect, while taxes decrease the room for spending on all kind of energy using products and services (negative rebound effect).

*Chapter 3: Framework for Evaluation of Impacts*
*(Elasticity analysis)*
The Energy Efficiency Directive (EED) states that for taxation measures (i.e. energy and CO2 taxes), energy savings are quantified on the basis of price elasticities, which represent the responsiveness of energy demand to price changes (see EED, Annex V, part 3, point a).
*(Gross and net savings)*
In case of subsidies it is important to note that, to calculate an estimated “absolute” energy change as a result of the measure, it is important to compare such estimate with a situation “without” intervention (the counterfactual to be able to obtain estimates of incremental impacts). In the case of taxation measures this is typically less of a problem. This is because the elasticities are already providing the “net” effect of the change in prices.

When estimating energy savings resulting from energy or carbon taxation measures, it would not be necessary to explicitly make adjustments for the counterfactual, as the consumption that would have prevailed in the absence of the taxation measure is reflected in the baseline level of pre-tax consumption, and consumer behavior represented by responsiveness to changes in price would implicitly be captured by the elasticity estimate.

The results for taxes exclude any underlying trends, changes in consumer’s income or cross-price effects from substitute products. However, having an idea of a counterfactual may be helpful in any case to assess any biases or omissions in the elasticities used (in particular, to assess or quantify effects which may not be included in the elasticities being used.

*(Policy baseline)*

Minimum levels of taxation applicable to fuels as required in Council Directive 2003/96/EC on restructuring the Community framework for the taxation of energy products and electricity or in Council Directive 2006/112/EC on the common system of value added tax (for the taxes).

*(Rebound effect)*

Any rebound effects occurring in response to tax changes would in principle be captured implicitly if appropriate price elasticity estimates are used.

# 9 | FURTHER READING

**About Regression analysis**

- Free-riding on tax credits for home insulation in France: An econometric assessment using panel data, Marie-Laure Nauleau, CIRED, France (regression on all factors as to implementing saving actions on dwellings, including CIDD program with tax credits) , available in : DOI 10.1016/j.enco.2014.08.11
- CRC Energy Efficiency Scheme Evaluation - Final synthesis report, CAG Consultants, July 2015 (DinD regression analysis on $CO_2$-emissions of non-energy intensive companies /organizations (not suited for energy taxes), available in : https://jepsl.sljol.info/articles/abstract/10.4038/jepsl.v4i1.7853/
- Boonekamp (2007) "Price elasticities, policy measures and actual developments in household energy consumption – A bottom up analysis for the Netherlands".

**About Energy taxation**

- Evaluation of Fiscal Measures in the National Policies and Methodologies to Implement Article 7 of the Energy Efficiency Directive, Final report, Europe Economics, 19 October 2016 (elasticities for EED, various countries), available in https://ec.europa.eu/energy/sites/ener/files/documents/final_report_on_fiscal_measures_used_under_article_7_eed_0.pdf
- Energy savings calculation methods under article 7 of the EED, EUR 27663 EN, Labanca & Bertoldi, JRC, 2016 , available in: https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/energy-savings-calculation-methods-under-article-7-energy-efficiency-directive
- Assessment of existing evaluation practices and experience, SEA, 2005 (case: Effect of energy taxes on energy efficiency, Sweden, Dargay, 2008), available in: https://www.epatee-lib.eu/media/docs/EMEEES_WP2_D1_Assessment_existing_evaluation_2008-04-21.pdf

**Relevant case studies**

Regression case studies:

- https://www.gov.uk/government/publications/evaluation-of-the-crc-energy-efficiency-scheme
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