Wuppertal Institute
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Energy

Brief Analysis on the Current Debate about Costs and Benefits of Expanding the Use of Renewable Energies in Electricity Generation

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Authors:
Dr. Stefan Lechtenböhmer
Sascha Samadi

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Wuppertal Institute for Climate, Environment and Energy
PO Box 10 04 80
42004 Wuppertal, Germany

Final Report

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1 Preface

The use of renewable energies, such as wind, hydroelectric power, solar energy and biomass to generate electricity in Germany has increased considerably during the past ten years. The share of renewable energies in total German electricity production between 1999 and 2009 rose from 5.4% to 16.4% (BMU 2010a). The Renewable Energy Act (EEG), which came into force in 2000, has contributed significantly to this rise. The EEG stipulates minimum feed-in tariffs for electricity from various renewable sources, and also grants this electricity priority access to the grid.

In its current energy concept the federal government is aiming to increase this share considerably, to 35% by 2020, and to 80% by 2050 (cf. Bundesregierung 2010). Further enhancement of the use of renewable energies is a policy goal for several reasons, not the least of them being the reduction of CO_2 emissions; but reasons of economic policy are also important.

Critics of the promotion of renewable energies, and especially of the EEG, consider the costs of the expansion of renewable energies too high. They call for a significant reduction, or even the termination of that support, and often refer to the CO_2 emissions trading system introduced in Europe in 2005, which in the view of many critics, is a sufficient and efficient climate protection instrument.

The present brief analysis provides an overview about costs and benefits of the promotion of renewable energies in the framework of the EEG. In Chapter 3, we describe the development of the EEG apportionment in recent years, and its possible development in coming years. Furthermore, the analysis examines the merits of some of the most commonly expressed points of criticism against the EEG in Chapter 4. Finally, in Chapter 5, we examine the extent to which the calculations regarding the costs of the expansion of photovoltaics, which are often raised in the media, are correct, and how they are to be interpreted.

2 Summary of Main Conclusions

The main conclusions of the present brief analysis can be summarized as follows:

- Despite the expected increase in 2011, the EEG apportionment will not exceed 15% of household electricity prices, a relatively small share. The average household will have to spend only about 0.3% of its net income on the support for renewable energies via the EEG.
- The main reasons for the major rise in the EEG apportionment since 2009 suggest that no further major increase in the surcharge is to be expected after 2011.
- Probably, the EEG apportionment will start to drop in several years, and by 2030 it will be reduced to below one cent per kWh.
- Many criticisms on the support of renewable energies are not in line with theoretical and empirical findings.
- An assessment of calculations by the Rhineland-Westphalian Institute for Economic Research (RWI) about the costs to consumers by promoting photovoltaics shows that these costs are overestimated by at least 6% and up to 42%. Implausible assumptions and the non-consideration of certain facts and contexts lead to wrong results.
- An appropriate assessment of the expansion of renewable energies will only be possible if the costs involved are communicated in objective and in generally understandable terms, and especially if the multifaceted and long-term benefits of this expansion are not ignored.
- Expanding the use of renewable energies reduces the negative external effects connected with fossil and nuclear power plants as well as the costs of technology, and thus increases the possibilities for successful climate protection, both domestically and abroad.

3 Costs and Benefits of EEG-Based Support for Consumers and the Economy as a Whole

3.1 The development of the EEG apportionment since 2009, and possible developments through 2030

The designation of the EEG apportionment permits a clearer evaluation of those costs, which consumers will have to bear, at a maximum,[1] now and in the coming years, as a result of the support of renewable energies in the framework of the EEG. The EEG apportionment is generally designated in cents/kWh. In order to calculate it, the EEG differential cost is first of all ascertained. Under § 53 of the EEG, this is the difference between the feed-in tariffs for renewable energies established under the EEG for total electricity production in one year, and the market value of the total quantity of electricity generated (average cost of electricity purchase). The EEG differential cost is then divided by the electricity consumption subject to the surcharge.[2] The result is the EEG apportionment in cents/kWh, which is the focus of the public debate, and is the basis for the calculation of the absolute annual or monthly burden upon an average household for the support provided under the EEG.[3]

It is important to emphasize that the EEG apportionment overestimates the actual costs to consumers due to support for renewable energies, since it doesn’t consider the merit order effect (see Section 5.2.2). The model calculations for 2008 suggest that in that year, approximately 80% of the EEG apportionment was compensated for by the merit order effect (izes et al., 2010).[4]

A current study for the BMU (Wenzel, Nitsch 2010) estimates the amount of the EEG apportionment through 2030. The authors of the study assume renewable energies facilities will be considerably expanded over the next two decades, and that the share of renewable energies in the total electricity production will rise from 16% in 2009 to 65% in 2030.[5] According to their calculations, the EEG apportionment will continue to rise for a few years – until 2016 – and then fall continually until 2030. Figure 1 shows the expected development of the EEG apportionment through 2030, dependent on the price of electricity. In addition to two different assumptions regarding the development of the price of electricity (“moderate” and “significant” price rises), a hypothetical electricity price is additionally stated, which completely considers the negative external effects of the CO_2 emissions of fossil fuel fired power plants.[6]

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[1] “Maximum” because the calculation of the EEG apportionment does not take into account the merit order effect (see Section 5.2.2).

[2] Not all final consumers of electricity must pay the same EEG apportionment for the support of renewable energies. Many companies with electricity intensive production pay a lower surcharge (0.5 cents/kWh; Wenzel, Nitsch 2010).

[3] According to current estimates, the EEG apportionment in 2010 was between 2.3 and 2.4 cents/kWh; it had been pre-estimated at 2.05 cents/kWh; see below.

[4] The extent to which our price reducing effects of renewable energy facilities are actually passed on to final consumers is also dependent on the structure of competition in the electricity market.

[5] The federal government, in its energy concept of September 28, 2010 (Bundesregierung 2010), predicts a share of renewable energies in total electricity production of 50% in 2030.

[6] This assumes costs due to damage from CO_2 emissions of €70 per tonne.

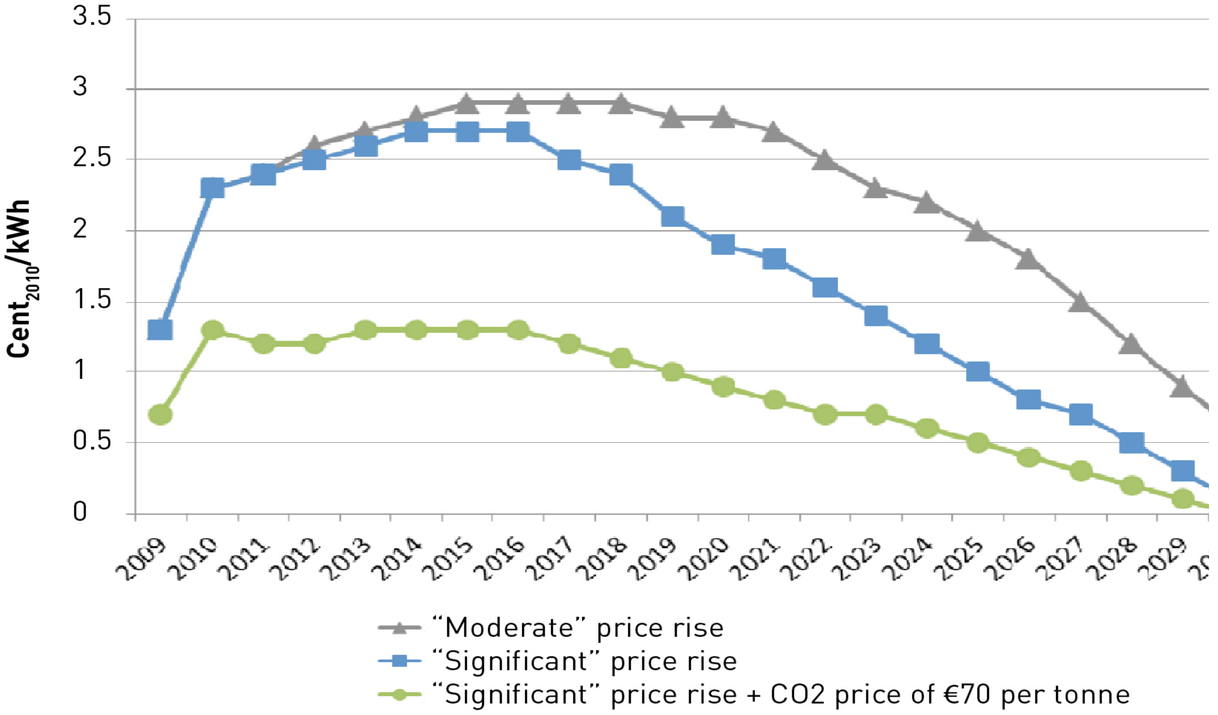

Figure 1 Expected development of the EEG apportionment through 2030, depending on the development of the price of electricity (Source: Wenzel, Nitsch 2010)

The EEG apportionment for each year is pre-estimated by the transmission grid operators. For 2010, an EEG apportionment of 2.05 cents/kWh was originally expected. Particularly due to the expansion of photovoltaics, which turned out to be greater than predicted, the actual apportionment for 2010 is currently expected to be between 2.3 and 2.5 cents/kWh. The deficit in the apportionment for 2010 will be added to the apportionment for 2011 (Wenzel, Nitsch 2010). This is the main reason why the increase of the EEG apportionment from 2010 to 2011 will be "officially" high. In Figure 1, the original estimate of the apportionment for 2010 is corrected, so that the apportionment as shown here is only slightly higher in 2011 than it was in 2010.

Nonetheless, the clear rise in the EEG apportionment between 2009 and 2011 is noticeable. The rise is essentially due to the expansion of photovoltaics over the past two years, which was triggered by significant drops in the price of photovoltaic systems. A similar expansion of photovoltaics is not expected after 2010, since the price drops in coming years will presumably be more moderate and the feed-in tariffs for new facilities will be reduced significantly: In 2011, the reduction is expected to be above 10%, after an "unexpected" additional reduction on top of the planned digression resulted in a 16% reduction in 2010.[7] Since 2009 a so-called "corridor" is in effect, which was already tightened in the current year (2010): If photovoltaics are expanded more within a year than the target values stipulated in the law, the digression will automatically be enhanced in the following year; i.e., the feed-in tariff will drop more than proportionately, which will dampen the demand for photovoltaic systems.

An additional reason for the significant increase in the EEG apportionment since 2009, beyond the major expansion of photovoltaics and the major increase in electricity production from small biogas systems, is the drop in the wholesale price of electricity (BMU 2010b). Here too, we have an exceptional and temporary effect. As a result of the economic crisis of 2009, the demand for electricity as well as the price for fuel and CO_2 plummeted, resulting in a drop in the price of electricity. In coming years, the price of electricity is expected to rise again (Wenzel, Nitsch 2010), which should have a dampening effect on the differential cost.

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[7] A slightly less pronounced degression of the tariff is applied for systems in so-called conversion areas (11%) and other open spaces (15%).

Finally, a one-time change in the calculation of the EEG apportionment contributed to a rise between 2009 and 2010: since the beginning of 2010, the costs of regulating energy caused indirectly by EEG electricity which has previously been incorporated into the calculation for the grid fee, are added to the EEG apportionment. In return, the grid fee is reduced, which is nothing more than a shift of costs.

Evidently, the significant rise in the EEG apportionment over the past two years is essentially due to a number of one-time or at least unusual effects. It is therefore expected (Wenzel, Nitsch 2010; Figure 1) that the EEG apportionment will be approximately 3 cents/kWh during the coming years[8] (or approximately 13% of the current average household price of electricity), and will start to drop toward the end of this decade at the latest – at least if the "corridor" policy for the expansion of photovoltaics is not continually exceeded over the coming years. Despite the assumed continued dynamic expansion of renewable energies, the apportionment will thus drop due in large part to lower specific feed-in tariffs, and will very likely continue to do so through 2030, to a level considerably below 1 cent/kWh (Wenzel, Nitsch 2010; Figure 1).

3.2 The burden on an average household due to the EEG

In order to consider the indirect effects of the expansion of renewable energies, which relieve households, the merit order effects can be subtracted from the differential costs.[9] Calculations of the merit order effect are only available for 2008. In that year, the merit order effect of electricity falling under the EEG was estimated at between €3.58 and €4.04 billion, while the EEG differential costs amounted to €4.65 billion (izes et al., 2010). Assuming a mean value of €3.81 billion for the merit order effect, the net burden on consumers due to the support of renewable energies through the EEG in 2008 was only €840 million.[10] Accordingly, the EEG apportionment for 2008 would drop from 1.1 cents/kWh to 0.2 cents/kWh. An average household with an annual electricity use of 3,500 kWh would have had to pay 59 cent per month. Without considering the merit order, the burden per household would have been €3.52 per month.

The EEG apportionment in the coming year could according to estimates (BMU 2010b) rise to as high as 3.5 cents/kWh, and hence would be higher than that expected in the above cited study carried out under contract to the BMU (Wenzel, Nitsch 2010).[11] If we assume such an increase, and assuming too, that the merit order effect would - as in 2008 - lead to a decrease of the price of electricity of approximately 1 cent/kWh (if passed on entirely to the consumers), the additional burden on consumers as a result of EEG support would be approximately 2.5 cents/kWh, or approximately 11% of the current cost of electricity for a household (Statistisches Bundesamt 2010). For this model household, with an annual consumption of 3,500 kWh, that would mean a monthly burden of approx. €7.30. That amounts to less than 0.3% of the average monthly net income of the German household (approximately €2,800 in 2005, according to the Federal Statistical Office [Statistisches Bundesamt] 2006).

In the following section the macroeconomic advantages provided by the expansion of renewable energies are explained, which stand in contrast to the burden described above.

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[8] While it is true that the Federal Ministry for the Environment is currently working with an EEG apportionment estimate for 2011 of 3.3 to 3.5 cents/kWh, it must, as stated above, be taken into account that 0.5 cents of that should actually be attributed to 2010, since the original estimate for 2010 (2.05 cents/kWh) proved to be too low.

[9] CF. Section 5.2.2 for a detailed explanation of the merit order effect.

[10] This assuming that the advantage of more favourable procurement costs of electricity as a result of merit order effects was passed on to consumers *in total*. This in turn presupposes competitive structures in the electricity market.

[11] Part of this amount (approximately 0.4 cents/kWh) is, as stated above, actually to be attributed to 2010.

3.3 Macroeconomic costs and benefits

The EEG differential costs are an initial approximate indicator of the macroeconomic costs of the expansion of renewable energies in the electricity system, for the merit order effect is not considered in such a macroeconomic evaluation, since it “only” leads to a redistribution of the profits of power plant operators to the benefit of the consumers, but not to any overall macroeconomic gain.

For 2010, EEG differential cost amounted to a total of approximately €8 billion, according to the original estimates of the transmission grid operators. Starting in 2016 however, it is to be assumed that the EEG differential cost will drop again (Wenzel, Nitsch 2010). This is on the one hand due to the digression of the feed-in tariffs, and on the other to the fact that it is becoming ever more lucrative for operators to dispense with EEG remuneration and to market their renewable power directly on the Exchange.

For the evaluation of the macroeconomic burden, it is helpful to place the EEG differential cost in relation to other numbers in order to place them in context. Thus, the differential cost estimated for 2010 of approximately €8 billion, for example, represent 0.3% of the German gross domestic product. Figure 2 shows the EEG differential cost for 2008 through 2010 and for 2030 (prediction by Wenzel, Nitsch 2010, assuming a moderate increase in the price of electricity) in comparison to support for environmentally damaging activities carried out in 2008, which amounted to approximately €49 billion (2010 value; UBA 2010).[12]

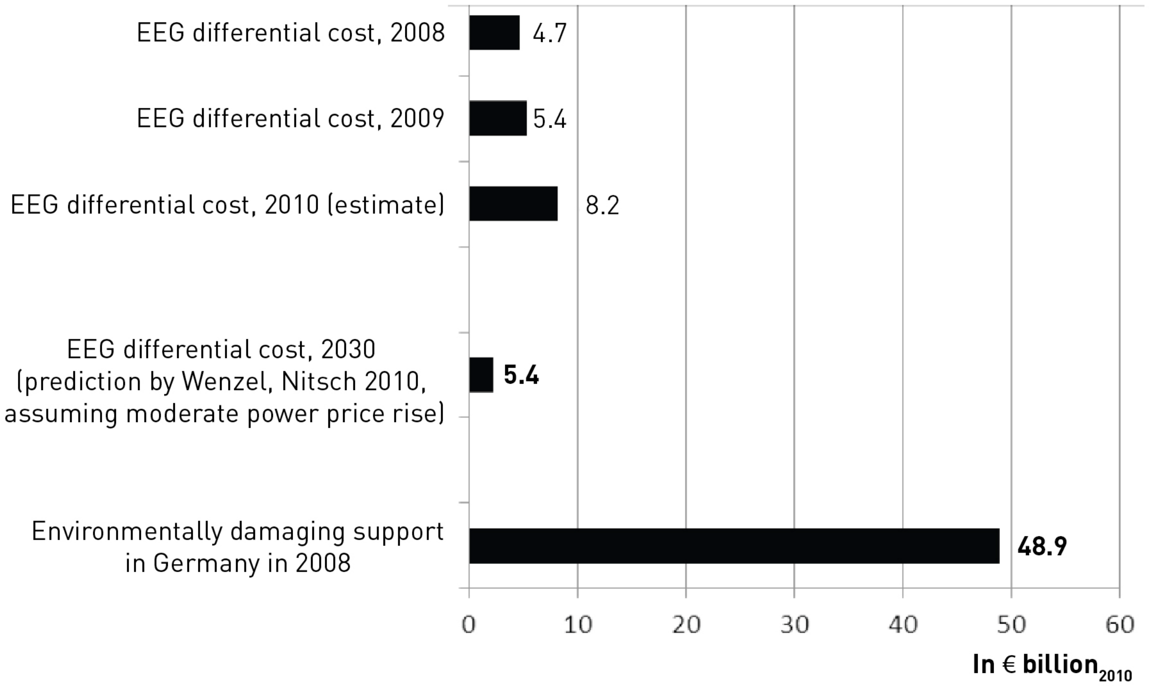

Figure 2 Comparison of EEG differential cost for 2008 through 2010 and for 2030 (prediction by Wenzel, Nitsch 2010), and support for environmentally damaging activities in 2008 (Sources: BMU 2010 B; Wenzel, Nitsch 2010; UBA 2010).[13]

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[12] For example: of the €49 billion, €2.6 billion are accounted for by hard coal subsidies. Another €8 billion are assigned to the free distribution of CO_2 emissions certificates.

[13] Here, it should be noted that the differential cost stated for 2010 is not completely comparable to the differential cost for the preceding years, since starting in 2010, marketing costs were also included. These were previously included under grid fees (BMU 2010b).

Here, it should be noted that the environmentally damaging support is not accompanied by any advantages comparable to those of the expansion of renewable energies. These advantages included in particular:

- Reduction in CO_2 emissions
- Reduction in air pollution
- Reduction of imports
- Preservation of finite energy resources, and hence a contribution to the reduction of the danger of geopolitical conflict around shortages of resources
- Generation of domestic value creation, and the creation of jobs
- No risks of major accidents
- No risks of proliferation as a result of radioactive wastes
- Contribution to the reduction of the cost of technology, thereby facilitating ambitious climate protection activities in other countries as well.

Ultimately, society must of course decide whether it is worthwhile during the coming two decades to accept the - in our view very reasonable - extra burden of today and the next 20 years in order to benefit from the short and long-term advantages of the expansion of renewable energies.

4 Examination of the Fundamental Objections to the Promotion of Renewable Energies through the EEG

Despite its obvious success during the last ten years with regard to the accelerated expansion of renewable energies in the electricity system, there is still fundamental criticism of the EEG, especially by economists (e.g. Sinn 2008; Frondel et al. 2010; Scientific Advisory Council of the Federal Ministry for Economics and Labour 2004). This chapter addresses the frequently stated criticisms of the EEG, and seeks to present the empirical and theoretical weak points of these objections to the EEG.[14]

4.1 Does emissions trading mean that the EEG-sparked expansion of Renewable Energies does not lead to any CO_2 savings?

Under the EU emissions trading system, the maximum emissions of electricity production are fixed by a five-year period. If emissions in the electricity sector of a country are lowered, e.g. due to the expansion of renewable energy production, the remaining emissions can be sold and emitted in other sectors or other countries.

The dynamics of the crowding out of fossil fuel based electricity production through the EEG and the accompanying lower CO_2 emissions are considered in the form of expected future expansion in the political decision-making process for establishing the emission trading cap.[15] Without the expansion of renewable energies initiated by the EEG and comparable feed-in systems in other EU countries, it would probably have been politically impossible to establish those caps. They would have otherwise – in comparison to the actual situation of the expansion of renewable energies – led to higher prices of certificates. This is evident from the planning for the third phase of the EU emissions trading starting in 2013: the Europe-wide cap established by the EU for this phase is based on the EU goal of reducing its overall greenhouse gas emissions by at least 20% over 1990 as of 2020. This goal in turn was established parallel to the expansion goal of renewable energies in the EU to 20% of final energy consumption by 2020. These two goals are directly interrelated, and can therefore not be considered separately.[16]

However, even if the level of the emissions trading cap had been determined with no consideration for past or future expected expansion of renewable energies, and even if the cost reductions induced by the expansion of renewable energies had not opened the door to more ambitious future climate protection, a positive effect on the climate of the expansion of renewable energies nonetheless have to be assumed: The cost reductions of technologies for the use of renewable energies sparked by the EEG and other comparable support instruments within the European Union has led to increased use of such technologies in foreign markets as well, including those not subject to CO_2 emissions trading (e.g. China, India and the US). It can moreover be assumed that the pioneer role of countries such as Germany, in connection with the cost reductions achieved in renewable technologies increases the probability that countries which are presently somewhat hesitant in terms of climate protection will in future be more willing to enter into international contracts and commit to domestic climate protection measures.

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[14] Sections 4.1 through 4.3 were taken from Fischedick, Samadi (2010).

[15] By contrast, current federal government plans for extending the lifespans of German nuclear power plants were not taken into account when establishing the emissions caps through 2020.

[16] The objection raised by Frondel et al. (2010) against the reference to the EU process for establishing the third ETS phase is not comprehensible. That would only be the case if such policy decisions as the establishment of the level of the cap were to "fall from the sky".

4.2 Can emissions trading alone ensure that climate protection can be achieved at the lowest possible cost via the market?

The conviction that the single use of emissions trading can achieve the desired reduction in greenhouse gas emissions economically efficiently, i.e. at the lowest possible costs, is based on environmental economic theory. Under that theory, given a state imposed limitation of emissions coupled with the possibility of free trade in emissions rights, market mechanisms will ensure that emissions reductions will always be carried out where they can be achieved by the lowest possible cost. Figure 3 shows the manner of the effect of emissions trading under this theory: Here, the government seeks to achieve a reduction of emissions from E to (E-X). A certain amount of emission rights are being distributed and the trade of these rights result in - at the point of intersection of the permitted emission quantity (E-X) and of the overall societal marginal abatement costs (MAC)- the market price p for one emission unit. The costs of climate protection are shown in Figure 3 by the crosshatched surface. These costs represent the overall societal minimum cost for the achievement of the emissions reduction goal, since emission trading insures that only most cost favourable emissions reduction measures will be carried out, i.e. those measures which are profitable at less than the price of emission rights.

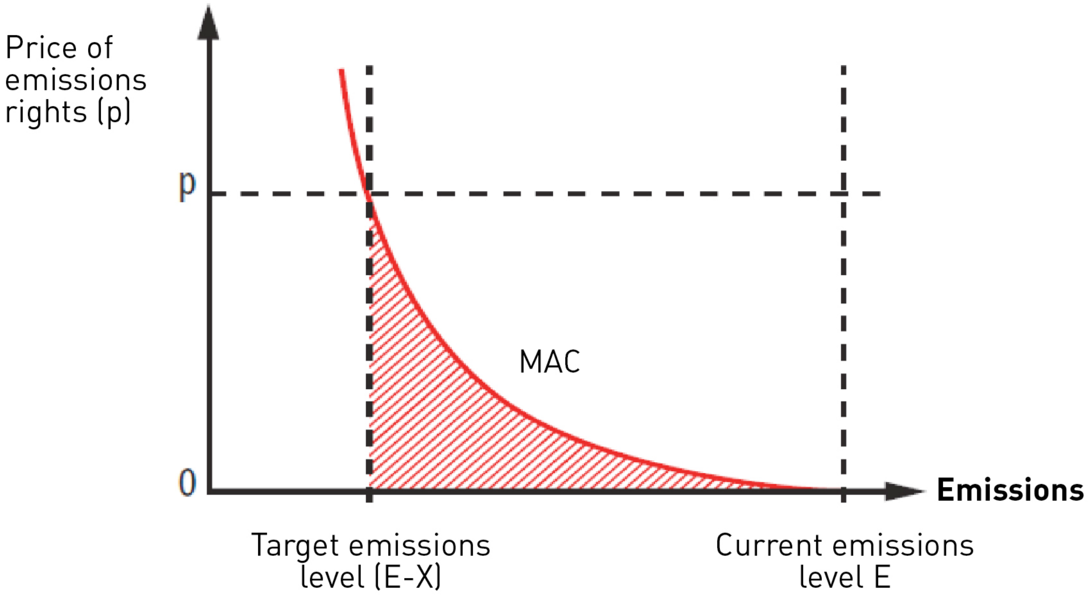

Figure 3 By means of emissions trading and in the view of classical environmental economics, the sought after climate protection goal (E-X) can be achieved at the lowest possible cost (crosshatched surface).

In fact, the clear conclusion of the cost minimizing climate protection instrument can only be maintained if it is assumed that it is impossible to press the MAC curve downward at a later date, by making use of initially more expensive avoidance technologies at the outset of the reduction effort. If this assumption is ignored it is possible that an overall societal MAC curve could exist, which in the range of lower emissions reductions is higher than its alternative MAC curve that depends on other technologies. However, in the course of further emissions reductions, the MAC curve intersects the alternative curve and from that point of the emission level it enables cost-effective emissions savings. Depending on how both these MAC curves are progressing and how strong emissions reductions are to be, it is possible (as shown in figure 4) that an initially higher MAC curve (identified in Figure 4 as MAC' curve) achieves a certain climate protection goal at overall lesser cost than the other MAC curve, even though the latter was initially lower.

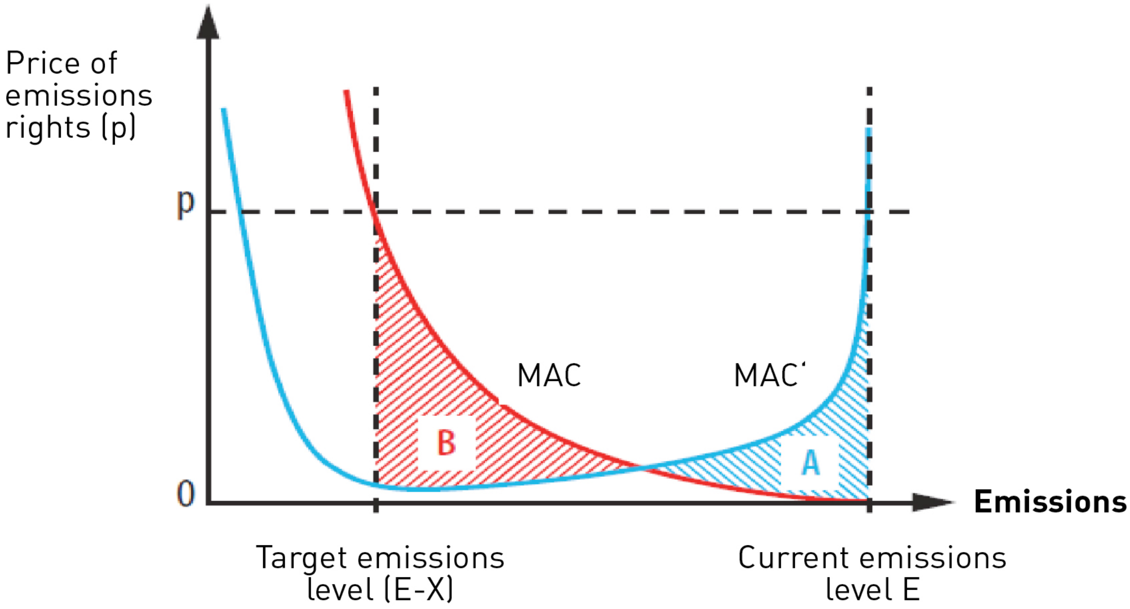

Figure 4 Here, emissions trading fails to achieve the sought after climate protection goal (E-X) at the lowest possible cost, since an alternative MAC curve (MAC') exists at which higher MAC occur initially, but enable lower MAC at a later date, and thus achieve the sought after climate protection goal at lower overall costs (surface A < surface B).

If emissions trading is the only climate protection instrument used to achieve the reduction goal (E-X), then emissions reductions will proceed along the non-minimum cost MAC curve. Market actors will not invest into technologies, which are more expensive than the certificate price p determined by the emissions trading market. On a macroeconomic level, it would be worthwhile to invest into these initially more expensive technologies. However, despite emissions trading, the market provides no incentive for individuals to achieve their individual share of macroeconomic emissions reduction by using such a technology.

Why should a MAC curve in the form of the MAC' curve illustrated in Figure 4 in fact exist? In economic textbooks, a curve is normally represented in the form of the MAC curve shown in Figure 3. Such a curve assumes that the marginal costs of emissions reduction will increase the more emissions have already been reduced. Initially, market participants will undertake those emissions reductions, which can be realized most cheaply. Options, which involve higher mitigation costs are only used once emissions are already reduced significantly. Such an assumption is an expression of a static analysis, which fails to consider interrelationships between the extent of the use of a certain mitigation technology and its costs.

Such a static view, and the resulting "typical" MAC curve progression, may be plausible for the use of conventional options for emissions reduction, such as increasing the efficiency of fossil fuel fired power plants, or substituting coal with natural gas. These procedures involve the further development of, or the switch to establish technologies with minimal potential for technological improvements, in comparison with newer technologies. At first, these mitigation options are generally available relatively cheaply, but their increased use results in cost reductions for particular technologies only to a minimal degree, and these cost reductions will be overcompensated by cost increases as a result of the necessary shift to areas of application which are less productive with respect to their emissions reduction potential.

For many innovative technologies for emissions reduction, which have not yet been applied or which are being used only to a very limited degree, a different progression of the MAC curve is plausible. These technologies are initially very expensive, since they are at the beginning of their development, and hence have so far profited little or not at all from cost reductions which emerge as a result of research and development (R & D) and the dissemination of these technologies on the market.

If these technologies do generate demand despite their initially high costs, very noticeable learning curve effects may be generated, i.e. the cost of the technologies will drop with their increasing use as a result of technological advances and organizational improvements in production and use. On the production side there will be positive economies of scale as a result of the dissemination of the technology, as well as further technological development. On the demand side, dissemination will lead to more experience in the application of the technologies and also to beneficial networking effects (see below).

Such considerable learning curve effects have been observed empirically for the various renewable energy technologies. Here, a clear correlation between falling costs and the expansion of a technology have been ascertained. For photovoltaics, for example, especially high learning rates of approximately 20% have been documented. That means when the use of photovoltaics is doubled, the specific cost of the technology will drop by approximately 20%. If such innovative technologies have not only high learning rates, but also great potentials for reducing greenhouse gas emissions, the early use of such technologies can lead to a falling MAC curve, as shown in figure 4 by the MAC' curve.

In the literature, various reasons have been identified to explain why cost-reduction potentials as a result of the learning curve effects have not been pursued on the free market to a sufficient degree (Jaffe et al. 2004; Goulder & Parry 2008). The primary factor here is the so-called "knowledge spill-over": Despite the possibilities of patent protection, nothing can prevent other market actors to benefit in part from the technological and organizational progress achieved from investments in new technologies.

Moreover, the public profits not only from the fact that production costs of the technology drop as production increases, but also from the fact that the cost of those benefits are reduced with increasing dissemination as a result of improved information and networking affects: There is then more information available about the correct application of the technology, and there is an improved infrastructure for its use, such as market actors who supply services connected with the technology, such as installation and maintenance.

The phenomenon of knowledge spill-over and networking affects, as well as a generally improved level of information lead to the fact that not only the original investor benefits from the effects of investments in innovative technologies, but rather, the other market actors in the form of positive external effects. For investors, this is a major obstacle and it cannot be overcome with emissions trading.

Some EEG critics point to the phenomenon of the learning curve, but don't agree that it justifies a technology specific support. The scientific advisory Council of the German Federal Ministry for Economics and Technology (2004) noted that "the learning curve... is a practically universal phenomenon", and adds that conventional energy technology profits from the learning curve as well. However, this statement, while not wrong, essentially misses the point: various technologies show different learning curves, and very different potentials for future emissions reduction.

Of course, not every technology, which demonstrates a learning curve effect, should benefit from government support. However such support makes sense for certain climate protection technologies if the learning rate is especially high compared to other mitigation technologies, and if use of the technologies promises a considerable potential for climate protection.[17] For then, the advance investment by society will pay off in the form of future climate protection.

Prof. Sinn, president of the ifo Institute for Economic Research, and a prominent critic of the EEG, does point out that investments in new technologies may lead to learning curve effects with "positive external effects for

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[17] Many technologies for the use of renewable energy, particularly photovoltaics, fulfil these preconditions to a high degree, according to the current state of knowledge. The highly efficient fossil fuel fired power plants, which have been lauded by the Scientific Advisory Council of the Ministry of Economics fare much worse in this respect.

companies which copy them", and may thus justify government support (Sinn 2008). However, regarding the different renewable energy technologies, he sees no reason for any differentiated support such as that provided under the EEG through its different feed-in tariffs. He refuses to accept the fact that the higher the learning rate and the higher the emissions reduction potential of a technology is, the higher the extent of positive external effects of technology development will be and that therefore different levels of funding make sense.

4.3 Should technology specific support be limited exclusively to the support of research and development?

While some critics of the EEG advocate government support for innovative and promising technologies in the area of the use of renewable energies, they see support for research and development (R & D) as a more suitable policy instrument. In one of its publications, the RWI claims that in order to achieve market maturity for renewable energy technologies, "research and development in these technologies could be supported more than has been the case with a fraction of the amount of annual feed-in tariffs" (Frondel, Schmidt 2006). The Monopoly Commission too has expressed support for "supporting basic research in the area of renewable energies” as a supplement to emissions trading – and as an alternative to the EEG (Monopoly Commission which 2009).

Evidently both the RWI and the Monopoly Commission demand that technology specific support be limited only to research and development, and that no support be provided for market entry for innovative technologies. However, this clearly contradicts with theoretical and empirical knowledge gained from innovation and diffusion research (cf. e.g. Wene 2008; Foxon et al. 2005; González 2008). According to this research, the effective and efficient support of innovative, but not yet competitive technologies requires a mix of various policy instruments.[18] Which support instruments are best suitable for a certain technology depends to a large degree on the state of development of that technology.

Support for the market introduction of new technologies carried out under the EEG has a number of advantages, which cannot be achieved by efforts limited to R & D. A technology must prove itself under real conditions if introduced to the market in significant quantities. The exchange between producers and users permits the identification of problems and weaknesses, which lead to technological advances and innovation – not at least due to the competitive pressure existing on the market. Therefore only market introduction allows the empirically proven cost-reduction potentials of enhanced production and use of technologies to be realized (learning curve effects, see section 5.2.4).

In addition, individual technologies cannot be viewed in isolation from their surroundings, particularly in energy systems. Government supported market introduction not only improves the technologies in accordance with the needs of the users, but also indicates what changes and additions are needed in the technological and organizational infrastructure of the energy system for it to be able to incorporate the new technologies.[19] Limiting government technologies support to R&D would not immediately lead to the market introduction of new technologies. As a consequence, the existing structures of energy systems will be maintained, and possibly even reinforced, which would make the later expansion of renewable energies more difficult or more expensive.

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[18] Moreover, the expansion of renewable energies, unlike the exclusive funding of R & D, contributes directly to reducing negative externalities, by replacing conventional energy sources.

[19] For instance in Germany, only since the major expansion of wind energy and photovoltaics in recent years has it shown that in addition to technological progress, technological and organizational solutions for the integration of large quantities of fluctuating electricity sources need to be targeted.

The expansion of renewable energies counteracts with the phenomenon known as "carbon lock-in", i.e. the reinforcement of structures of the existing energy system (Unruh 2008). These advantages can only be achieved by means of a rapid market introduction of technologies for the use of renewable energies, and not by means of exclusive support for R&D. For example, the *Stern Review* recommends: “In addition to direct emissions pricing through taxes and trading and R&D support, there are strong arguments in favour of supporting deployment in some sectors when spillovers, lock-in to existing technologies, or capital market failures prevent the development of potentially low-cost alternatives.” (Stern 2006)

Moreover, thanks to the economic success of the renewable energy sector, interest groups have emerged whose influence may be able to ensure the necessary reliability of government support for successful technology development over the long term. Over the past decades, it has been shown in Germany and other countries that government expenditures for R&D in the energy sector are subject to major fluctuations, both in terms of their total volume and with regard to the technologies supported. Changing political majorities and government budget situations can very rapidly cause reductions in research expenditures. To depend only on this instrument of R&D support for the purpose of the expansion of renewable energies, which is so necessary for climate protection, therefore seems highly questionable for this reason as well.[20]

4.4 Is net job creation as a result of the support for renewable energies negligible or even negative?

The fact that the expansion of renewable energies has created numerous jobs in Germany is largely uncontested. To an increasing degree, these jobs depend on the export of the technologies originally developed for use in Germany, or on the services connected with them. Comprehensive current studies on the issue (BMU 2010c; Lehr et al, 2008) come to the conclusion that the job creating affect of the EEG is still positive even if the direct and indirect effects of the support, which caused job losses in other industries, are taken into account. In addition, the fact is that jobs in the renewable energy industry – especially in photovoltaics and biomass – are being created especially in regions, where the economic prospects are weak.

4.5 Does the development of EEG subsidy tariffs for wind energy since 2000 show that the EEG is not achieving its goal of cost-reduction in technology?

This assertion is found in Frondel et al. (2010), as follows: “[T]he 2009 tariffs for electricity produced from biomass and wind converters are above the levels of the year 2000.” Here however, the nominal feed-in tariffs are unjustifiably compared with one another. Adjusted for inflation, the tariff for onshore wind energy use in 2009 is about 12% lower than in 2000.

In addition, 1 kWh from a new wind power system today is from a systemic point of view worth more than 1 kWh from a typical system in 2000: Today, modern systems take over functions of grid stabilization (as stipulated in the EEG) which they had not yet assumed during the first years of EEG support. Moreover, today’s wind power systems are considerably quieter and more space-saving (per kWh) than was the case ten years ago. That means that the expansion induced by the EEG has sparked technological advances, which are reflected not only in falling real costs per kWh, but also in other aspects.

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[20] Under no circumstances does this mean that government support for R&D should be considered superfluous. Successful technology development requires a mix of instruments. Government R&D expenditures in the energy area, and particularly in the area of renewable energies, could be considerably increased, in accordance with the problems faced, so as to promote basic research and technological diversity.

The real costs per kWh for onshore wind energy systems has thus dropped during the past ten years, even though it has been possible to reduce negative external effects,[21] despite the fact that less favourable wind energy sites had to be chosen over time and the price of the important input factor steel increased. This was an essential reason for the increase in the feed-in tariffs stipulated by the revision of the EEG in 2008. So viewed correctly – i.e. in real prices – and considering all relevant aspects, the technological development in the wind energy sector over the past 10 years is a clear sign for the positive innovative effects of the EEG induced expansion.

The increase in the feed-in tariffs from biomass is only applicable if major requirements, such as the use of excess heat, are fulfilled, but it also serves to strengthen support for relatively small systems, a politically intended structural effect with positive impulses for regional economies. Due to the differentiation of feed-in tariffs from biomass in the EEG revisions of 2004 and 2008 with regard to the type of biomass and the type of system used, an undifferentiated comparison of feed-in tariffs, as undertaken by Frondel et al. (2010) is inappropriate. It would be just as easy for instance to point to the minimum remuneration for medium-sized systems between 151 and 500 kW, which dropped by 22% (in real terms) between 2000 and 2009.

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[21] The reduction of external effects includes especially the significant reduction in noise pollution, lower specific land-use, and the contribution to grid stability.

5 Does the Support for Solar Energy through the EEG over the Past Ten Years in Fact Amount to €66 Billion?

According to calculations by the RWI, the total costs accumulated by photovoltaic facilities built between 2000 and the end of 2010 under the EEG – added together and expressed in the monetary value of 2007 – amounts to €66 billion (Frondel et al. 2010). The RWI authors add together the annual support costs, which will be due for these systems throughout the period of their subsidy, which yields the so-called “net present cost” of the subsidy. That means that not only the support paid between 2000 and 2010 enters into this cost calculation, but also the support that is to be paid for these facilities over the coming two decades.[22] The subsidy costs are defined as the net costs – also known as differential cost – calculated as the difference between the feed-in tariffs and the electricity price on the exchange.[23] This takes into account the fact that 1 kWh of electricity from subsidized renewable energies makes the purchase of 1 kWh of power from conventional sources unnecessary.

In recent years, the RWI authors have published similar calculations in various forums (Frondel et al. 2009; Frondel et al. 2008). Their cost calculations have been covered in the media. However, it has not always been stated clearly that the support costs ascertained by RWI will to a large part only arise over the coming two decades. For instance, in its issue of September 20, 2010, *Der Spiegel* states with reference to RWI, that “the support over the past ten years has, as calculated by the RWI, come to a total of €60-€80 billion.” Estimates published in media reports in early October 2010 and attributed to information from the RWI even claim that “by the end of this year, a total burden of some €85 billion will have been accumulated as a result of solar energy systems” (e. g. *Frankfurter Rundschau* 2010). Where this increase of up to €19 billion over the numbers given by Frondel et al. (2010) comes from is not stated in these reports.[24]

In the following, we will first of all provide an overview in Section 5.1 of the corrections and additions to the RWI calculations of support cost of photovoltaics undertaken in the context of this analysis; and then in Section 5.2 provide a detailed explanation of each of the modifications of the RWI calculations that we have undertaken.

5.1 Summary of an examination of the RWI calculations of the costs of support for photovoltaics

An examination of current calculations by the RWI (Frondel et al. 2010) shows that erroneous data, implausible assumptions and various methodological decisions by the authors have caused the costs to be overestimated by at least €4 billion, and possibly by as much as €20 billion, i.e. by at least 6% and up to 42%. In these corrected figures, a number of macroeconomic effects have not yet been considered, especially the reduction of negative external effects and the achievement of cost reductions for future photovoltaic investments. The RWI calculations are therefore a clear overestimate of the actual costs to be paid for by the consumers.

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[22] Thanks to the 21-year guarantee of feed-in tariffs under the EEG – including the year of entry into operation – those facilities installed in 2010 will receive support through 2030.

[23] For this purpose, the RWI calculation needs to make assumptions about future prices on the EEX. Compared with current assumptions by Wenzel & Nitsch (2010), the future rise in the price of electricity on the EEX assumed by the RWI authors is indeed moderate, but such long-term assumptions are always uncertain, and the development assumed by the RWI authors seems to be within the range of plausibility from today’s point of view. The future price of electricity is therefore not modified in the following examination of the calculations by Fondel et al. (2010). Moreover, the assumption of a future inflation rate of 2% has also been left unchanged.

[24] One possibility is that the monetary value of the 2007 euros used by Frondel et al. 2010 has been adjusted to 2010 euros; however, that would only account for a small portion of the difference, for €65.5 billion (2007) correspond to a current monetary value of approximately €68.2 billion. Even updating the calculations to account for the actual expansion of photovoltaics in 2009 and now, the expected expansion in 2010 cannot explain the difference, as is shown at the end of Section 5.2.2.

In any case, the following mistakes and implausible assumptions need to be corrected in the calculations undertaken by the RWI authors:

- The additional power generated by photovoltaic facilities in 2007 is estimated at 50% higher than it in fact was.
- It is assumed that between 2005 and 2010, all new additional photovoltaic systems were small facilities with a maximum output of 30 kW_p; in fact however small systems accounted for only 60% of the system capacity installed.
- It is assumed that each photovoltaic facility will generate exactly as much power in its twentieth year of operation as it did in its first year.
- According to the RWI calculations, facilities receive support for only 19 years after the year of their entry into operation, rather than the legally stipulated 20 years.

Although the correction of the last point leads to an increase in support costs, and we in addition consider indirect system costs of photovoltaic power, the bottom line is a subsidy volume of €61.8 billion, or 6% less than the €65.5 billion certified by the RWI authors. Quantitatively more significant are other additional aspects that do not enter into the RWI calculations, but which would, if taken into account, reduce the subsidy cost considerably:

- The additional provision of electricity from photovoltaics reduces the prices on the Energy Exchange due to the merit order effect (see Section 5.2.2) and savings are at least partially passed on to consumers.
- Many consumers, as system operators, receive benefits from the lifespan of photovoltaic facilities, which probably considerably exceed the EEG support period.
- Costs to be incurred in future are generally weighted less than current costs (discounting); this has not been done in the RWI calculations.

If these aspects are considered, the net present cost of the support calculated by the RWI authors would, given our assumptions (see next section) drop by an additional €16 billion. In all, the net present value would thus be 46 billion, or 30% less than the RWI value. In other words, the RWI calculations which yield a net current cost of the support of €65.5 billion are too high by 42%.[25]

What is still not taken into account quantitatively here is that as a result of the support of photovoltaics, an additional benefit is achieved through the reduction of negative external effects. If these avoided effects, which are however almost impossible to quantify, particularly for the next two decades, were taken into account, the actual net cost of the support of photovoltaics would be further reduced considerably.

Finally, the RWI calculations do not in any way consider future worldwide benefits due to considerable cost reductions of photovoltaic technology, which is only become possible as a result of the support of the last ten years (cf. Section 5.2.4).

The following table provides an overview of the effects of the individual corrections and expansions of the RWI calculations of the net current cost calculated by Frondel et al. (2010) of the support for photovoltaics paid for or committed to by the end of 2010:

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[25] A basic criticism of the RWI calculations is that there is great uncertainty regarding several factors which determine the result, such as the development of the electricity price and the degree and course over time of the merit order effect, and that no sensitivity calculations are carried out to reflect this fact.

	Adjustment	Support costs (in bn $€_{2007}$)	Change (considered individually, in bn $€_{2007}$)	Change (cumulative, in %) compared with original value
Original		65,5		
Corrections	Consideration of lower feed-in tariffs for large facilities	62.9	- 2.6	- 3.9 %
	Correction of electricity production for systems installed in 2007	60.1	- 2.9	- 8.3 %
	Consideration of the aging affects of photovoltaic modules	59.1	- 1.0	- 9.8 %
	21 year remuneration and consideration of indirect costs	61.8	+ 2.7	- 5.6 %
	Corrections, total	61.8	- 3.7	- 5.6 %
Additional incorporation of quantifiable aspects	Consideration of the merit-order effects (estimated)	58.4	- 3.4	- 10.8 %
	Consideration of electricity production after the end of the	54.7	- 3.7	- 16.5 %
	Discounting of future support costs to 2010 (discount rate: 3	46.0	- 8.7	- 29.8 %
	Additional aspects (incl. corrections)	46.0	- 19.5	- 29.8 %
Non-quantifiable aspects	Consideration of negative external effects	⇩	⇩	⇩
	Consideration of the achievement of cost reductions in technology	⇩	⇩	⇩

Table 1 Overview of the changes in the calculations in Frondel et al. (2010), which are described in detail in the following section. The point of departure is the net present cost of support paid for or committed to by the end of 2010 for all photovoltaic facilities installed between 2000 and 2010 as calculated by the RWI authors.

A balanced assessment of the support for photovoltaic facilities should juxtapose the total costs and the total benefits. Ignoring a major share of the benefits while at the same time exaggerating the costs by means of implausible assumptions is not a suitable basis for factual political and societal dialogue about the present photovoltaic support policy.

5.2 Detailed analysis of the RWI calculations of the costs of support for photovoltaics

5.2.1 Corrections of the RWI calculations

Correction of annual feed-in tariffs

From 2005 on, the RWI authors assume as the basis for the remuneration of each kWh of photovoltaic power produced the highest possible tariff, although this tariff applies only to small systems with a capacity of 30 kW_P or less; power from larger photovoltaic facilities is remunerated at lower tariffs. We too have no reliable statistics for the shares that various system sizes account for in the total of additional photovoltaic installations per year, but obviously, a non-negligible share of new facilities will be greater than 30 kW_P, and will thus receive a considerably lower tariff per kWh.

We have assumed by way of approximation that the shares of new facilities in the facility sizes distinguished under the EEG has remained constant during the years 2005 through 2010, and has corresponded to the shares published by the Federal Network Agency as of the end of 2008 for all existing photovoltaic facilities remunerated under the EEG (Bundesnetzagentur 2010). According to this data, only 62% of the total output of all systems is accounted for by small systems of up to 30 kW_P.[26] If more plausible numbers are used as the basis for this calculation, this would lead to a reduction of support costs of approximately €2.6 billion, to €62.9 billion. Compared with the €65.5 million calculated by the RWI, this amounts to a reduction of almost 4%.

Correction of the additional electricity of photovoltaic facilities installed in 2007

If the current numbers of the Federal Ministry for the Environment (BMU 2010d) are used as the basis for approximately deriving the power production of new facilities, the result for 2007 clearly deviates from the numbers given by the RWI authors. They assume an additional power production in 2007 of 1.28 billion kWh, while in fact additional power production was much lower – only 850 million kWh. In 2008 in contrast, the numbers used by the authors again correspond largely with the actual statistics presented by the BMU (additionally approximately 1.3 billion kWh).

In an earlier publication by the RWI authors from 2008, the same inflated figure is stated for 2007, citing as a source a publication of the Association of the German Solar Energy Industry BSW. However we were not unable to find this information in the BSW publication, nor could we derive that figure from the information provided there. In any case, this figure is evidently a forecast. In their later publications, the authors apparently failed to correct this forecast.

The correction of the additional power feed in from photovoltaic facilities in 2007 results in an additional reduction of support costs by just under €3 billion, to €60.1 billion. Together with the above stated correction, this represents a total reduction of 8% over the original value.

Correction considering the aging effect of photovoltaic modules

Over the course of its lifespan, the degree of effectiveness of a photovoltaic module diminishes. In the literature, this so-called degradation rate is reported as amounting to 0.2% to 1% per year for the crystalline silicon solar cells, which dominate today (Vázquez, Rey-Stolle 2008; Zweibel 2010). An annual degradation rate of around 0.5% would for instance mean that the electricity production of a photovoltaic system in the twentieth year of its operational life would be approximately 10% less than in its first year. This effect is not taken into account by the RWI authors. Instead, they assume that a photovoltaic facility will produce the same amount of power after 20 years of operation as it will during its first year.

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[26] An additional 17% is accounted for by systems of between 30 and 100 kW, and 8% by systems between 100 and 500 kW; the remaining 13% by systems greater than 500 kW.

If this assumption is corrected, and instead a linear degradation rate of 0.25%[27] is assumed, the volume of support would be reduced by an additional €1 billion, to €59.1 billion. Together with the two previous corrections, this amounts to a reduction of 10% over the original value.

Corrections, which increase the cost

In addition to the above described requirement for correction, there are effects that were not taken into account by the RWI, which - if included - would cause the net current cost of the support to *rise*.

First, the RWI authors assume in their calculations that new photovoltaic facilities are eligible for feed-in tariffs under the EEG in the year that they were installed and in the following 19 years. However the EEG guarantees feed-in tariffs for 20 years *in addition to* the year of installation.

Second, no costs are considered in these calculations, which occur indirectly as a result of the expansion of renewable energies, and ultimately have to be paid for by the consumer. These indirect costs include additional regulating and balance energy, and in addition costs for the expansion of the grid and also transaction costs i.e. administrative costs incurred by companies in the energy industry as a result of implementation of the EEG.

If the additional indirect costs are considered,[28] the net current cost of the support as calculated by the RWI would rise by approximately €2.7 billion. It would then, considering the previous corrections, amount to €61.8 billion, which is still almost 6% below the costs calculated by the RWI authors.

5.2.2 Considering additional aspects

Considering possible merit order effects on the price of electricity

Even though the RWI authors published their calculations under the chapter title “long-lasting consequences for electricity consumers”, they failed to consider one indirect effect of support for photovoltaics upon final consumer costs that has been much discussed in the scientific literature: Due to the fact that the electricity from renewable energies has a priority of purchase and covers a portion of the electricity demand, less power from conventional sources – i.e. from fossil fuel and nuclear power plants – has to be provided. That means that power plant operators in many situations do not need to use certain power plants, which are relatively expensive to operate. Since the electricity price on the Energy Exchange (EEX) is always oriented towards the most expensive power plant, so that that power plant can still be operated economically – this is called the merit order effect – the reduced use of expensive conventional power plants causes a drop in the average power price on the EEX.

If the low prices on the EEX are passed on to the consumer,[29] this merit order effect will cause consumers to have to pay less for a kWh of conventionally produced electricity as a result of the support for renewable energies, compared with a hypothetical situation in which such support did not exist. Any calculation of the cost of support for renewable energies to the consumer should therefore consider this indirect effect, which keeps the price of electricity down, and hence (partially) offsets the cost of supporting renewables. This is not done in the calculations undertaken by the RWI. Despite different views regarding the size of the merit order

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[27] Here, a value is used for the degradation rate, which is at the lower end of the range of figures found in the literature. This low value has been selected in order to carry out a conservative calculation of the requirement for correction of the RWI calculations. If however the degradation rate were for instance to be 0.75%, the net current costs calculated by the RWI would be reduced not by €1 billion, but rather by €3 billion.

[28] The indirect costs of photovoltaic facilities installed between 2000 and 2010 could only be estimated roughly on the basis of information in the literature (izes et al. 2010). Particularly because no more exact or verifiable data or estimates were available, it was necessary to go by the simplified assumption that one kWh of photovoltaic power would cause exactly the same indirect costs as one kWh from any other renewable energy source, and that the costs to be attributed to existing photovoltaic facilities for regulating and balance power would in future remain constant.

[29] For them to be fully passed on, it is especially necessary that the market for supplying the end consumers is competitive.

effect, it is in our view not plausible to assume – as the RWI authors implicitly do – that the merit order effect will not have *any* impact upon the electricity price paid by consumers.

Various studies in recent years have modelled the merit order effect caused by the support for renewable energies. To supplement the RWI calculations to take the merit order effect into account, we referred to three different publications – BMU 2007, Sensfuß et al. 2008 and izes et al. 2010 – which provide information for 2001 and for 2004 through 2008, for the merit order effects caused by all EEG supported renewable energies. For the other years, simplified assumptions have been made; in particular it has been assumed that the merit order effects would be reduced continually over the coming years, to zero by 2020.[30] Moreover, due to the lack of calculations on particular energy sources, it is assumed that the merit order effect is attributed proportionally to all types of renewable energies.

If, given these assumptions, support costs to the consumer are reduced by the merit order effect, the support costs calculated by the RWI would be reduced by an additional €3.4 billion over the course of the entire period under consideration.[31] Then, together with the corrections made in the previous section, these costs would be reduced to €58.4 billion, for an 11% reduction over the original value.

Considering longer lifespans for photovoltaic facilities

It is improbable that photovoltaic facilities will not be able to produce any electricity at all after their remuneration under the EEG expires, or that they will purposely be shut down. Experience with photovoltaic facilities set up during the 1980s, as well as laboratory experiments, indicate that the average lifespan of photovoltaic modules is at least 25 to 30 years (Dunlop & Halton 2005; Zweibel 2010). Due to the negligible maintenance costs of photovoltaic systems – a power inverter has to be replaced approximately every ten years – it can be assumed that despite their above-mentioned slight loss in degree of effectiveness, the systems can continue to operate for a certain amount of time after the expiration of their EEG support.

The extremely low electricity generation cost after write-off of the systems is in any case a macroeconomic advantage. It could be argued that at least part of this advantage represents an additional benefit to consumers, who are in many cases the same people who operate the facilities.

In order to consider these effects in the calculations, we will conservatively assume an average lifespan of 25 to 26 years for the system. This means that each system will continue to produce power for five years after expiration of its EEG support. If the benefit of this electricity is valued, as has been the case, according to the expected price on the Energy Exchange, an additional advantage of €3.7 billion will be accumulated, which can be subtracted from the support costs originally calculated.[32] That reduces the amount of the support to approximately €55 billion. Compared with the original value, and together with the previous corrections, that yields a reduction of 16%.

Considering possible time preferences by consumers

Basically, the addition of all the support costs to a single value – identified as “net current cost” by the authors – is easy to misunderstand. The total support costs do not after all hit the consumers all in the same year, nor are they distributed among the years 2000 through 2010; in fact, they are distributed across three decades. Much more relevant and of much greater importance to consumers are the annual differential cost and also the EEG apportionment (cf. Chapter 3).

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[30] Regarding the reasons why a reduction of the effect is to be expected in the medium term, see e.g. BMU 2007. The assumption made here that the effect would dissipate entirely by 2020 can be seen as an unlikely assumption, which is however being made for the sake of a conservative estimate of the merit order effect.

[31] If we do not assume that the reduction in the purchase price of electricity due to the merit order effect will be passed on in its entirety to consumers, this amount would be reduced accordingly.

[32] That assumes that the benefits from longer operating times can be fully assigned to the consumers. This “optimistic” assumption offsets the more conservative assumption of an average lifespan of 25 to 26 years.

If however the net current cost of the support is calculated, those costs, which are to be incurred in future are normally discounted, i.e. they are weighted less than the costs currently being incurred. In simple terms, that assumes that the cost burden in future will, due to expected greater prosperity (i.e. per capita GDP) be easier to handle than it is at present. Such discounting is not incorporated into the RWI calculations. The German Federal Environment Agency (UBA) recommends that for the period in question of approximately 20 years, a discount rate of 3% per year be applied (cf. UBA 2007). In that case, the capital value of the support costs would drop considerably, by another €8.7 billion, to €46 billion.[33] Together with the previous corrections, this represents a reduction over the original value of 30%.

Updating the information in Frondel et al. (2010) on additional electricity generation through photovoltaic facilities in 2009 and 2010

At the time of the calculations carried out by the RWI, there were as yet no data for 2009, nor were the estimates for the additional electricity generation from facilities built in 2010 available; both are now available. An update shows that the expansion of photovoltaics in 2009 was overestimated by the authors – or by their source – while they probably underestimated the expansion in 2010. In 2009, the authors assume an additional feed-in from photovoltaic systems of 3.1 billion kWh, while the actual value was 2.2 billion kWh (BMU 2010 D). In 2010, the authors likewise assumed 3.1 billion kWh of additional power from photovoltaic facilities, while the true number, according to current estimates (BMU 2010b; Energy Brainpool 2010) is probably 4- 5 billion kWh.[34]

If the RWI calculations by Frondel et al. (2010) are updated for 2009 and 2010,[35] and otherwise left unchanged, the net current cost calculated for the expense of the support rises from €65.5 to €69.6 billion. Applying the corrections discussed in Section 5.2.1 to this updated number, the value drops to €63.2 billion.[36] If this value, which in our view can be seen as the maximum current value of the support of photovoltaics, is stated in terms of today's euros, i.e. adjusting for inflation from 2007 through 2010, the result is a figure of €65.7 billion. This is almost €20 billion less than the €85 billion which are currently being reported in the media – such as in the *Frankfurter Rundschau* (2010) – with reference to the RWI.

If moreover the additional aspects discussed in this section are considered, the net current cost of the support is reduced to €47.5 billion (2007 value). On the other hand these costs must be juxtaposed to the various benefits of the expansion of photovoltaics (see the following two sections).

5.2.3 Failure to consider external effects (non-quantified)

One fundamental point of criticism of the results by the RWI authors is the fact that 1 kWh of electricity from a photovoltaic facility is regarded to have exactly the same value as 1 kWh of conventionally produced power. The numerous advantages of electricity production from photovoltaics or renewable energies in general compared with its production from fossil fuel and nuclear power plants is not considered, in some cases it is indeed denied (cf. Sections 4.1 and 4.4). These advantages include in particular:

- Reduction in CO_2 emissions compared with fossil fuel fired power plants
- Reduction in the emissions of other greenhouse gases and air pollutants, such as SO_2, NO_x, N_2O, etc.
- Reduction of import dependence

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[33] This reduction of the net current cost of the subsidy occurs because the reduced weighting of future costs more than compensates for the higher weighting of past costs – i.e. those incurred between 2000 and 2009.

[34] According to the RWI calculations, it is assumed that the additional electricity generation from photovoltaic facilities, in each case compared to the previous year, would correspond in any year to the typical electricity generation of the new facilities installed in that year. This assumption, while it leads to inexact results, particularly because not all new facilities are brought online at the beginning of the year, can, due to the lack of any more exact data, be seen as an approximation of electricity generation from new facilities.

[35] Using additional electricity feed-in of 4.5 billion kWh for 2010.

[36] As in the data in Frondel et al. (2010), these figures refer to 2007 value euros.

- Savings of finite energy sources, and hence a contribution to the reduction of the danger of geopolitical conflicts over scarce resources
- Generation of domestic value creation, and the creation of jobs
- Lack of risks due to major accidents, particularly with respect to nuclear power plants
- No risks from proliferation, or from the disposal of nuclear waste, again with respect to nuclear power plants.

These effects are “external effects”, i.e. effects which (at least partly) do not need to be considered by market actors, and hence are not reflected in market prices. Often, these effects can be expressed in monetary terms only with difficulty or not at all. However, that does not mean that these effects are unimportant or negligible. Society as a whole, and hence all consumers, profit from these advantages, in some cases in the short term, in others over the medium or long term. The expressed purpose of the EEG legislation is to pursue these goals, as is stated in the introductory section of the law (BMU 2008).

5.2.4 Failure to consider the positive effects of technological development (non-quantifiable)

A major goal of the current support for renewable energies, and specifically for photovoltaics, is to realize cost reductions (BMU 2008). In contrast to conventional power generation technologies, renewable energy technologies have been in operation on a large scale only for a few decades. Since these technologies are relatively new, and are moreover produced in relatively large batches, due to their largely decentralized, small-scale application, the specific costs, i.e. the costs for the facility of a certain size, can be continually reduced by increased production. The phenomenon of falling costs per unit as a result of increased production is known as the learning curve effect.

It is important to stress, that the reduction in costs in a new technology is not first and foremost dependent on the amount of time that has elapsed since its introduction, but rather on the produced quantities of the technology. This fact is supported by numerous empirical investigations. That means that as long as no investments are made in a technology, that technology will not become any cheaper. It is therefore not possible to simply wait with market introduction until the cost of technology for the use of renewable energies has dropped.

The experience of the last ten years with the support for renewable energies by means of the EEG has impressively demonstrated the connection between technology investment and falling costs. This is particularly true of photovoltaics. Due to the major expansion of production as a result of EEG support based demand, the production cost of a photovoltaic system has dropped considerably. Figure 5 shows how this drop between 2006 and 2010 has affected prices. Analogously, the feed-in tariffs for electricity from new photovoltaic facilities dropped as well: compared with the original remuneration stipulated in 2000, the feed-in tariffs, adjusted for inflation, of large facilities have dropped by more than 50%.

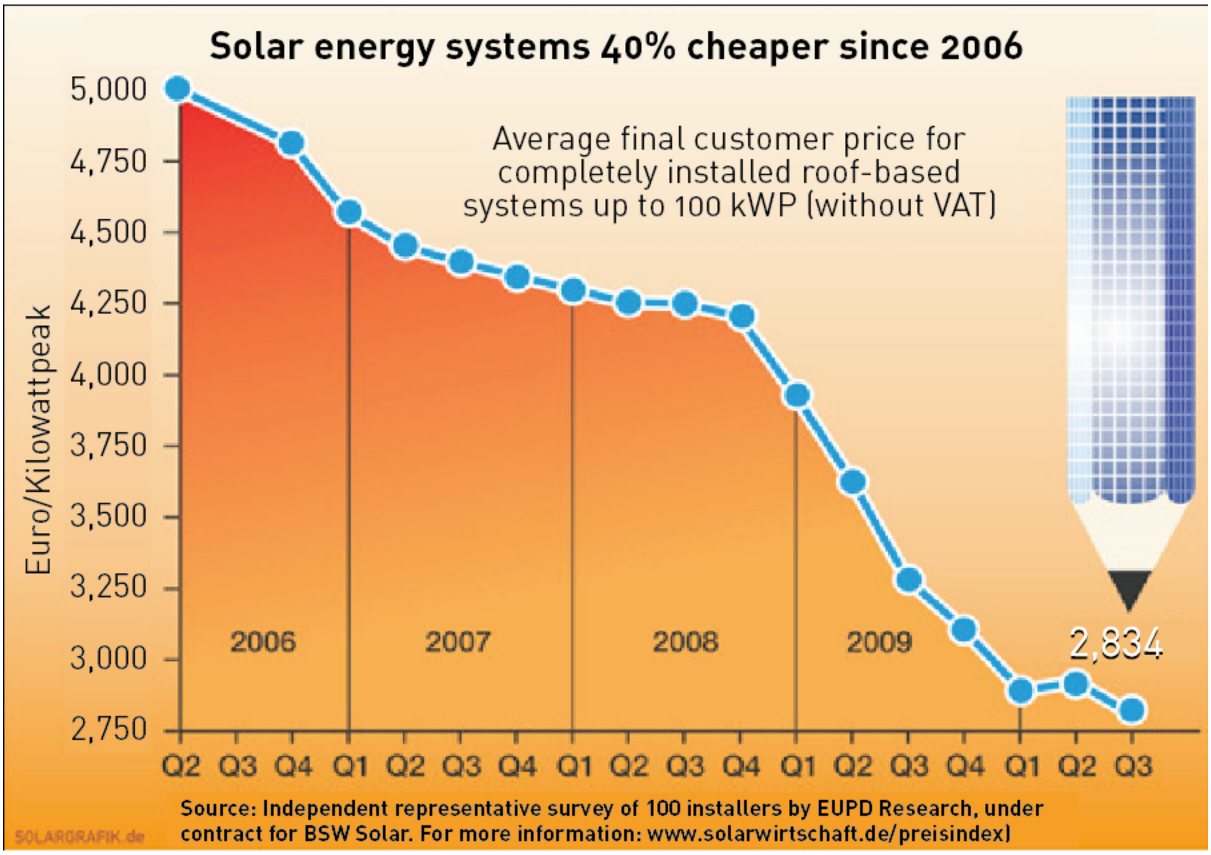

Figure 5 Price development for completely installed roof-based photovoltaic systems up to 100 kW_P, from 2006 to 2010 (Source: www.solarwirtschaft.de/preisindex).

If the climate protection goals in Germany and worldwide are to be met through 2050, the current view is that photovoltaics will have to play an important part in the future electricity system. Current climate protection scenarios for Germany assume a rise in the photovoltaic share of electricity production from approximately 1% in 2009 to between 5 and 15% in 2050 (WWF 2009; BMU 2009; SRU 2010; BMWi 2010). Globally, the share of photovoltaics in total electricity production will increase much more, from the 0.02% in 2007 (IEA 2010a) to 6% to 16% by mid-century (IEA 2010b; EREC, Greenpeace 2010). Thus, photovoltaics, due to the extremely high potential of solar energy, is a key technology for combating global warming in future, both in Germany and globally.

By investing in this technology today, it is possible to reduce the cost of future expansion, which particularly in terms of climate protection, will presumably be indispensable. A considerable share of the benefit from the support of photovoltaics in the past ten years will therefore only be realized via future investments – in the form of considerably reduced investment costs. This is an essential reason why the expansion of photovoltaics is systematically assessed overly negatively by the RWI authors, because they fail to consider the fact that photovoltaics is an important technology for the future. As a result, they simply ignore a key benefit achieved by the support for photovoltaics over the past ten years (i.e. considerable cost reductions).

In this context it should be considered that not only Germany will in the future profit from lower investment costs for photovoltaics, but other countries will as well. In the past ten years, Germany was far and away the leading country in terms of added photovoltaics capacity. Other countries also profit from the cost reductions sparked by these investments, since they can now invest to a greater degree in photovoltaics as a result of the cheaper technology costs. Thus, this support for photovoltaics can also be seen as a German contribution to protecting the global climate. The increased demand for photovoltaic facilities abroad also additionally benefits German photovoltaic manufacturers and their suppliers, including the semiconductor, glass and machine tool industries, which profit from a growing export market.

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