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How to increase the transparency of ex-ante impact evaluations of energy efficiency and climate policies. Illustrated by the example of a funding program for energy and resource efficiency in industry in Germany.

Iska Brunzema[1] (iska.brunzema@isi.fraunhofer.de), Barbara Schlomann[1], Andreas Kemmler
[1]Fraunhofer ISI, [2]Prognos AG

ABSTRACT

Both at European and national level, the requirements for reporting on measures introduced to achieve EU-wide and national energy efficiency and climate targets have increased considerably in recent years. While ex-post impact evaluation of policies and measures is nationally as well as internationally rather well documented, ex-ante reporting processes are still rather inconsistent and often suffer from a lack of transparency. In Germany, the need for a transparent and consistent methodological approach to quantify the impact of new climate measures on the reduction of greenhouse gas emissions has been strengthened by the Federal Climate Change Act from 2019. The new law both requires scientific estimates of probable greenhouse gas reduction effect as well as other economic, social and environmental impacts and gives the newly founded Council of Experts on Climate Change a prominent role in reviewing these estimated impacts. Against this background, this paper aims at developing a consistent methodology for a good practice of ex-ante impact evaluations, which provides a common methodological guideline for the design and monitoring of energy and climate policies and measures.

First, we derive the key factors to be taken into account for a consistent and transparent ex-ante impact evaluation of these policies. These include (a) the relevant assessment criteria (b) the assumptions on key framework data (c) the methodological approach for determining gross impacts of the measure (d) the effect adjustment approach for the calculation of net effects and (e) requirements for a transparent handling of uncertainties. Secondly, we suggest concrete methodological procedures and possible data sources for each of these steps. A case study, the ex-ante impact evaluation of a funding program for energy and resource efficiency in industry for the period 2021 to 2030, serves to illustrate the methodological approach and its different steps. We also show that a standardised data collection significantly increases the transparency and comparability of the impact evaluation process and the evaluation results. This can e.g. be implemented by a standardised template for the documentation of input parameters, evaluation methods and output parameters.

Introduction

Both at European and national level, the requirements for reporting on measures introduced to achieve EU-wide and national energy efficiency and climate targets have increased considerably in recent years. While ex-post impact evaluation of policies and measures is nationally as well as internationally rather well documented, ex-ante reporting processes are still very inconsistent. The goal of this presentation is to develop a consistent methodology for a good practice for ex-ante impact evaluations, which provides a common

methodological guideline for the design and monitoring of energy efficiency and climate policy measures and programmes.

Against the background of numerous reporting obligations at national and EU level on the achievement of energy and climate policy goals and on the impact of the measures introduced to achieve the goals, their monitoring and evaluation is becoming increasingly important. Both at European level and in Germany, the requirements for reporting on measures introduced to achieve EU-wide and national energy and climate targets have increased again in recent years. In the EU Regulation on the Governance System for the Energy Union and for Climate Protection ((EU) 2018/1999) requires information on energy and climate policy measures in several annexes. The most detailed are the requirements for the communication of measures and methods for the implementation of Article 7 of the Energy Efficiency Directive (Directive 2012/27/EU, Annex III). The Federal Climate Protection Act (KSG) of December 2019 provides for reporting requirements in several places, which also include the evaluation of measures. This applies in particular to §8 (emergency programme if annual emission levels are exceeded), §9 (climate protection programmes) and §10 (reporting).

The focus of this working paper is on methodological issues in the assessment of measures with regard to their impact on energy consumption and greenhouse gas emissions. Depending on the objective, however, an assessment of energy and climate policy measures can include numerous other assessment criteria. These include, in particular, the economic efficiency of the measures, questions of acceptance and diffusion of energy efficiency and climate protection technologies, securing long-term savings incentives or possible economic, social and ecological consequences (costs and benefits).

Furthermore, the focus of consideration is on the development of a uniform methodology for the future (ex-ante) impact of measures. While there are already some guidelines for the ex-post evaluation for the savings effect already achieved, these are still largely lacking for the future consideration. However, the existing guidelines for ex-post evaluation also form an essential methodological basis for estimating future impacts and are therefore also used as a basis in this paper. Furthermore, reference is made to an internal working paper recently prepared by Öko-Institut and Fraunhofer ISI within the framework of the project "Policy Scenarios X" on behalf of the Federal Environment Agency (UBA) (Öko-Institut et al. 2021). This paper provides a uniform methodology for estimating the ex-post and ex-ante impacts of the climate protection policy instruments quantified in the project. A working group of the Steering Committee of the Science Platform for Climate Protection (WPKS) has also prepared an orientation guide for ex-ante evaluations (Matthes et al. 2021), which was also used for the preparation of this brief paper.

With regard to the ex-ante impact assessment of measures, a distinction must be made, whether it is one or more measures, and whether their individual impact is estimated bottom-up or the impact of the measures is mapped top-down within the framework of integrated modelling. It should be noted that even in the context of integrated modelling, such as is done for the NECP scenarios or the projection report, some measures are first estimated bottom-up and only integrated into the modelling in a second step.

In the following, the Industrial Funding Programme (EEE) is introduced before describing a good practice for ex-ante assessments. This is followed by the case of the evaluation of the EEE. Finally, the assessment and the methodology are discussed and summed up.

The EEE Industrial Funding Programme

With the programme "Federal Funding for Energy Efficiency in the Private Sector", several previously valid funding measures were bundled in 2019 and the funding of energy efficiency measures in the private sector was thus restructured. In addition to a grant and loan variant of the programme, which is in turn divided into several modules, a funding competition is offered in a separate funding guideline. Both funding guidelines were amended as of 1 November 2021. In addition to improved funding conditions for off-site waste heat utilisation, electricity efficiency and SMEs, the new funding object resource efficiency was introduced in both funding guidelines and added to the programme title. In the grant and loan variants of the programme, the new funding

item Transformation Concepts was also introduced to support companies in planning their decarbonisation strategy. Thus, from 1 November 2021, the amended federal funding for energy and resource efficiency will comprise the following elements:

Module 1: Cross-sectional technologies
Module 2: Process heat from renewable energies
Module 3: I&C, sensors and energy management software
Module 4: Energy and resource-related optimisation of plants and processes
Transformation concepts

The programme targets private companies, municipal companies, freelance professionals if the business premises are predominantly used for freelance activities and contractors all within Industry and Commerce/Trade/Services.

Within the EEE grants and loans are provided for energy-efficient cross-cutting technologies, process heat from renewable energies, measurement and control equipment including energy management software and energy optimizations of specific processes and plants (Bundesministerium für Wirtschaft und Energie 2020b). The last module is open to all technologies in order to facilitate and simplify investments in more complex energy efficiency measures and targets a large variety of participants. To meet the diverse needs and projects with different degrees of complexity, a funding competition is offered in a separate funding guideline for the funding categories and the target group of module 4. The concepts are evaluated according to their funding efficiency per tonne of CO_2 saved and the funding is awarded on a competitive basis.

The programme aims to reduce GHG emissions by 2.8 Mt CO_2 per year until the end of 2023 through realising about 24 000 measures. The goal of the funding programme is an average funding efficiency of 25 euros per tonne of CO_2 saved per year, calculated over a plant lifetime of ten years" (Bundesministerium für Wirtschaft und Energie 2020b).

The German constitution specifies certain obligations for publicly funded instruments such as the EEE: The Federal Court of Auditors is obliged to evaluate government spending. The obligations span three main areas of evaluation: target achievement, impact assessment, and cost-effectiveness (Art. 114 II 2 GG) (Federal Republic of Germany 1949). The evaluation process can be illustrated by a Plan-Do-Check-Act cycle. In the planning phase, general goals are formulated as well as specific goals for the individual programme components. The implementation of these goals then leads to a funding regulation, which is translated into practical funding by the funding institutions. Regular monitoring takes place parallel to this implementation, which allows simple conclusions to be drawn about the success of the programme on the basis of the information collected by the funding institutions. The intended evaluation is to increase the coverage and quality of this analysis, taking into account this information, further programme data, surveys and, where necessary, estimates. On this basis, further development impulses for the action phase are to be given, for example, to redesign or change the funding regulation and/or procedural instructions.

The Federal Office of Economic Affairs and Export Control (BAFA) handles the applications for the investment grant, while the credit line is handled by KfW. The funding competition is administered by the programme executing organization VDI/VDE-IT. Both variants are applied to by use of an application form which must submitted electronically. In the case of the grant variant, the documents are checked by BAFA and if the funding requirements are met, a notice of approval is issued. In the subsequent approval period, the funding recipients should implement and complete the project. Completion is documented by means of various declarations and proof of use. These documents are subsequently checked by BAFA. After successful verification, the funding is paid out to the funding recipient as a grant. In principle, the funding process at KfW is similar. However, a bank is involved in the overall process as an additional intermediary, which takes over the loan guarantee. In the run-up, applicants are first asked to determine the framework data for an application via KfW's portal. This is followed by a meeting with the financing partner, which, if positive, results in an application that is forwarded to KfW for review and determination of the interest rate based on the economic circumstances. If the review is positive, the beneficiary receives a repayment subsidy to repay the loan.

Module 4 and the funding competition address the same target group and both promote the energy-related optimisation of plants and processes in a technology-neutral manner. Nevertheless, the two programme lines are not intended to compete with each other. Rather, they are intended to meet the different requirements of companies. Roughly speaking, there are two different sets of interests. For companies, in addition to the direct costs of an investment, downtimes, plannability and administrative effort play a decisive role. If these calculations are in the foreground, a funding competition is not the most suitable system, on the one hand because of the higher time expenditure until the next round of competition, and on the other hand because of the lack of plannability due to the possibility of not being selected. For these cases, the more classic programme lines of grant and loan are available.

In contrast, however, the possibilities for comparatively simple energy efficiency measures are limited. In order to promote particularly far-reaching and complex technical modernisations and to enable their implementation, the funding in the classic programme lines is often too low. In order to nevertheless also achieve the goal of implementing particularly complex projects, the funding competition is offered. The funding competition is distinguished from the investment grant and the promotional loan by a more attractive funding rate and easier conditions. The competition is therefore particularly interesting for those projects that require higher funding for their implementation and are therefore prepared to develop particularly innovative project ideas and to accept the uncertainty about the funding decision in the context of a competition. It is not only the low-hanging fruits that are addressed.

Methodology - good practice for ex-ante evaluation

Based on the literature so far and the practical context of policy evaluation, different aspects were identified which need to be disclosed with regard to a transparent and easily comprehensible evaluation of measures:

- Evaluation criteria considered and indicators to be shown
- Assumptions made regarding key framework data for the impact assessment
- Methodological procedure for determining the (gross) impact of the measure
- Methodological procedure for effect adjustment (net effect of the measure)
- Dealing with uncertainties

The most important assessment criterion for an ex-ante evaluation of energy efficiency policies is their climate protection effect, which is reflected in the effect on energy savings and greenhouse gas (GHG) reduction achieved by a measure as the main indicators. Other important criteria are e.g. economic effects (such as effects on energy costs, investments, employment or value added), distributional impacts, acceptance and diffusion. The quantitative indicators can be provided in different metrics:

- The new annual savings describe the additional savings achieved by the measure compared to the previous year and can thus be represented as the difference between the savings determined for successive years; for ex-ante evaluations, assumptions must be made for the development of savings over time.
- The added (or cumulated) annual savings in a year (e.g. in a target year for an energy or climate target) are more frequently shown, especially in ex-ante evaluations; they are calculated by adding or cumulating the new annual savings, taking into account the duration of the effects triggered by the measures.
- The total (cumulative) savings over the period under consideration time (e.g. an evaluation period or a commitment period for a savings target) are a special case.

In order to consistently calculate the indicators for the energy savings impact of a measure, certain framework assumptions must be made. For bottom-up impact assessments, these include the following aspects

in particular: Energy prices, lifetimes, emission and primary energy factors as well as the underlying reference development (baseline) (Fraunhofer ISI et al. 2020). Energy prices are highly variable over time and differ for households as well as small and large enterprises. While for ex-post estimates, the methodology guide recommends either collecting the prices oneself as part of an evaluation or using regularly collected statistical data sources, for an ex-ante estimate, energy price forecasts should be used, for example from a current scenario such as the projection report or the NECP (Öko-Institut et al. 2021; Bundesministerium für Wirtschaft und Energie 2020a). The lifetimes of individual energy efficiency or climate protection measures can be determined empirically. As a rule, however, assumptions on average lifetimes are used. The lifetimes of the European Committee for Standardization, which are also used in the NAPE monitoring of the Federal Ministry for Economic Affairs and Energy, are recommended here (Europäische Kommission 2006; Europäisches Komitee für Normung 2007). Emission and primary energy factors are relevant for bottom-up impact assessments insofar as such factors are used to convert final energy savings into primary energy and GHG savings. The choice of the factor can have a significant influence on the result. This is especially true for the assessment of electricity savings, as these factors change over time due to continuous changes in the electricity mix, while the factors for fuels remain largely constant. It is important that the impact assessment on energy consumption at least differentiates between savings from electricity, fuels and combustibles. When selecting the factors, it is also relevant which perspective (polluter or sources) is chosen and whether effects from the upstream chains are to be taken into account. For ex-ante assessments it is recommended to use values from a current scenario. Furthermore, a baseline is established to ensure the additionality of the effect of a measure or a bundle of measures compared to a status quo. In a bottom-up impact assessment of individual measures, the reported savings can either refer to a before-and-after comparison (especially if the implemented measure is a pure replacement or an extension of the existing stock) or to the comparison of the effect of the measure with a reference technology adapted to the state of the art in regulation and technology (especially in the case of investments in completely new plants, equipment or processes). Possible baselines include, in particular, a legal minimum standard, a market or stock average, or a market trend over longer periods of time. In some reporting obligations, the approach of a specific baseline is also specified, so that a baseline must also be taken into account in a before-and-after consideration (e.g. for reports under Article 7 EED existing EU regulations (e.g. minimum efficiency standards under the Ecodesign Directive).

In principle, a distinction should be made between gross and net savings when reporting savings by means of indicators. The indicator values "influenced" by the measure are called the gross effect of a measure. Following the procedure of an ex-post evaluation, the impact model should first be determined also for an ex-ante evaluation. Such an impact model contains the idealised assumption of the impact of an action (here: implementation of a measure) in the sense of a causally justified sequence (Figure 1). However, a generally binding definition of how to determine the gross impact of a measure is not possible, as the individual policies are too heterogeneous and the method chosen depends on the specifics of each policy measure. A commonly used approach for bottom-up impact assessment of financial support measures is to link an appropriate activity measure to a specific saving:

Activity (number of cases, outflow of funds)	x	**Specific Savings** (per activity)	=	**Absolute Savings** (energy, GHG)

If possible, larger funding programmes are broken down into homogeneous sub-areas (funding categories) and their effects are calculated separately. The estimation of the reduction effect for an ex-post period is based, as far as possible, on actual implementation data (budget outflows, case numbers, etc.), which are updated in an ex-ante consideration according to the static and/or dynamic approach. The values for the specific savings are, as far as available, taken from existing evaluations or are based on expert estimates. Matthes et al. (2021) mention cost-benefit analysis, cost-effectiveness analyses and multi-criteria analyses as further

methods for ex-ante impact assessment, in addition to the simulation of measures in computer-based energy system models.

For effect adjustment, the net impact of an instrument is determined. The net effect addresses the criterion of the effectiveness of a measure. The question is to what extent the evaluated measure was "causal" for the determined gross impact and to what extent "additional" savings were achieved. To determine the net effect, it is necessary to adjust the gross values for corresponding effects such as e.g. free rider, rebound or interaction effects (see Table 1).

Table 1: Effect Adjustment

Effects	Description
Gross impact	
- Deadweight and substitution effects	Effects due to the deadweight loss of subsidies and early replacement (corresponds to delayed deadweight loss)
+ Spill-over effect	Effects through spill-over (transfer) to third parties and other areas
+ Lag effect	Effect due to delayed onset of measures
x - Structural effects	Effects due to changes in central structural variables (e.g. different weather conditions over the term)
x - Rebound effects	Effects due to additional consumption as a result of energy cost savings
= Net effect (individual measure level)	Effect after adjustment for effects
x - Interaction effect	Effects through interactions between individual measures at the level of a bundle of measures
= Net effect (bundle of measures level)	Effect after adjustment for interactions

Source: Fraunhofer ISI et al. (2022)

In order to keep the determination of the gross and net effects of the measures as transparent as possible, the methodological guideline (Fraunhofer ISI et al. 2020) from an ex-post perspective, it is recommended to show both the gross and net values of the evaluation. In order to obtain complete transparency about the various adjustment steps, it is recommended that all three stages of the impact assessment of a measure be reported separately. In the interest of transparency, such a procedure is also recommended for other comparable ex-ante quantifications of individual measures in the context of bundles of measures.

Lastly, uncertainties exist at all described stages of the ex-ante evaluation process. In this context, it seems useful to distinguish between uncertainties regarding implementation and allocation of a policy measures as well as technological and political uncertainties. Some methods to reduce uncertainties are already used in practice whereas the implementation is more difficult, e.g. due to poor data availability and challenges in quantification. However, inherent uncertainties cannot be completely avoided in ex-ante impact assessments, thus, it is important to transparently present not only the assumptions on which the evaluation is based, but also the associated uncertainties.

The case study

The guidelines "Federal Promotion for Energy Efficiency in the Economy - Grant and Loan" and "Federal Promotion for Energy Efficiency in the Economy - Funding Competition", which were introduced in 2019 and represented a reorganisation of a number of previous promotion measures, were amended in October 2021. The two new guidelines came into force on 1st November 2021. The amendment includes the following changes:

- improved eligibility conditions for off-site waste heat recovery, electricity efficiency and SMEs in the grant and loan variants of the programme,
- improved funding conditions for electricity efficiency and a higher maximum funding rate in the funding competition,

- the introduction of the new funding item "transformation concepts" in the grant and loan variants of the programme as well as
- the introduction of the new funding item resource efficiency in both sub-programmes.

In addition, the approved funding for the programme was already significantly higher in 2019 and 2020 than originally expected. It can be assumed that this development will continue in the coming years.

In order to take these changes into account, the original estimate of the expected final energy savings through the "Federal Promotion of Energy Efficiency in Industry" in the Communication on measures and methods for the implementation of Article 7 of Directive 2012/27/EU by the Member States is therefore updated below. In contrast to the original estimate, a current scientific evaluation of the restructured programme for the first funding year 2019 can be used. Since this evaluation covers both funding guidelines with a uniform methodology, both parts of the programme - the grant and loan variant as well as the funding competition - are presented and evaluated together.

The ex-ante impact assessment only refers to those measures that are expected to be implemented in the period from 2021 to 2030. The impact of earlier measures is not included. For the parts of the programme that already existed before the amendment of the guidelines, the ex-ante impact assessment is based directly on the results of the ex-post evaluation of the programme for the funding year 2019. Methodologically, the following three-stage approach is used here:

- The gross impact of the previous programme before the amendment is determined by linking the specific final energy savings per subsidy euro determined in the evaluation for the year 2019 (separately for electricity and fuels) with the expected annual subsidy volume for the years 2021 to 2030. As in the evaluation, the estimate is made separately for the four modules and the funding competition. In addition, module-specific assumptions are made on the average lifetime of the measures implemented, which are also derived from the evaluation (8 years for modules 1, 2 and 4 as well as the funding competition, 5 years for module 3). The distribution of the funding volume assumed for the years 2021 to 2030 among the four modules and the funding competition is analogous to the year 2019.
- The estimation of the gross impact of the newly added transformation concepts is based on an evaluation of six more comprehensive savings concepts submitted under the previous programme in 2019 and 2020 (Module 4 or funding competition), which already have the character of transformation concepts. The average specific final energy saving of these concepts was around 15 kWh per funding euro. The maximum funding amount for the transformation concepts is limited in the funding guideline to a maximum of 80,000 euros. Here, based on the experience from the savings concepts, an average funding per concept of 20,000 euros is assumed. It is further assumed that an average of 100 transformation concepts will be funded from 2022 onwards. As in Module 4, the average lifespan of the measures implemented on the basis of the transformation concepts is assumed to be eight years. The assumptions for adjusting for deadweight, spill over and pull-forward effects are also taken from Module 4. As soon as more precise effects are available in the context of the programme evaluation, these assumptions can be adjusted accordingly.
- The final energy savings for which the programme is actually responsible are determined by adjusting the gross values for deadweight, pull-forward and spill-over effects (net effect 1). These effects were also estimated on a module-specific basis as part of the programme evaluation on the basis of a survey of funding recipients and are adopted here. For the newly added transformation concepts, the same values are applied as for the comparable Module 4. In addition, an internal programme interaction effect must be taken into account for the transformation concepts, since the preparation of a savings concept under Module 4 is first required for the application of a transformation concept. In order to take the resulting interactions into account and to consider only those savings that would not have been achieved without the additional application for a transformation concept, a further reduction factor of 40% is applied.

- In addition to the effect adjustment at the individual measure or module level, interactions with other measures to promote energy efficiency measures in industry are also taken into account in a third step (net effect 2). However, major overlaps of the programme with other promotion programmes are not to be assumed, as the measure largely covers the promotion of the industrial sector. Nevertheless, there may be isolated minor interactions. Therefore, as in the original impact assessment, an interaction factor of 0.95 is assumed (see Bundesministerium für Wirtschaft und Energie 2020a).

Table 2 shows the final energy savings of the measure determined on the basis of the methodology described above and the additional assumptions made for the new funding objects, also separated into electricity and fuels. The new annual savings are shown as gross and net effect (net 1 effect). The net effect is also shown as an added annual saving in 2030 (so-called NAPE logic) and as a cumulative saving over the entire commitment period 2021-2030 (so-called EED logic). Compared to the savings originally reported under Article 7 EED in the NECP for federal support for energy efficiency in business (grant and loan as well as funding competition), the cumulative savings estimated over the entire commitment period are thus around 27 percent higher.

Table 2: Impact Assessment for the EEW

Saving of.	Annual new final energy savings (PJ/a) 2021		New annual final energy savings (PJ/a) as of 2022		Annual final energy savings (PJ/a) in 2030 added net	Final energy savings (PJ) in the period 2021 to 2030 cumulative net
	gross	net	gross	net	net	net
Burning substances	6,9	5,4	9,3	7,6	60,4	376,3
Power	6,4	5,1	7,0	5,7	45,0	288,5
Total	13,3	10,5	16,4	13,3	105,4	664,8
Total (net effect 2 with interaction factor of 0.95)		10,0		12,6	100,1	631,6

Discussion and Conclusion

The ex-ante assessment of the EEW shows the importance of calculating not only the gross effect, but also net 1 and net 2. With transparent methods and clear assumptions behind the estimations, uncertainties can be reduced considerably. The EEW can contribute largely to the decarbonisation of the industry sector in Germany. Interaction with other instruments directed at the industry sector only slightly reduce the savings estimated for the instrument. Reporting gross and net impacts as well as annual and cumulative savings increases the transparency and plausibility of the assessment.

Overall it can be assumed that especially Module 4 will largely contribute to GHG and energy consumption reductions as it targets very diverse actors and processes. Overall, even after an adjustment based on deadweight, substitution, and spill-over effects as well as interaction, it can be assumed that the programme is an important instrument on the way to reaching Germany's targets for 2030. As in the context of current requirements for reporting for climate and energy policies and the requirements for reaching net zero, precise and consistent methods are required, in particular for ex-ante assessments which are necessary but also strongly entailed with uncertainties. The methodology presented here provides a transparent and well replicable

approach which can be adjusted to different conditions and instrument types. The quality of the assessment is, as always, highly dependent on the available data, so this is a challenge that needs to be addressed in order to further improve the quality and replicability of ex-ante assessments.

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