Renewable energy deployment – do the benefits outweigh the costs?

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1 INTRODUCTION

The increasing use of energy from renewable sources (RE) for the generation of heat and electricity in Germany has also led to an increasingly intensive debate on its advantages and disadvantages. Especially, effects on companies, households as well as overall economic effects are discussed in the scientific community and in the media. Criticism has recently been fuelled by the substantial increase in the EEG surcharge and indications of possible further drastic increases in the years to come.

In contrast, any benefits associated with the expansion of energy from renewable sources have tended to take a back seat. Beneficial effects often are harder to quantify. Benefits comprise indirect effects or effects which lie far in the future. Scientific studies also frequently focus on single aspects, which cannot be aggregated easily, because they occur in different sectors and comprise technology system-wide effects, distributional effects or overall macro-economic effects. Thus, the diversity of the effects and their many dimensions have resulted in the lack of a comprehensive, scientifically based overall picture of the effects that an analysis on costs and benefits can provide. Therefore, the Federal Ministry of the Environment, Nature Conservation and Nuclear Safety has commissioned a study on an overarching approach that helps to answer the following questions:

- How can effects from the increase in renewable energy be defined more clearly and separated from other energy policy related effects (e.g. which part of the extension of the grid truly is caused by the increase of renewables?)?
- How can effects be added and balanced?
- Which methodological approach is suitable to evaluate these effects?
- Which (support) mechanisms facilitate the RE increase?
- What is a suitable time/ spatial system border?

The analysis has been ongoing since 2009. Its purpose has been twofold: Firstly, starting from a set of definitions which map all effects methods have been developed to actually measure and quantify the effects. Secondly, a monitoring system has been established and the data set is annually updated.

After a brief sketch of the definitions and the methods applied, this contribution will present estimates from the monitoring process. It closes with suggestions on possibilities how to add and balance the effects.

2 MEASURING THE COSTS AND BENEFITS OF RENEWABLE ENERGY DEPLOYMENT – DEFINITIONS AND METHODS

To establish a framework for the measurement of costs and benefit of renewable energy (RE) deployment, we agree upon the limits of this framework first. We have to define, which effect is in and which effect is outside of our scope of analysis.

Thus, we ask questions of scale and of system boundaries. In the spatial dimension, the analysis can cover regions, the nation or also international partners. German RE policy can have effects on each of these levels. In our analysis we have focused on effects at the national level in most cases. The analysis of employment effects, however, also covers exports, which are can be considered a consequence of support from German energy policy as will be shown below.

The temporal dimension sets the time period for which the effects will be calculated. In our analysis we have established a monitoring of past effects. Until now, it covers the years 2008-2012.

The third dimension adds a further category concerning the focus of the analysis. Are we interested in the effects of certain policy measures – for instance the Renewable Energy Sources Act (EEG – Erneuerbare Energien Gesetz) – or in the effects of RE deployment, regardless of the support mechanism?

Renewable energy is supported in Germany by a variety of measures. The most prominent is the above mentioned EEG which has been "exported" to more than 20 countries in Europe and worldwide. The significant elements of the EEG are the priority access of electricity generated from renewable sources to the grid and the technology specific feed-in tariff, which allows for a diverse mix of sources and technologies. It also is designed as to spur innovation because it has built-in degression mechanisms with decreasing tariffs over the different generations of electricity generating technologies. The heat sector applications are supported by the market incentive program (MIP) and by regulation for the building sector which sets certain quota for the use of RE in heat generation (space and water heating, as well as cooling) respectively alternative measures to cover primary energy consumption. On top of these mechanisms, KfW gives soft loans at below market rates. This contribution focuses on regulatory mechanisms.

Globally as well as locally RE investment moves significant amounts of money. Global investment has been in the realm of $250 in the last three years, RE investment in Germany exceeded or came close to 20 bn. Euro in the last four years.

With increasing funds allocated towards the modernization of the energy system the distribution of the impacts of RE deployment becomes more interesting. Who is paying for additional costs from RE electricity generation? Does the EEG surcharge discriminate against low-income households? How can benefits be attributed to investors, especially in the housing market?

On the more aggregate level, macroeconomic effects come into play. Will RE deployment lead to additional employment and, therefore, growth? Is the decrease in fossil fuel imports wise in the face of an already very unbalanced trade balance? How about energy security?

Thus, from an economic point of view, we ask:

- How efficient are the resources allocated?
- Which distributional effects are triggered by the measures?
- What are the effects on growth and stability?

From these central questions we have derived a scheme for our analysis. In the following we will be looking separately at macroeconomic effects, distributional effects and system-related (or system-analytic) effects.

Macroeconomic effects

Macro effects comprise all macro indicators such as investment, imports, employment, GDP and exports. To analyze macroeconomic effects such as impacts on GDP or employment, we apply a macroeconometric model (PANTA RHEI), because thus the interdependence of the economy can be modeled and simulated. Some effects are additionally derived from official statistics and industry surveys. To derive results for the GDP impacts of RE increases, we compare two simulation runs: one serves as a reference and consists of a world without any RE expansion and a second simulation, or scenario, includes the respective RE increase. The simulations lead to different development paths for the economic indicators and the difference show the macroeconomic costs and benefits of an RE increase scenario compared to the reference case.

Distribution effects and price effects

Distributional effects are not coming with resource consumption in an economic sense. They are a mere reallocation for instance of funds, often as a consequence of political measures. The feed-in tariff redistribution mechanism, for example, has all customers bear the costs of RE via a surcharge on their electricity bill. The surcharge is the reallocation of the additional costs of the RE technologies. Other examples include the eco-tax, increasing rents after thermal insulation etc. Distribution effects add up to zero, thus they should not be partially included in the calculation of net benefits or net costs.

System -related costs and benefits

System-related or -analytic costs and benefits comprise all direct or indirect costs of the RE increase, which are connected with a direct or indirect use of resources. Direct costs include the costs of installation and operation and maintenance of a RE technology, while indirect costs are induced by RE deployment, e.g. transactions costs or costs of grid operation. System analytic costs do not take distributional effects into account. Thus, they can be aggregated and compared to system analytic benefits. System analytic benefits originate in the protection of resources by the use of RE. A typical benefit is the mitigation of climate change effects.

Which effects can be added?

As pointed out, distributional effects do not belong in a net costs or net benefit calculation. Further, an important condition for comparing and adding effects is that they are all measured in the same unit. Before any balance can be approached, all costs and benefits have to be assessed in monetary terms. Moreover, it is important to check, whether and to what extent external effects have been at least partially taken into account (internalized) within the economic system by other environmental or energy policy instruments. Both steps in the analysis are very demanding from a methodological point of view. Generally speaking, effects from the same category and the same unit of measurement or reference may be added.

Overview of costs and benefit in 2012

The following table provides an overall picture of the most important cost and benefit factors of renewable energy expansion that have so far been quantified. The table shows results for 2011 (in current prices).

Table 1: The results at a glance: Effects in Germany 2012 (preliminary data)

Category	Topic	Electricity	Heat	Total
			in billion Euro	
System-related effects	Direct additional costs	10.3	1.7	12.0
	Balancing costs	0.18		0.2
	Grid costs	0.46		0.5
	Additional costs, total	***10.9***	***1.7***	***12.6***
	Avoided environmental costs	**8.0**	**2.1**	**10.1**
Distribution effects	EEG-surcharge	16.9	1.5	18.4
	Special equalization scheme (EEG)	2.5		2.5
	Merit-Order-Effect*	4.6		4.6
	Public budget			0.6
	Deployment			0.3
	R&D			0.3
	Taxation of RE Electricity**	1.6		1.6
Macroeconomic effects	Import reduction	3.9	4.9	10.0
	Investment	16.5	3.0	19.5
	Turnover			22.0
	Employment (jobs)			377,800

* Estimate from previous years: 2010

** Mean

price base 2011 except avoided damages (price base 2010)

MIP: Market incentive program

*** net of biomass imports

In the following, methods and results for each of these categories will be explained in more detail. For a deeper dive into the methods applied, the reader is referred to ISI et al. (2010a) and the literature therein.

3 SYSTEM ANALYTIC COSTS AND BENEFITS

This approach is aimed at the costs and benefits that occur within system boundaries – ignoring costs accruing from a particular instrument. Additional costs, for instance, are measured comparing two electricity generating systems with different generation technologies independent of political redistribution instrument.

This section gives a brief overview of methods and results to quantify system-related costs and benefits of the RE increase. The analysis is an ex-post evaluation. The database for RE deployment relies on the annually published data on renewable energy in Germany (BMU 2013).

3.1 ADDITIONAL COSTS - ELECTRICITY AND HEAT GENERATION

3.1.1 ADDITIONAL COSTS OF ELECTRICITY GENERATION

The system-oriented analysis of additional costs of electricity generation from renewable energy (Nitsch et al. 2010) compares levelized costs of electricity (LCOE) for different energy sources. For all fuels, LCOE include the annuity on investment, operation and maintenance costs and fuel costs. Wind, water, solar and geothermal energy, obviously, has zero fuel costs. However, though the necessary statistical data for this comparison exist on the renewable energy side of the equation, they are not available for fossil fuel based generation. Therefore, an alternative calculation scheme has been developed, which defines the additional costs as follows

Additional costs = (levelized costs (RE) – "applicable price") * RE electricity amount

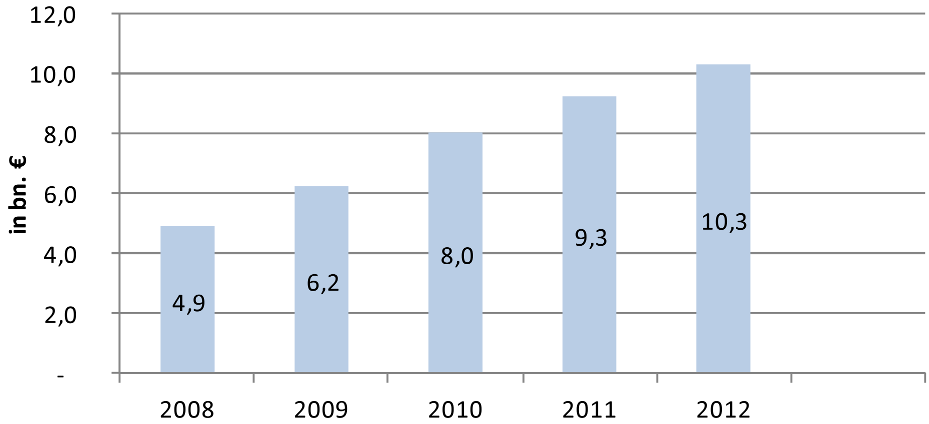
The applicable prices are defined technology specific and basically reflect the market price of electricity at different voltage levels and from different fossil fuels. Intermittent renewable energy plants thus are compared with the prices for electricity from gas fired plants.

The largest advantage of this calculation scheme is that it is capable of capturing also "negative additional costs". Electricity from hydropower, e.g., already is less costly than fossil fuel based electricity generation. Therefore, hydropower decreases the overall economic costs of electricity generation. All other RE based technologies are thus far more expensive than fossil fuel generation, though the priority of access and the large amount of PV and wind energy on quite a few days during the year decrease the electricity prices at the spot market.

However, the thus determined additional costs will always be smaller than the additional burden that can be observed on the monthly electricity bill. Firstly, the feed-in-tariffs sometimes exceed the levelized costs to a slight extend. Secondly, the burden sharing process is biased towards households, because large consumers are exempt. Decreasing the denominator in a division always increases the result. Thirdly, and most important, the surcharge is determined against the power spot price whenever RE-electricity is fed into the grid. Since high amounts of RE-electricity decrease the power spot price (cf. the section on Merit-Order-Effects), electricity from renewables artificially gets more expensive the more it is produced.

The above described calculation scheme abstracts from these effects. Thus the additional costs increase over time, driven only by increasing capacities installed and by the technology mix. The strong increase of PV in recent years of more than 7GW on average is more and more counterbalanced by the price drop of this technology. PV prices fell by more than 40% in 2012 and 2011 and 20% in 2010. Wind energy as the more mature technology does not exhibit as steep a learning curve. However, wind energy is facing overcapacity in production and might be heading for some significant price drops (O'Sullivan et al. 2013).

Figure 1: Additional costs of RE electricity generation, in billion Euro



Source: GWS, own calculation; current prices

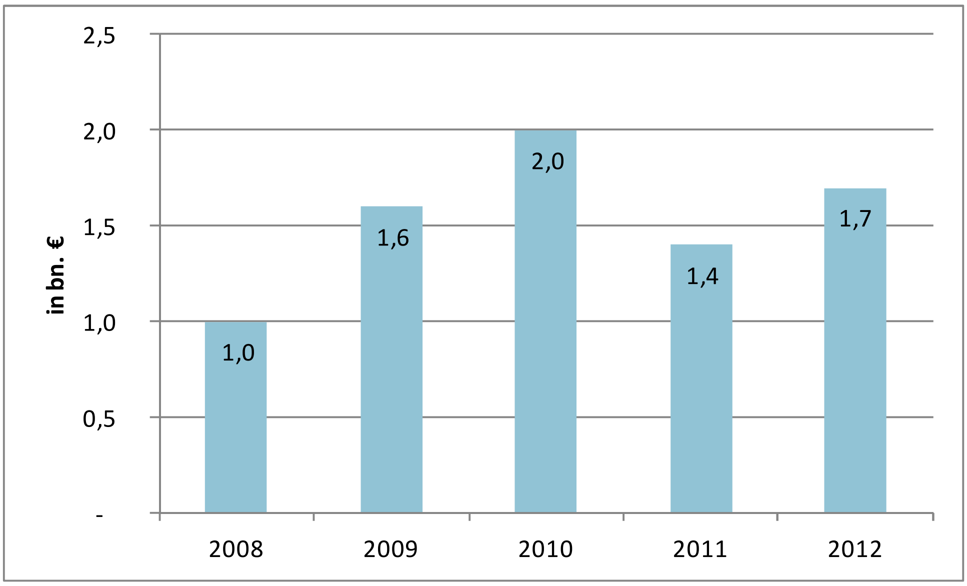
Figure 1 shows the development of the additional costs from RE electricity generation. Projections in the literature foresee a peak in 2020 and declining costs thereafter.

3.1.2 Additional costs of heat generation

The system-oriented analysis of additional costs of heat generation from renewable energy sources (RES-H) compares generation costs of RES-H with fossil fuel based heat generation. The generation costs include the annuity on investment, operation and maintenance costs and fuel costs. The calculation is based on different RES-H reference technologies (wood pellet boilers, wood log boilers, heat pumps air/water, heat pumps brine/waster, solar thermal collectors) as well as fossil fuel based reference technologies (gas boilers, heating oil boilers). Since the level of generation cost is decisively determined by the thermal energy demand of the individual building, technologies are combined with reference buildings representing the German building stock.

The additional costs of RES deployment for heating are reflected by the difference between the generation costs of RES-H technologies and the substituted fossil fuel based energy systems. In 2011 they are estimated to range around 1.4 billion Euro (current prices). However, it should be noted that higher needs for thermal heat due to cold winter as for example in the previous year influence the additional costs considerably (figure 2).

Figure 2: **Additional generation costs of RES-H, in billion Euro (current prices)**



Source: Fh- ISI, own calculation; current prices

3.2 Balancing intermittent generation – the costs of forecast errors

The integration of RES generation causes additional costs mainly for balancing forecast errors of wind and PV generators. The methodology to integrate RES electricity into the German electricity market has been improved since 2007. Until 2010 the RES generation was physically sold by the TSOs to all utilities that provide electricity to end customers. This was done via a constant profile that had to be provided by the TSOs. As real RES generation deviates substantially from a constant profile additional or missing energy had to be bought or sold by the TSOs on the electricity market. Any integration costs were compensated via the grid tariffs. Since 2010 all RES generation has to be sold at the spot market by the TSOs and the physical distribution is not in place any more.

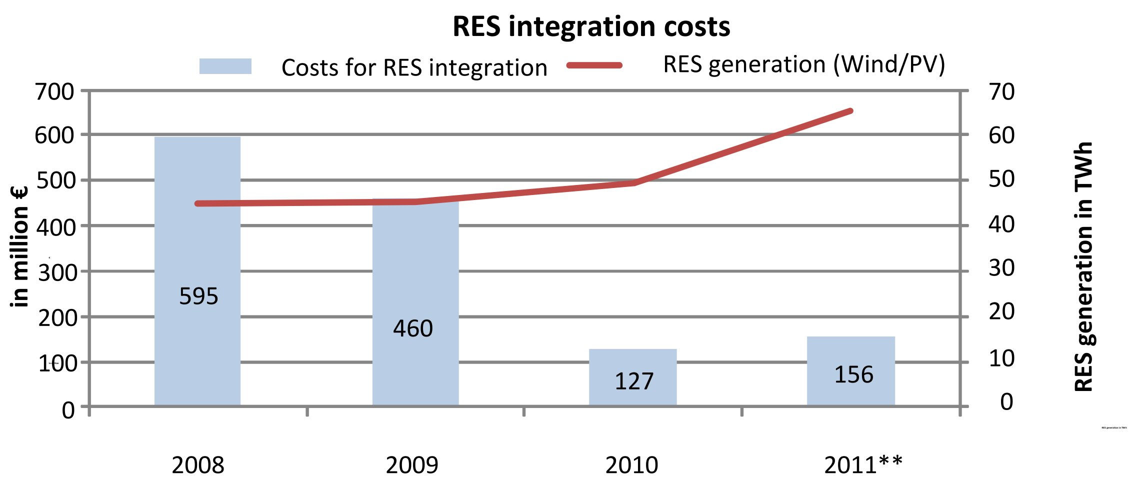
The main cost factors relevant for RES integration are therefore:

- Costs related to intra-day‘s trading by the TSOs to adapt to forecast errors of RES generation
- Costs for balancing energy to compensate forecast errors that could not be compensated in intra-day markets
- Costs for the preparation of wind and PV power forecast on a day-ahead in intraday time scale
- Costs related to the participation at the spot market and costs related to the trading infrastructure

The costs for RES integration in Germany are estimated to amount to about 156 million Euro in 2011 (see Figure 3). They decreased especially in 2010 from 460 million Euro to

127 million Euro due the above mentioned new approach that was implemented in 2010. Because the amount of RES generation from wind and PV generators increased, the specific costs have dropped to less than 3 Euro/MWh integration costs for each MWh of wind or PV generation.

Figure 3: Development of RES integration costs from 2008 until 2012



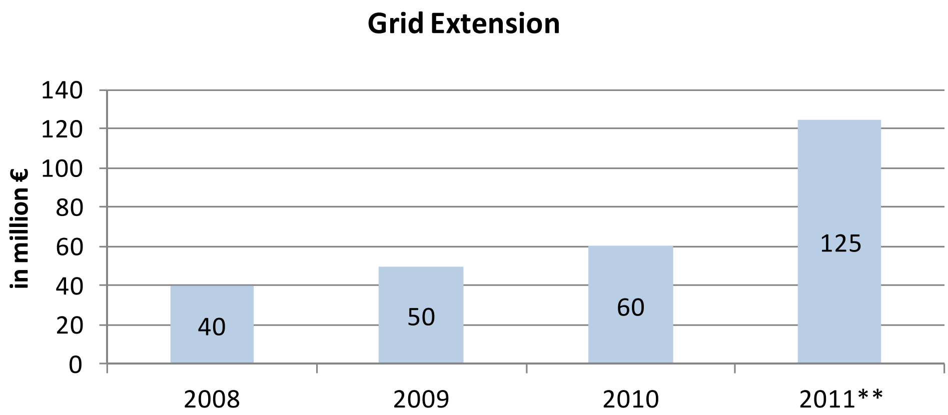
*Source: BNetzA 2012; current prices ** preliminary figures.*

3.3 THE FUTURE BOTTLENECK – COSTS OF GRID EXPANSION

RES deployment has a major impact on the necessary grid infrastructure because the distance between the location of generation and demand increases. In the case of offshore wind generators, also the costs for grid connection are relevant. Therefore the analysis of grid costs comprises the costs related to the transmission grid extensions and to offshore wind grid connections. So far, the costs related to distribution grids are not considered in the given figures. For the future development additional costs in the distribution grid are expected to be of the same relevance as for the transmission grid and should be considered as well. Main sources for the assessment of grid costs are studies (DENA I 2005, DENA II 2010) provided by a consortium led by the German Energy Agency (DENA) in cooperation with the 4 German transmission system operators.

The extension of the transmission grid is in many cases beneficial to all grid users, namely for electricity suppliers with RE and fossil sources. Therefore it is difficult to identify which costs are related to the extension of renewable generators and how these additional costs should be allocated to the various users in the grid. Therefore the given figures are only partly related to the extension of renewable generators. The first DENA study identified the need for additional grid capacity of 850 km of new lines. The investment needs for the new capacity was estimated to 1.1 billion Euro until 2015 without costs for offshore grid connections. However, until the end of 2011 little more than 210 km have been built. The overall investment is estimated to be around 400 million Euro for the onshore grid extensions until 2011. Furthermore the first offshore grid connections have been implemented, e.g. Alpha Ventus in the North Sea and Baltic 1 in the Baltic Sea. The construction of several offshore grid connections has started in 2011 as for Baltic 2, BorWin 2 or Riffgat. A total of 2 billion Euro is estimated for investments in offshore grid connections until the end of 2011. The annuity of these investments is calculated with an interest rate of 6.5 % and a lifetime of 40 years. The annuity indicates annual costs for grid extensions over the lifetime. They are estimated to range around 125 million Euro in 2011 (see Figure 4), while for 2008 the annual costs were estimated to be 40 million Euro only. For 2012 the same calculation yields 460 million Euro.

Figure 4: Development of grid extension costs from 2008 until 2011



*Source: calculations of Fh-ISI, ** preliminary figures; current prices*

3.4 Avoided damages from negative external effects

Avoided environmental costs, also often called avoided social costs, are so far the only quantified significant benefits of the RE deployment. They comprise avoided costs of damages from green house gas emissions (GHG) as well as from other airborne pollutants (AP) like SO_2, particular matter (PM), NO_x, etc.. The largest negative impact is caused by climate change (loss of land and resources, health impacts, etc.) due to GHG emissions but damages from other AP, such as health effects, material damages, losses of biodiversity and yields are included. The calculation of the avoided environmental costs relies on four main inputs:

- final energy consumption from RE
- emission factors for each GHG and AP in g per kWh based on life cycle emissions
- substitution factors (in %) that indicate to what extent each RE source replaces fossil energy sources
- damage costs of emissions, per t emitted GHG or AP (in Euro/t)

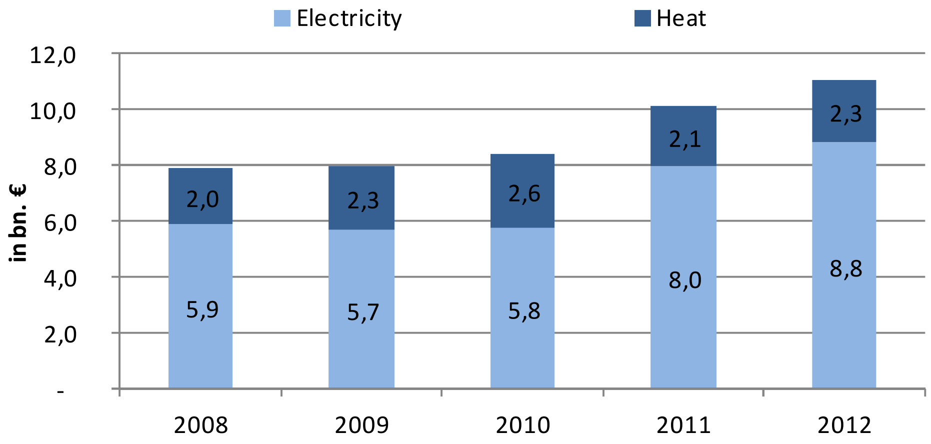
Much work has been done on each of these inputs but still there prevails uncertainty about their final impact or size. For example the emission factors represent average values that are based on a currently applied mix of generation technologies, which, however, changes over time. The substitution factors refer to a counterfactual scenario – a hypothetical situation, namely a hypothetical power generation without RE policy or deployment. However, the wide range of feasible damage cost assessments of GHG and AP exerts the largest impact on avoided environmental costs and rises uncertainty about the actual value of avoided environmental costs.

For GHG, the damage costs are assessed by means of integrated assessment models that are based on several assumptions e.g. on emissions scenarios, environmental effects, technology costs etc. and integrate the complete causal chain of the climate change (man-made emissions, changes in climate, effects on the environment and society). Next to the different causal relations the monetary quantification of future effects in combination with their probability of occurrence is difficult. Therefore, as a result, the applied assessment models based on differing assumptions e.g. for CO_2 emissions, come up with a rather broad range of damage costs (alone the FUND model gives a range between 20 and 410 Euro/t (see UBA 2012 and NEEDS 2009)). In this paper, the damage costs for 2011 rely on results of a methodological analysis published by the German Federal Environment Agency (UBA 2012), that is 80 Euro / t CO_2 while for the previous years a damage cost of 70 Euro/t CO_2 according to Krewitt et al. (2006) and adapted according to NEEDS (2009) has been applied.

For AP, the damage cost assessments of the EU project NEEDS (2009) adapted to prices in 2010 have been applied.

The calculations (Figure 5) show that due to the RE deployment about 8.1 billion Euro avoided environmental costs accrue in 2011. Further, when taking into account the partial internalization of external effects through the CO_2 certificate prices (in the framework of the ETS) the avoided costs range around 9 billion Euro. However, due to the large bandwidth of damage costs assessed with different models, the depicted avoided environmental costs in Figure 5 should be considered as a feasible value within a given damage range.

Figure 5: Avoided environmental costs due to RE deployment, in billion Euro



Source: calculations of Fh-ISI; price basis 2010

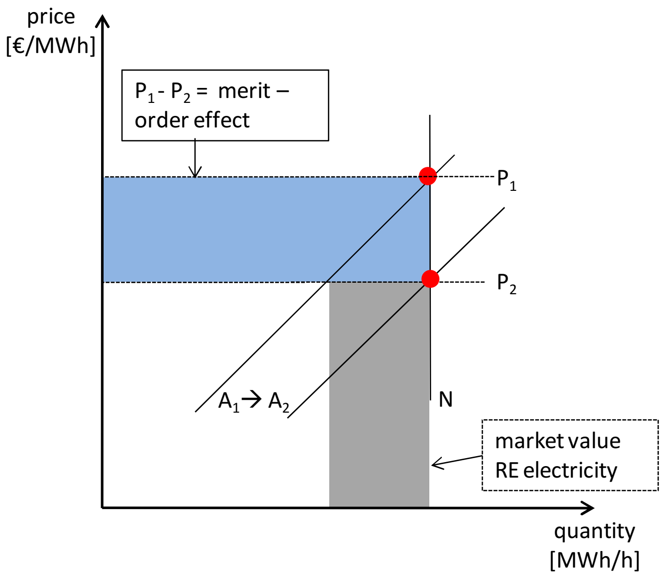
4 DISTRIBUTIONAL EFFECTS AND PRICE EFFECTS

4.1 MERIT-ORDER-EFFECT – SPOT MARKET PRICES GO DOWN

The development of renewable electricity generation in Germany has been characterized by considerable growth rates throughout the past 15 years. This development is mainly driven by a guaranteed feed-in-tariff which has been in place since 1991. The additional costs for the feed-in-tariff have to be paid by the consumers via the EEG surcharge described in the next section.

However, the electricity generated by renewable energy sources also has an impact on the market prices itself and hence influences the market value. A stylized overview of the discussed effects of renewable electricity generation for a single hour is given in Figure 6. The additional electricity generated by renewable energy sources shifts the electricity supply curve (A1) to the right (A2). Thereby it is assumed that the electricity demand (N) is inelastic in the short-term perspective of a day-ahead market. The supply curve represents the merit-order-curve. It is a step function of single plant units in the real world. It is simplified as a linear supply-curve in the figure below. As long as this supply curve has a positive slope the shift to the right leads to lower prices (from P1 to P2) in the power market. As this effect shifts market prices along the German merit-order of power plants this effect is called merit-order-effect.

Figure 6: The merit-order effect of renewable energy generation



Source: Fh-ISI

Since electricity demand and renewable electricity generation vary on an hourly basis, an estimation of the actual value of the merit-order effect is far more complex than the estimation of the market value. Therefore the analysis is carried out using the PowerACE Cluster System which is able to simulate hourly spot market prices. A detailed description of the PowerACE model can be found in (Sensfuß 2007, Genoese et al. 2007).

The model provides a detailed representation of the German electricity sector. The model simulates reserve markets and the spot market. The spot market prices are calculated on hourly level for an entire year. Based on a price prognosis power plants and pump storage plants place their bids on the reserve markets and the spot market. For the given simulation the bid price for power plants is based on variable cost and start up cost. Demand and renewable load place inelastic bids on the market. Thereby it is assumed that the entire electricity demand is traded at the simulated spot market while in the real world situation only a share of it is traded at the spot market and an important amount of electricity is traded in bilateral contracts which are likely to be less volatile than the spot market. Further, the simulated spot market prices are based on fundamental data and are therefore less volatile than real world market prices

In a first scenario a time series of hourly prices for the target year is calculated where all data, such as prices and renewable generation, is taken from the historic data for the given year. In a second step the same procedure is applied to a simulation without renewable electricity production called counterfactual scenario). Since the development of large hydro plants has not yet been affected by the renewable support scheme, electricity production of large hydro plants is taken into account in both simulation settings. The total volume of the merit-order effect is calculated by taking the difference of the electricity prices between the two scenarios multiplied by the demand for electricity (on hourly basis) and adding up the products over the corresponding year. The calculation is depicted in the following equation.

$$v = \sum_{h=1}^{h=8760} (x_h - p_h) \cdot d_h$$

Legend:

Variables			Unit	Indices
d	=	Total electricity demand	[MWh]	h = Hour
p	=	Price including renewable generation	[Euro/MWh]	
x	=	Price excluding renewable generation	[Euro/MWh]	
v	=	Total volume of the merit-order effect	[Euro]	

The results for the years between 2007and 2011 are presented in Table 2. The results indicate a considerable reduction of the market price by about 5.27 Euro/MWh in the year 2010. In total the volume of the merit-order effect reaches about 2.8 billion Euro in 2010. 2011 showed a massive increase to 4.6 billion Euro.

Table 2: Merit-order effect and reduction of spot market price (Phelix Day Base)

	merit-order effect	reduction of phelix day base	add. power generation due to EEG
	billion €	€/MWh	TWh
2007	3.71	8.82	62.5
2008	3.58	5.83	69.3
2009	3.1	6.09	76.1
2010	2.8	5.27	83.5
2011	4.6	9.92	91.2

Source: Fh-ISI, own calculation

4.2 The EEG surcharge – redistributing additional costs

The German Renewable Energy Sources Act – EEG (2012) defines the tariffs at which RE electricity generation is sold to grid operators. Grid operators have to sell the electricity on the markets and pay the tariffs for electricity fed into the grid. The surcharge is defined as the total amount of money paid to RE system owners for RE electricity minus the revenue from sales at the electricity market. The system provides allowances for large consumers (industries) to maintain their international competitiveness.

Expected additional costs have to be published by grid operators 3 months ahead of the start of the year and the final calculation for the past year is then published during the second half of the consecutive year. The balance sheet is published at the beginning of the new year, but during the course of the year, multiple correction, transactions from earlier years and other balances are added.

Table 3: EEG surcharge in billion Euro

Euro	EEG-surcharge
2008	4.7
2009	5.3
2010	9.4
2011	13.5**
2012	16.9**

*Source: GWS; **preliminary estimation*

4.3 Burden of the surcharge by household type

Households have spent 2,6% of their household income in electricity on average. But this average analysis can be misleading if it comes to the burden which is placed on different household types regarding size and household income. Distributional effects are most vital when it comes to public acceptance of energy and climate policy. When people feel they have to reconsider their budget allocation and they have no means to influence the additional burden, they reject the policy. In the case of electricity consumption, this concerns the possibilities to buy new energy efficient equipment. If a new refrigerator is too costly for a household, or, in the case of retired people, they feel that investments into long lasting appliances are not paying back within their expected lifespan, the burden of additional electricity costs is unavoidable. Additional expenditure for electricity for an upper expected path of the EEG surcharge showed regressive effects in a simulation experiment. The additional expenditure lay between 28 and 51 Euro per annum and household (for more cf. Lehr and Drosdowski 2013).

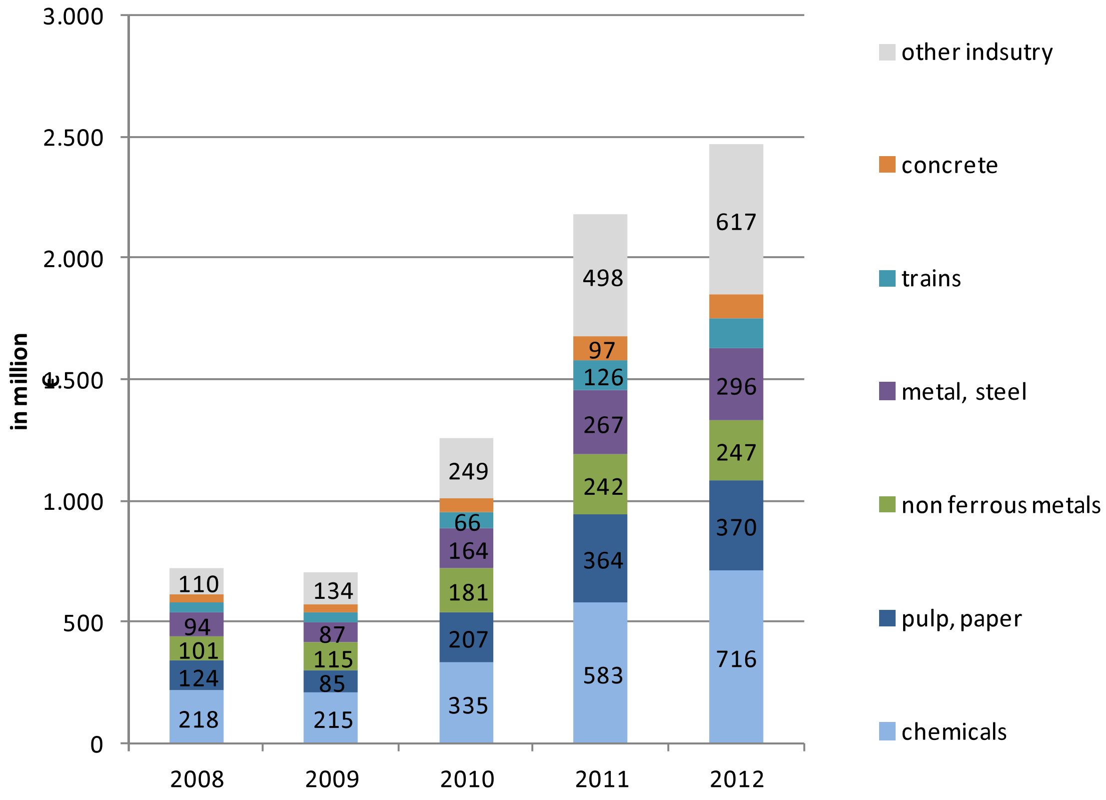
4.4 Energy intensive industry - Special equalization schemes

The special equalization scheme is designed not to put the international or intermodal competitiveness of electricity-intensive manufacturing enterprises with high electricity consumption or rail operators at risk. Therefore, 2011 the EEG surcharge was limited for some 600 of consumers to 0.05 cent/kWh or 0.4 cent/kWh. For all other consumers, the surcharge has been 3.53 cent/kWh in 2011. The identification of potentially risked enterprises is mainly based on electricity consumption per year and ratio of the electricity cost at gross value. Furthermore the use of an energy-management-system for consumers with more than ten GWh per year is a pre-condition.

The additional cost between the limited and full EEG surcharge has to be reallocated to all other not-privileged end-consumers such as all other manufacturing industries, commerce, trade and services as well as private and public consumers. With increasing difference between the fixed limited and the full EEG-surcharge as well as the extension of privileged electricity consumption within the amendments to the act, the burden of these reallocated costs is also increasing. The burden is shifted only within the both groups - privileged and non-privileged consumers. In total, the policy costs are unchanged.

Based on the TSO published data (approved by an auditor) the privileged companies saved around Euro 1,200 million Euro in 2010. Based on the predictions of the transmission system operators a reallocation of more than 2,200 million Euro is to expect in 2011 and around 2,500 million Euro for 2012. All calculations are based on the assumption that – from the economic point of view – the difference between the limited average EEG surcharge and an EEG surcharge, that would be exist without the special equalization scheme, describes the real costs of the special equalization scheme.

Figure 7: **Savings for privileged industries and rail operators through the special equalization scheme for electricity-intensive manufacturing enterprises with high electricity consumption or rail operators, in million Euro**



Source: IZES, own calculation, 2008 to 2010 based on the results of a financial audit of the EG-surcharge, 2011/2012 based of an estimation of TSO; current prices

4.5 Taxation of electricity from renewable energy

The ecological tax reform in 1999 introduced an electricity tax with a standard rate of 2.05 ct/kWh since 2003. Hence, electricity from renewable energy sources is essentially taxed as electricity from fossil and nuclear energy. In return, the Market Incentive Program, promoting renewable energy sources in the heat sector, is partly financed from electricity tax revenues.

In 2012 the electricity tax revenue amounted to 7.247 billion Euro. Exempts especially for the manufacturing industry caused deficiency in tax receipts of 3.535 billion Euro per year, which cannot clearly be assigned to the energy sources used. Using two different approaches, the amount of the current electricity tax which can be assigned to renewable energy is estimated to 1.452 billion Euro and 1.68 billion Euro respectively.

As part of balancing the costs and benefits of renewable energy it should be noted that the electricity tax does not contribute to a differentiated internalization of external effects of electricity generation. An exemption for renewable energy from the electricity tax would in principle be justified on terms of energy and environmental policy and, above all, should be examined carefully when discussing future development of renewable energy support policy.

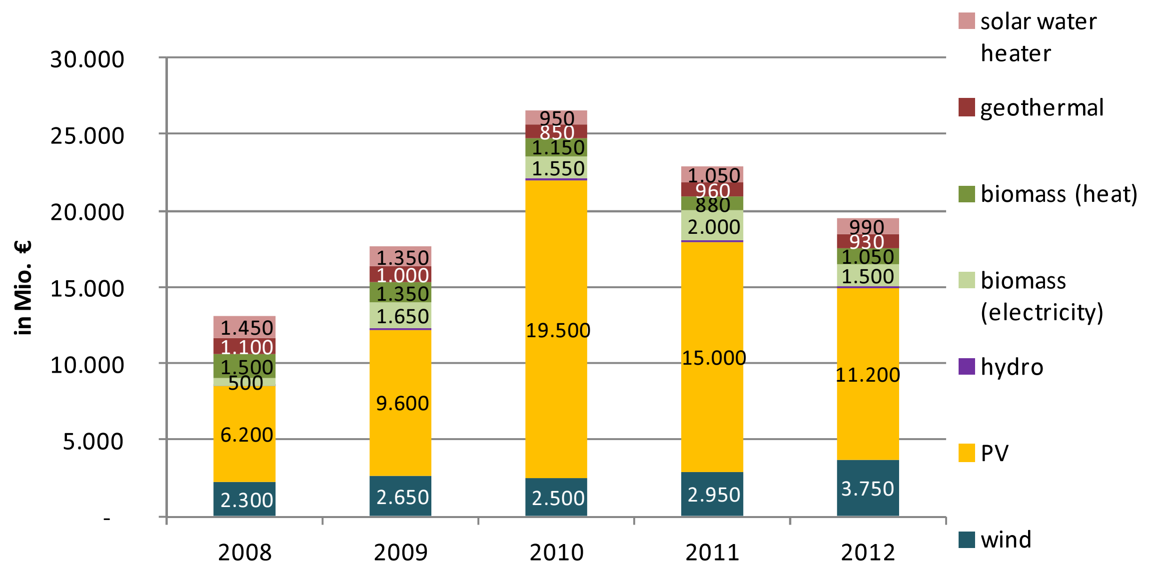
5 Macroeconomic effects

The category of macroeconomic effects also comprises effects, which cannot be easily added or included in the „net“ balancing sheet of a cost-benefit analysis. Partly, these effects are included in other categories e.g. the system analytic approach, but still are of interest also as a single category. Partly, they are not easily added because of different units of measurement; the best example is employment. In this section we report the finding for investment in renewable energy, turnover of the German industry and employment in the production of systems and components (manufacturing), the operation and maintenance and in fuel production. Further, we conclude this section with an estimate for import reduction, an issue related to energy security. Germany is poor in own resources and most fossil fuels are imported.

5.1 Investment in renewable energy in 2012

Investment in renewable energy in Germany leads to the capacities installed and is directly related to the respective contribution possibilities of renewables to the energy mix. While investment has been rising steadily over the last 5 years, 2011 showed a turning point: For the first time, investment fell, from 26.6 billion Euro in 2010 to 22.9 billion Euro 2011. Capacity installed, however, again was higher than the year before. The main driver behind this development is the tremendous price decrease in the photovoltaic industry. While in 2010 investment needed for the installation of 7.4 GW exceeded 19 billion Euro, total installation of 7.5 GW in 2011 only cost 15 billion Euro. Investment in all other technologies rose. Especially the wind industry has seen remarkable increases in investment.

Figure 8: **Investment in renewable energy – electricity and heat production (in million Euro)**

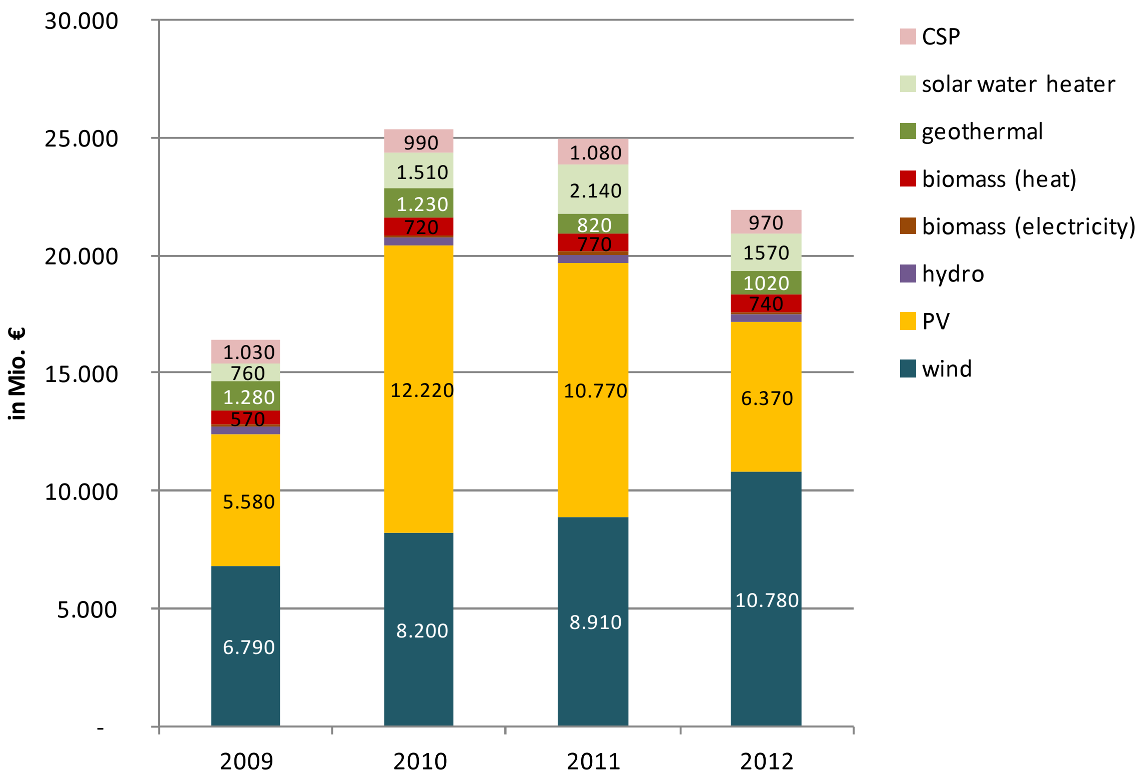


Source: O'Sullivan et al. 2010, 2011, 2012, 2013

5.2 INDUSTRIAL TURNOVER

To determine employment from renewable energy increases – one of the major co-benefits of renewable energy policies – turnover of German companies is the starting point. It can be deduced from investment knowing imports and exports. In 2011, turnover from systems and components of companies producing in Germany held the level of 2010. The largest increase exhibits the biogas sector. This reflects the changes in the German regulation and anticipation thereof among investors. Further positive development can be observed in the wind industry, for solar water heaters and for heat pumps. Each of the latter industries showed increasing turnover after two years of decrease. The drivers of this development are quite different: while the wind industry benefited from increasing exports, the residential heat applications seem to have recovered on the domestic market. Turnover in the photovoltaic industry fell, again, mostly driven by the massive price decreases on international market.

Figure 9: **Turnover of German RE- industry (in million Euro)**



Source: O'Sullivan et al. 2010, 2011, 2012, 2013

5.3 EMPLOYMENT – RENEWABLES AS A JOB MOTOR?

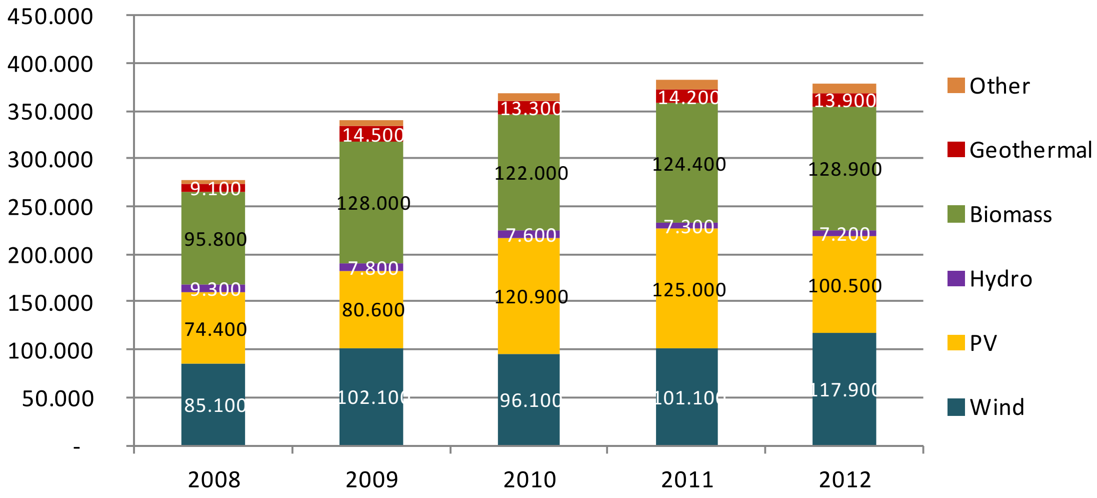
As has been stated above, employment is the largest co-benefit of renewable energy policies. A study commissioned by the German Environmental Ministry analyses the employment effects from renewable energy (Lehr et al. 2011, 2012) comprehensively. Part of this analysis is an annual report on gross employment from new capacities, operation and maintenance and the provision of biofuels. Gross employment comprises direct effects in the respective RE industries and service sectors as well as indirect effects from multiple rounds of intermediary inputs from all economic sectors.

Since the start of the above mentioned analysis (2004) a methodological framework has been established and improved. Annual data are published since 2006. Employment has increased since 2004 by almost 178%. In 2012, employment in production, operation and maintenance, fuel provision and research and administration with public funds has reached 377,600 jobs. Past analysis has shown that these jobs often require higher skills than the industrial average.

For the first time in 2011, this analysis has been complemented by a regional analysis on the level of the German Bundesländer. Results can be found at Ulrich et al. (2012). An updated version shows that the basic structure has been maintained, but the PV crisis has hit states severely when they had a focus on PV industries. However, the distribution of intermediary production makes the distribution of gains and losses more homogenous. It shows that East German production is still receiving a large amount of input from West

German producers. Installation of PV modules further smoothes gains and losses, because installation is highly work intensive and has gained speed in several East German states.

Figure 10: Employment from renewable energy in Germany



Source: O'Sullivan et al. 2010, 2011, 2012

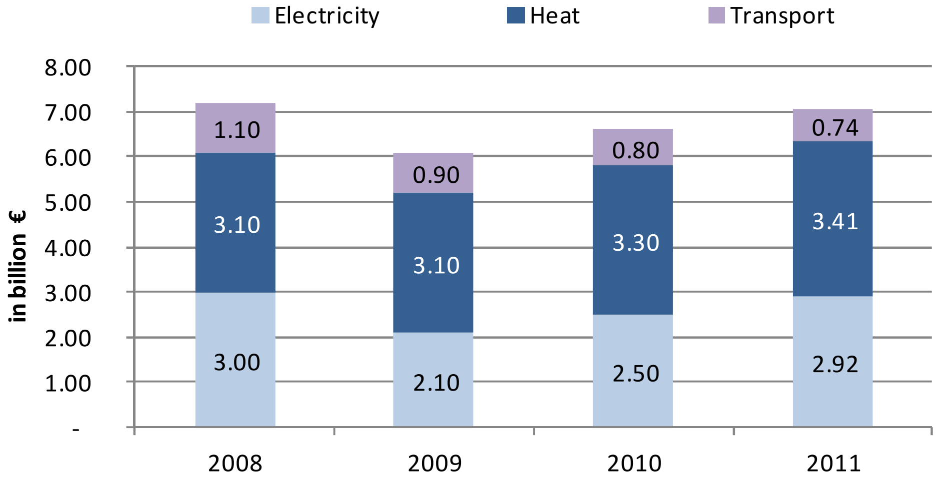
Thus we can see besides the relative high relevance of wind energy use for the regional labor market in those countries which are conventionally associated with the wind industry (Bremen, Lower Saxony, Schleswig-Holstein, Saxony-Anhalt, Mecklenburg-Western Pomerania) that in the states with strong economies - North Rhine-Westphalia, Baden-Württemberg and Bavaria – the relative importance of onshore wind power tends to be low. Nevertheless, these three states account for over a third of direct and indirect employment.

5.4 IMPORT REDUCTION – ONE STEP TOWARDS INCREASING ENERGY SECURITY

Energy security also is an often mentioned co-benefit of renewable energy policies, especially for countries with few domestic fossil fuel energy resources such as Germany. Import dependence of fossil fuels in Germany is high and leaves the country vulnerable to the risks of sudden price changes or supply shortages worldwide. The switch to domestic sources increases energy security.

To find a measure for the seemingly obvious facts, however, has proven difficult. Diversity measures help to show, that a more diverse portfolio serves as risk mitigation (Lehr 2009). A more simple approach, which is reported below, is to look at the reduction of fossil fuel imports in monetary terms. The approach is the following: Reductions in primary energy as given by the renewable energy statistics are multiplied with import shares and given a monetary value multiplying them with the respective import prices. The results are given in figure 11. Though more and more primary energy is substituted by renewable energy, the monetary value of the import reduction reflects international fossil fuel prices. The 2009 values show the rather low oil price compared to 2008. 2011 values already reflect the changes on the gas market from unconventional gas.

Figure 11: Development of import reduction, in billion Euro



Source: GWS, own calculation.

6 Conclusions and Outlook

Comprehensive cost benefit analysis of the transition to an energy mix with large shares of renewable energy is a challenge. This contribution summarizes the findings of a large study for Germany which created a systematic approach and attempted to give estimates – at least for the most important fields. It has been shown benefits more or less outweighed the costs, for the observed time span (2008 – 2012). This holds true for those categories, where the system boundaries coincide, the same units of measurement, time frame and region apply so that the results can actually be added.

Other categories exceed the boundaries but still point to a beneficial development: additional employment has been created and in total the sector leads to employment of 377,800 people. Renewable energy lowers the power price during the middle of the day on a sunny day by significant amounts – but increases the households' electricity bills by the EEG-surcharge. Since both are distributional effects – and all non-privileged electricity customers pay for the additional cost - a simple cost-benefit analysis is not applicable. Looking at the public debate, however, the distributional effects are the most heatedly debated.

There are certain significant benefits of renewable energy expansion that cannot be recorded in the above category, or only to a limited extent. This applies particularly to the contribution of renewables to energy supply security and the associated issue of strategic security policy aspects. Another important aspect when assessing supports for renewable energy is their long-term dynamic impact on innovation. One task for the years ahead is to undertake a more detailed scientific analysis and, if possible, a quantification of these and other barely analyzed effects. At the same time, the analysis of known effects also needs to be refined. In future, an overall view of the effects outlined will provide a sound basis for economic statements about the arguments for renewable energy. In view of the unresolved questions indicated, however, there is no sign yet of a final unequivocal judgment about the overall economic costs and benefits of renewable energy expansion.

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