Energy efficiency targets for industry – evaluating implementation options

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Abstract

The German Energy Concept of 2010 proposes measures for industry to advance energy efficiency in the industry sector e.g. energy management system (EMS). In our study, we characterize various experiences with policy instruments to accelerate the improvement of energy efficiency. We define implementation options which describe how the achievement of energy efficiency targets and financial incentives can be linked on the base of an EMS. The implementation options are characterized by their target type (energy efficiency improvements or installation of energy efficiency measures), the level at which targets have to be achieved (branch or company level) and in the type of indicators for verification (energy intensity improvement vs. energy efficiency investment). All implementation options aim at setting pertinent incentives for energy efficiency improvement in each company. One evaluation criterion is the capability of dealing with the variance of energy efficiency improvements over time. We conducted an analysis of the historic annual energy savings in the period 2000–09. The results show a large variance, which results from the discontinuity of various impact factors. This must be considered, if consistent incentives for energy savings shall be provided over time. Furthermore, we evaluated the ability to formulate effective energy efficiency targets. The study quantifies the energy savings potential of the German industry until 2020 under different scenarios. We discuss for each implementation option how well it supports the realization of the resulting energy savings potentials. A third criterion relates to the integration of energy efficiency targets into a companies' decision-making process. A company will consider the implementation of an energy efficiency measure, if the payback period for additional investment cost is short enough or sufficient financial incentives exist. We expect that by the time of the Summer Study we can report about the outcome of the actual discussions in Germany.

Introduction

The Federal Government of Germany has set the objective to reduce primary energy consumption by 20 % by 2020 and by a total of 50 % by 2050 (BMWi, BMU 2010). Since the industry sector is responsible for almost a third of the country's total energy consumption (AGEB 2011), it is expected to play an important role in the effort to achieve these targets. The Energy Concept, in place as of September 2010, proposes various measures to advance energy efficiency in the industry sector. The German government commissioned a set of studies in order to translate these measures into concrete plans for implementation (IREES 2011, Prognos 2011). This paper reports on our contribution (Eichhammer et al. 2011).

As an initial step we compare different measures, types and costs of energy savings. Defining these aspects is an essential first step when formulating energy efficiency targets. In the following, we estimate the potential for future energy savings in the German industry sector. There are different options for translating these potentials into actual energy efficiency targets and energy saving measures for the German industry sector. We explore how effective each of these options is in accelerating the realization of energy savings.

Characterization of Energy Savings

LIFETIME OF ENERGY SAVING MEASURE

The lifetime of an energy saving measure is an important factor for the impact assessment. Naturally, a short lifetime of a technical measure has no direct long-term effect. Nevertheless by a change in product demand, the overall market may change to more efficient products; operational measures have no real lifetime, but need constant monitoring and verification.

ABSOLUTE COSTS OF ENERGY SAVING MEASURE

The absolute costs of an efficiency measure influence investment behaviour significantly. Measures with high absolute investment costs are subject to strong barriers, for they are highly dependent on capital availability.

RELATIVE COSTS OF ENERGY SAVING MEASURE

The economic payback of an efficiency measure is driven by the relative costs, which include in some way the refund from the saved energy. Efficiency measures are mostly evaluated by their payback time, whereas the internal interest rate is the more appropriate approach.

TECHNICAL AND OPERATIONAL CONDITIONS FOR IMPLEMENTATION

Measures, which achieve their savings just by their technical implementation (such as the use of more efficient motor drives) have relatively small uncertainties in the impact assessment. In contrast, operational measures as well as technical measures, which require systemic changes, have larger uncertainties concerning their estimated savings.

TYPE OF ENERGY SAVED (ENERGY CARRIER/ TYPE OF USEFUL ENERGY)

Electricity and fuel savings have quite different impacts on GHG emissions as well as on energy economy. Fuel savings are not subject to conversion losses and are independent of the energy carrier mix for electricity production. The different types of useful energy may also be a criterion for the evaluation of energy savings.

REFERENCE OUTPUT

When energy efficiency targets are discussed, we have to relate the energy consumption to an activity. This activity may be:

- A **physical unit** such as tonnage of produced goods. This is only applicably for homogenious production conditions.
- **Economic indicators**, such as turnover, production value or added value. They can be uses for heterogenic processes or sectors, but they are not as accurate as the physical units, for they have other influencing variables.
- **Production indices**, which are closer to the physical production that economic indicators, for they are adjusted of purely economic impacts. See generally Graichen et al. (2011).

Criteria for the Measurement, Reporting and Verification of Energy Savings

FINAL VS. PRIMARY ENERGY

The consideration of final energy for the saving measurement has the advantage of an independency of the energy carrier mix for electricity production, which is another time variant variable. Concerning climate change issues, primary energy is the more accurate approach, for the differences in GHG potential are reflected better. An energy carrier change may be an advantage in terms of final energy, but may lead to increased primary energy consumption.

ABSOLUTE VS. RELATIVE SAVINGS

Energy efficiency targets in a policy context are often converted to absolute energy saving targets, for the measurement, reporting and verification (MRV) mechanisms are much easier to implement. However, absolute saving targets do not necessarily imply an efficiency gain, but may be reached by reduced activity. In a macroeconomic context this problem is of importance when large changes of economic activities occur. This was the case in 2008 for the effects of the financial crisis. In a microeconomic context, the problem is even larger, because changes in type or amount of production in a single enterprise can heavily influence the absolute power consumption. Therefore, a real efficiency target, which relates the energy consumption to an activity index, is more accurate in reflecting the efficiency gain.

However, if an absolute target is measured against a bottom up evaluation of efficiency measures, only real efficiency improvements would be accounted for and a reduction in output would not lead to accountable savings.

BENCHMARKING

Alternatively to absolute or relative savings, benchmarks may be used for the MRV. They may work well for homogeneous products and processes, but have large implantation problems if products and processes become more diversified.

AGGREGATION LEVEL

If a high aggregation level is chosen, structural effects in single sectors (i.e. a change in the composition of output) may falsify the results of the efficiency measurement. On the other hand, data collection on an aggregated level is much easier, because national statistics generally give information on a sectoral or sub-sectoral level.

On a company basis, the energy consumption is easy to identify, nevertheless the selection of a reference output may become problematic, because economic indicators or production indices are not necessarily available on a company level.

REFERENCE YEAR VS. REFERENCE DEVELOPMENT

As reference for a target the energy efficiency or energy consumption in a base year may be chosen. This baseline is relatively easy to identify and free of larger uncertainties. Nevertheless, a reference year calculation does not reflect autonomous developments in any case and economic impacts, if absolute savings are calculated. These issues are handled, if a reference development is used, but the development of the reference is linked to a great amount of uncertainties due to the assumptions needed for developing the reference. See generally Graichen et al. (2011).

Potential Future Energy Savings in the German Industry Sector

The energy savings potential of the German industry sector until 2020 is quantified under four different framework scenarios (Eichhammer et al. 2011). The underlying model covers all relevant cross-cutting technologies and contains also more than 250 process-specific energy saving options for energy-intensive industries. See generally Schlomann et al. (2011), Fleiter (2011). The model differentiates the handling of barriers and the pace of technology diffusion.

First, a market potential is calculated assuming that both, monetary and non-monetary barriers, exist such as the lack of information or certain legal provisions, which inhibit the implementation of energy savings. Under such scenario only a part of the potential energy savings will be realized.

Second, the economic potential is estimated based on the assumption that industrial actors behave like a "homo economicus". Under this scenario non-economic barriers are irrelevant and all economic energy saving measures will be implemented.

Third, the nearly economic potential is calculated under the assumption that for each investment the most energy efficient option is chosen, even if it is not yet economic. However, realistic technology diffusion rates are reflected in this scenario. Furthermore, the typical operating life time of a technology or facility is considered; an early replacement (premature capital retirement) is excluded.

Fourth, a technical potential is reported assuming an accelerated diffusion of existing technologies. Energy efficient measures are implemented earlier than under the other scenarios. The technical potential could be even larger if all technically available energy saving options would be implemented immediately, for example, if all engines would be substituted by the currently best available technology, regardless of organizational or financial frameworks.

The following table presents the estimated annual electricity and fuel savings for each scenario. The figures reflect the industry sector average.

Options for implementing energy efficiency targets

The formulation and implementation of energy efficiency targets might be designed in various ways. The main questions are:

- Target: What has to be achieved?
- Target measure: How is success measured?
- Compliance: Who has to achieve the target?
- Reward allocation: Who will be rewarded?

We discuss four options that cover a wide range of possible formulations and implementations of energy efficiency targets. Table 2 summarizes the differences between the implementation options.

The first two options are based on industry-specific targets for reducing energy intensity. These options apply a top down approach: an energy efficiency indicator is applied to measure target achievement. This indicator reflects the energy consumption of an industry sector or a company against its physical production, its output value or its value added. The design of the first implementation option requires that the energy efficiency target is achieved in average on industry sector level. If the achievement of sufficient energy savings can be proved by an industry sector, all companies of that sector are rewarded e.g. via tax exemptions or other financial incentives. In contrast, the second implementation option privileges only those companies that meet the formulated energy efficiency target on company level.

The third implementation option is also based on an industry-specific energy efficiency target. It is similar to the second proposal regarding the target compliance at company level. However, instead of applying an energy efficiency indicator for monitoring target compliance, the energy savings achieved by individual investments must sum up to the energy efficiency target (bottom up approach). Those companies, which achieved sufficient energy savings by installing technical measures, are rewarded. Technical measures are cross-cutting or process specific technologies. This definition excludes opportunities from process optimisation and potential efficiency backlogs, which describe the untapped economic potential savings that can be achieved by organizational measures and behavioural changes without (significant) investment. It is necessary to define a reference value for determining the additional energy savings, for example, the specific energy consumption of an old machine or a benchmark. Technical measures eligible for this implementation option are managed on a technology list that is regularly adjusted to the current market developments. The technology lists also includes information on the average energy savings potential of the eligible technical measures as compared to standard technology.

For the fourth implementation option, companies must also conduct and prove the implementation of technical measures

Table 1: Average annual energy saving potentials in the German industry sector between 2010–2020.

	Market potential	Economic potential	Nearly economic potential	Technical potential
Electricity	0,52 %	1,31 %	1,53 %	1,67 %
Fossil fuels	0,48 %	0,94 %	1,04 %	1,05 %

Energy saving potentials for electricity refer to the total electricity consumption. Energy saving potentials for fuels refer to the total fuel consumption.

Table 2: Implementation options for linking energy efficiency targets to rewards.

<table>
<tr><th>Option</th><th>Target</th><th>Target measure</th><th>Compliance</th><th>Reward allocation</th></tr>
<tr><td>1</td><td rowspan="3">Industry-specific energy efficiency target</td><td>Energy efficiency indicator
(Top down approach)</td><td>Industry sectors</td><td>All companies in the sector</td></tr>
<tr><td>2</td><td>Energy efficiency indicator
(Top down approach)</td><td>Individual companies</td><td>Those companies, which have achieved the target</td></tr>
<tr><td>3</td><td>Sum of energy savings from installed technical measures
(Bottom up approach)</td><td>Individual companies</td><td>Those companies, which have achieved the target</td></tr>
<tr><td>4</td><td>Investment in eligible energy efficiency technologies</td><td>Investment in technical measures eligible against reward scheme cap
(Bottom up approach)</td><td>Individual companies</td><td>Those companies which have pursued investment</td></tr>
</table>

to achieve energy savings on company level e.g. installation of a new engine. Here, the reward is directly linked to the cost of additional investments into implementation of technical measures, which are defined like in implementation option three. The higher the investment cost, the higher the reward up to a certain reward scheme cap. Investment costs exceeding the reward scheme cap will not be "reimbursed". Technical measures eligible for this reward scheme are managed on a technology list that is regularly adjusted to the current market development. The technology list covers information on the average energy savings potential and the incremental cost of the eligible technical measures as compared to standard technology.

All implementation options aim at setting pertinent incentives for energy efficiency improvement in each company. We assess them against three evaluation criteria.

Criteria 1: Ability to formulate effective energy efficiency targets

Incentives for energy savings can only be set by formulating appropriate energy efficiency targets. Often the specific energy consumption is used as an indicator for target formulation, for example the energy consumption of an industry sector per units of its output. The main challenge for applying such an indicator to measure energy efficiency is the significant variance of annual energy savings. It results from the discontinuity of investment, the variance of prices, value added with economic cycles, sectoral shifts, and the changes to average energy intensity with capacity utilisation levels.

We conducted an analysis of the historic energy savings achieved by 14 industry sectors and their sub-sectors in the period 2000–2009. The result shows that the annual rate of energy efficiency changes at sub-sector level is a multiple of the long-term average. Each industry sector experienced at least one year where its specific energy consumption changed by more than 10 percent compared to the previous year. At company level fluctuations will even be larger. Hence, the capability of dealing with the variance of annual energy savings must be considered in the design process of an implementation option, if consistent incentives for energy efficiency improvements shall be provided over time. The smaller its influence on an implementation option is, the better can effective energy efficiency targets be formulated.

We observe difficulties in handling the variance of annual energy savings under the first and second implementation options. Both options' performance monitoring is based on energy efficiency indicators, which reflect the energy consumption of an industry sector or a company against its physical production, its output value or its value added. In particular, when being calculated from output value or value added the performance indicator might show a large variance due to mentioned reasons such as the variance of prices. Hence, it might not reflect the efforts taken to improve energy efficiency. As a consequence industry sectors or companies might not achieve their targets in certain years, although they spent significant effort, while in other years they qualify for a reward without any additional work.

Under the third and fourth implementation option energy savings have to be achieved by installing individual technical measures. The savings resulting from installation are calculated bottom-up. Calculated this way, the amount of annual energy savings shows less variance than the energy efficiency indicator under the first two implementation options. Energy efficiency targets formulated under the implementation options three and four can hence be more effective.

Criteria 2: Integration of energy efficiency targets into a companies' decision-making process

A company will consider the implementation of an energy efficiency measure, if the payback period for additional investment cost is short enough or sufficient financial incentives exist (IW 2011). If the volume of financial incentives is large enough, a company's management will take the necessary organizational steps to ensure that this benefit can be claimed.

The importance of energy efficiency targets to decision makers furthermore depends on whether the respective company or part of the company, which contributes to the target, will benefit from the reward.

We tested each implementation option by applying the following assumption: the more direct the link between financial incentives and energy efficiency improvements the more probable the integration of energy efficiency into the decision-making processes of companies.

Since energy efficiency targets have to be met on industry sector level under the first implementation option, the strength of the incentive also depends on the accountability and cooperation within the sector. The qualification for a reward only partly depends on a single company's effort. This reduces the incentive on company level and might lead to free-rider behaviour. The effect is the stronger the larger the industry sector and the smaller the contribution of an individual company to the overall energy consumption of the sector. Due to competition laws, companies within an industry sector must not unify production or investment decisions or agree on sanction mechanisms. This might also lead to a heterogeneous behaviour regarding the achievement of an energy efficiency target.

Under the second implementation option target achievement is monitored on company level. For compliance intra-company structures which support the integration of the energy efficiency target into each investment decision are crucial. Here, the large variance of annual energy savings might again reduce the importance of the target to the company, since it might be achieved in some years effortless, whereas in others it cannot be met even with substantial investments. Implementation option three allows the direct link between the installation of a technical measures and its contribution to target achievement. Thus, the company-wide target can serve individual departments directly as an indicator for monitoring the progress achieved by the investment in energy saving measures.

Under the fourth implementation option the consideration of energy efficiency aspects for investment decisions is strongly supported, since the investment costs will directly be reimbursed up to a certain reward scheme cap. Under this design option, the integration of energy efficiency targets into a companies' decision-making process rather depends on whether the reward is high enough to incentivize the installation of technical measures.

Criteria 3: Administration of timely monitoring

The effectiveness of an implementation option strongly depends on the administration process necessary for monitoring target compliance timely. Timely monitoring is the requirement to issue rewards in good time, which will incentivize further investments into energy savings. (In particular, annual tax incentives require the availability of compliance data.) The demand for timely monitoring requires the fastest possible acquisition of data. However, the shorter the time to collect data, the higher the administrative burden at both – public and company side tends to be. Therefore, we evaluate each implementation option against the effort for data collection and reporting cycles and the potential timeliness of monitoring.

The first implementation option requires monitoring at industry sector level[1]. Prior experience with this exists from the monitoring of the voluntary agreements of German industry (RWI 2011). Under this implementation option data can be used from public statistics. This requires limited effort, but bears the disadvantage of a time lag between target achievement and the compilation of public statistics for monitoring.

The determination of the energy savings at company level is based on a performance indicator under the second implementation option. Monitoring gets easier, if information can directly be provided by the accounting system of the company or by the energy management system. If necessary information cannot be taken from the accounting system, the calculation and monitoring effort increases.

The proposed design of the third and fourth implementation options results in more administrative complexity compared to the first two options, since individual energy saving measures or additional investments must be identified and evaluated. Verifying the installation of technical measures listed on a technology list is formally quite simple. An electronic organization of the procedure should not increase the effort to much, so that the potentially large number of individual measures does not necessarily lead to a large administrative burden. The creation and maintenance of such a technology list could be performed by an independent research organization. Alternatively, the responsibility might be given to an authority with relevant technical skills.

Outcome

The main challenge in setting an energy efficiency target for the German industry sector is to formulate requirements so that they create sufficient incentives for improving energy efficiency, while being able to monitor the compliance at reasonable cost, without burdening the company or the public management.

We explored four implementation options with regards to effectiveness and practicability for industry and authorities. Two implementation options, which monitor energy efficiency improvements top-down via an energy efficiency indicator, prove little effective in dealing with the variance of annual energy savings and in formulating effective energy efficiency targets. The other two implementation options provide a solution to these challenges by capturing energy savings resulting from investments into technical measures bottom-up. There is also a difference in performance of the implementation options with regards to enabling the integration of energy efficiency targets into a companies' decision-making process. Here, implementation options three and four provide the most incentivizing solution. This high performance in criteria 1 and criteria 2 has a price: Implementation options three and four result in higher administrative effort, while the first implementation option ranks best here. Overall, it seems that the fourth implementation option performs best in setting pertinent incentives for energy efficiency improvement in each company (see Table 3).

1. The effectiveness and efficiency of (voluntary) industry agreements has been subject of a controversial debate, cf. IPCC (2007), Millock and Salanié (2001).

Table 3: Performance of implementation options according to suggested criteria.

Option	Criteria 1	Criteria 2	Criteria 3
1	Low	Low	High
2	Low	Medium	Medium
3	High	Medium	Low
4	High	High	Low

The proposed options are currently discussed in the political process. We expect that by the time of the ECEEE Summer Study we can report about the outcome of the discussions of the German government.

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