The German Energy Transition – *Status Quo* and Perspectives[1]

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Abstract

In September 2010, the German government enacted an Energy Concept as a long-term strategy setting out ambitious targets for German energy policy until the mid of the century. After the reactor disaster in Fukushima, Japan, in June 2011 the phase-out of nuclear power was enshrined in law in an all-party consensus, rendering this system of targets yet more ambitious. The Energiewende, the transformation of Germany's energy system, is a major challenge for a leading industrial country. It entails a fundamental restructuring of the German energy system.

The present paper describes the indicator system to monitor the energy transformation and the hierarchy of targets. The developments in greenhouse gas emissions, renewable energy, energy security and energy efficiency are described. One of the major problematic areas emerging from the stock taking is the resulting costs of the support scheme for renewable energy. Given these developments, a special emphasis is placed on the implications of the energy transition on affordability, economic costs and competitiveness. The basic problems of the current renewable support scheme are analysed and a policy proposal is presented.

Keywords: German Energy Transition, monitoring, renewable support scheme, economic costs

THE GERMAN ENERGY CONCEPT

In September 2010, the German government published an Energy Concept as a long-term strategy setting out ambitious targets for German energy policy until the mid of the century. After the reactor disaster in Fukushima, Japan, in

1 The first part of this article is based on the Statements of the Expert commission on the "Energy of the future" monitoring process on the monitoring reports by the German government. I thank my colleagues from the energy expert commission, Georg Erdmann, Frithjof Staiß, and Hans-Joachim Ziesing, for the fruitful discussions during the last years. Of course I take full responsibility for all opinions expressed in this article. The sketch of a new market design is based on the discussion papers: Löschel *et al.,* 2013a, 2013b and 2013c.

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June 2011 the phase-out of nuclear power was enshrined in law in an all-party consensus, rendering this system of targets yet more ambitious. The Energiewende, the transformation of Germany's energy system, is a major challenge for a leading industrial country. It entails a fundamental restructuring of the German energy system.

The primary targets of the Energiewende are clear: greenhouse gas emissions should be lowered by 40% compared with 1990 levels by 2020 and by 80 to 95% by 2050; the use of nuclear power should be fully phased-out by 2022. The enablers of decarbonisation are an expansion of renewable energy sources together with a reduction in energy consumption through greater energy efficiency. The share of renewables in electricity production is to be increased to 35% in 2020 and primary energy consumption to be reduced by 20% compared with 2008 levels. In the long-run until 2050, the goal is to reduce primary energy consumption by 50%. Renewables will then account for 60% of gross final energy consumption and 80% of gross electricity consumption. The German government has implemented a series of more than 200 individual measures to achieve these ambitious targets. All these measures in the restructuring of the energy supply have to be assessed under the energy policy triangle of security of supply, affordability and environmental soundness.

To this end, the German government established a monitoring process to assess the progress in the energy transformation in attaining the targets and to take stock of the implementation of measures. Besides the yearly monitoring reports, every three years a forward-looking progress report is published and new measures are proposed. The monitoring reports are built on a wide range of relevant indicators. An independent energy expert commission supports the monitoring process scientifically. Every year, it publishes an independent opinion on the monitoring reports by the German government. These statements aim to examine and assess the German government's monitoring reports from a scientific perspective. The monitoring process is an important element in transforming Germany's energy system and provides the basis for an assessment of the status quo and prospects of the Energiewende.

The present paper draws heavily on the statements of the energy expert commission. It describes first the indicator system to monitor the energy transformation and the hierarchy of targets. Then the developments in greenhouse gas emissions, renewable energy, energy security and energy efficiency so far are described. One of the major problematic areas emerging from the stock taking is the resulting costs of the support scheme for renewable energy. The surcharge under the Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz- EEG) to be paid by the end users of electricity rose to well over 6 ct/kWh with a total support volume of more than 20 bn Euro anually. Given these developments, a special emphasis is placed on the implications of the energy transition on affordability, economic costs and competitiveness. Then the basic problems of the current renewable support scheme are analysed and a policy proposal is presented. Finally, conclusions and an outlook are provided.

TARGETS OF THE ENERGY TRANSITION

The first monitoring reports of the energy transition developed a framework for this new task, identified suitable indicators and stated the necessary data on which to base this. In the "Energy of the future" monitoring process, a complex package of political aims and objectives has to be mapped and evaluated with the help of indicators. This type of framework improves continuity, planning certainty and the comparability of the monitoring process over the course of time. The Energy Concept and the subsequent decisions taken by the German government provide an extensive list of targets to transform Germany's energy system. Given the large number of targets – many of them conflicting targets – in the Energiewende, it seems unavoidable that some targets are missed and priorities must be set. Initially, all targets were treated as equally important by the government. Meanwhile, the government has followed a proposal of the energy expert commission that the Energiewende is defined by two superordinate targets: lowering greenhouse gas emissions by at least 80% by 2050 and phasing out the use of nuclear power by the end of 2022. These superordinate targets are reached via two main pillars: renewable energy and energy efficiency. Various sectoral sub-targets should give a coherent picture of the transformation pathway. However, sub-targets and political measures to implement the targets should in turn be adjustable flexibly. If the achievement of a sub-target proves to be economically unviable, socially not acceptable or environmentally not sensible, substitutes have to be explored

– always bearing in mind that this must not compromise the attainment of the superordinate targets.

Whilst the German government uses only indicators which are linked to a quantitative target in the Energy Concept as lead indicators, a broader approach which also takes into account the non-quantitative aims of security of supply, economic viability and environmental soundness – beyond greenhouse gas emissions – of the energy supply as well as the acceptance and societal impact of the Energiewende seems to be appropriate. This is of course much more difficult, especially when it comes to the affordability and competitiveness implications of the energy transition – some new indicators are introduced later. The system of indicators guides the course of action to be taken. Crucial lead indicators might encompass indicators for the subordinate targets greenhouse gas emissions and the phase-out of nuclear power, energy supply (share of renewables in gross final energy consumption, final energy consumption), security of supply (System Average Interruption Duration Index (SAIDI) for electricity, the power balance), economic viability (national energy accounts and energy per unit costs, innovation), social impacts (energy poverty and acceptance). Some of these indicators are well established, other are new and to be developed in forthcoming years.

GHG EMISSION REDUCTION

It is crucial for achieving GHG emission reduction targets to create incentives through the appropriate framework conditions to improve energy efficiency and to gear the structure of electricity generation more towards renewables and other low emission energy sources. Here it is also important to take into account that irrespective of the restructuring of electricity generation required any way, there is also the zero-emissions electricity which will be lost with the shutdown of the nuclear power plants and which will have to be replaced. The largest individual contributions to greenhouse gas emissions reduction are from efficiency improvements or lowering the energy requirement for heat as well as the expansion of renewable electricity generation.

As Germany's overall objective – besides the phase-out of nuclear power by the end of 2022 – is the attainment of the GHG targets, the EU Emissions Trading

System (EU ETS) takes a centre stage in the Energy Transformation. But the EU ETS is in deep trouble. A heavy over-supply of emission rights to companies across Europe, resulting from the economic crises, the massive inflow of international credits and the interaction of the ETS with renewable energy promotion (like the German Renewables Energy Act – EEG) and energy efficiency policies, led to sharp decreases in certificate prices. Low CO_2 prices in the EU ETS, which covers in Germany about half of CO_2 emissions, have substantial implications for the energy transition in Germany: Even if its structure still fulfils the objective – the capping of European-wide CO_2 emissions to the level prescribed by policy – it provides very weak incentives for regulated companies in Germany to make investments in low-carbon technologies. This becomes apparent, *e.g.*, in the KfW/ZEW CO_2 Barometer, which has been surveying all German companies covered by the EU ETS since 2009. While most of the surveyed German companies have made investments or changes in the production process that have led to a reduction of their CO_2 emissions, these measures were actually aimed at reducing energy and resource costs and tapping into general efficiency potentials. Only 9% of the companies had the explicit aim of reducing CO_2 emissions. Given the current situation this number is not likely to increase in the medium future.

But there is more to it: While electricity generation from wind and solar increased substantially, hard coal and lignite did not diminish accordingly. Even more pronounced than the reduction in nuclear power was the decline in electricity generation from gas-fired plants. Indeed, while coal plants are still profitable, gas-fired power plants are unprofitable in Germany. This situation is induced by the poor electricity demand, relatively low coal prices, and the continuing replacement of profitable peak load during mid-days by renewables. The costs of carbon permits are way too low to discourage carbon-intensive coal-fired power generation in favour of less carbon-intensive gas-fired generation. As a consequence, energy-related CO_2 –emission increased in Germany in the last years.

There is a significant risk of the central aim of the energy concept, to cut greenhouse gas emissions by 40% by 2020 against 1990 levels, not being met. The 2020 GHG emission target can only be attained if GHG emissions are cut by approx. 28 million tonnes of CO_2 equivalent on average each year up to 2020 (a total of 170 million tonnes). This equates to a drop by over 3% as an annual average for 2013 to 2020. If these figures are compared with the longer-term changes in the years from 2000 to 2014, in which the temperature-adjusted greenhouse gas emissions dropped by scarcely more than 9 million tonnes of CO_2 equivalent on average each year, it can be seen that the rate of emission reduction must be at least tripled in the few years until 2020. The Federal Government has adopted different measures in the last two years in order to reach the target. These measures particularly include the 2020 Climate Action Programme, the National Action Plan on Energy Efficiency and the initiative to decommission older lignite-fired power plants. But policies in emissions trading sectors in Germany run the risk of being ineffective – leading to no additional emission reductions in Europe. The German government could also possibly buy up emissions rights itself and then put them on hold to reach its domestic reduction targets. Another option is to actively promote efforts to lower emissions in the sectors outside of the emissions trading system, which are largely subject to national provisions. This in particular concerns the area of buildings with its continued high potential for greater efficiency. However, necessary political majorities for potentially effective instruments like tax breaks to improve the energy performance of buildings couldn't be secured by the government. In addition, measures in the building and transport sectors might turn out to be more costly than expected. Again, European approaches seem to be more appropriate. It is clear that a strong EU ETS is important to back the energy transition in Germany. However, at this stage, the re-establishment of the EU ETS as the cornerstone of EU climate policy is more than doubtful for the years to come.

STATUS QUO **2014**[3]

In 2014[3], the development of the target indicators varies widely. In some cases, Germany is already on line to achieve the target *(e.g.* renewables-based electricity generation); in others, it is well off the pace *(e.g.* greenhouse gas emissions and efficiency in transport). There are more or less pronounced risks to target attainment in the case of certain indicators which in turn provides comprehensive

3 See for this *status quo* evaluation Löschel *et al.*, 2015.

needs for action. GHG emissions were 4.3% lower in 2014 than in 2013, but only 1.7% lower if temperature is taken into account. In 2015, emissions increased again. The last years did not see a return to the desired reduction pathway in temperature-adjusted greenhouse gas emissions, quite the contrary. It stills seems very likely that the additional policy activities will not suffice for the attainment of the target, especially as the world market prices for energy make it more difficult to reduce emissions in the electricity sector, heating and transport.

Germany is doing much better in reaching the renewable energy targets as set out in the Federal Government's Energy Concept. The attainment of the 35% minimum target by 2020 for the proportion of electricity consumption covered by electricity generated from renewable energy seems likely. It may even be the case that there is significant over-achievement of the target. This is welcome as it contributes towards the overriding climate change mitigation goal and offers potential to offset other more difficult renewable goals. In 2015, a 30% share has been attained. This development has been stipulated by the Renewable Energy Sources Act (EEG). The renewed revision in 2014 defines deployment corridors for specific forms of renewable energy and thus specifies the politically desired quantitative expansion, whilst the overall target is still expressed in terms of relative variables. A 40-45% of gross electricity generation is to be attained by 2025. Future developments obviously depend heavily on the future systemic change in the Renewable Energy Sources Act. The continued increase in costs of the financial support scheme underscores the need for a reform of the EEG which will be discussed later.

Germany has to meet a national contribution to gross final energy consumption of 18% by renewable energy in 2020. In the National Renewable Energy Action Plan pursuant to Directive 2009/28/EC, which launched the implementation of the directive in Germany, the Federal Government assumes that it is even possible to attain a 19.6% share by 2020. At present, however, renewable energy only accounts for 13.5% of gross final energy consumption according to the Federal Government's Monitoring Report; in 2013, the figure was 13.2%. The proportion of renewable energy outside the electricity sector Federal Government seems to stagnate.

The Federal Government aims to boost final energy productivity in Germany by 2.1% a year, starting from 2008. However, there was an average annual increase of only 1.8% during the 1990-2014 period. In fact, the rate (temperature-adjusted) was only 1.2% from the base year of 2008 until 2014. So Germany has remained consistently below the target curve over the last six years. If the 2020 target is to be attained, final energy productivity will have to increase by approx. 3% each year from 2015 on. Primary energy consumption is to be reduced by 20% by 2020 compared to 2008 levels. Over the last six years, from 2008 to 2014, it dropped by 6.5% after adjustment for temperature; if the target is to be attained, this rate must be more than doubled during the remaining six years up to 2020. This necessitates considerable additional effort, especially as the target curve was clearly missed over the last four years. The situation for gross electricity consumption situation is clearly different. The target is a 10% reduction between 2008 and 2020. In the 2008-2014 period, the fall was 4.6%, or already almost half of the target. The main factors here were increased efficiency in the use of electricity and the economic situation in the industrial sector, particularly in electricity-intensive sectors. However, it is also the case that 2015 is recording a slight rise in electricity consumption, so it is not sure that the declining trend will continue. The instruments intended to cut electricity consumption under the National Action Plan on Energy Efficiency play a special role in this respect. Because the instruments of the National Action Plan on Energy Efficiency are still at the testing or planning stage, or just starting to be implemented, results-oriented ex-post monitoring of the Plan is not possible at present.

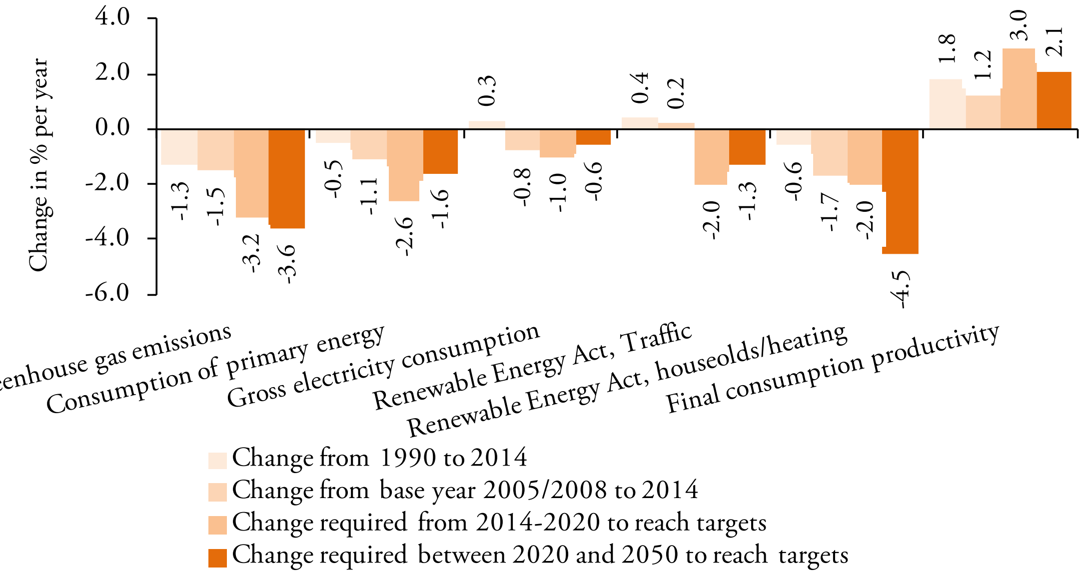
The increase in final energy consumption in transport in 2014 marks a further setback in terms of the Energy Concept target. This development is due both to passenger and to freight transport on the roads. Both sectors registered an increase in the overall distance travelled to the highest ever figures in German history, and this was not offset by progress on efficiency. Here, a crucial role is played by rebound effects between improved vehicle efficiency and distance travelled, as well as between vehicle efficiency and vehicle weight and distance travelled. For the transport sector, the situation in terms of the attainment of the target of cutting consumption by 10% between 2005 and 2020 is particularly problematic. If this target is to be attained, energy consumption needs to be cut by 2% each year from the 2014 level - but in the years between 2005 and 2014, there was on average a slight rise of 0.2%.

In the energy transition renewable energy replaces conventional sources. This development must not endanger the security of the energy supply which can be described aptly along the value chain from primary energy, conversion, transport and distribution to the final consumer. The remaining reliably available capacity as a result of the power balance can be used to measure the long-term security of electricity supply. Even if there are still some analytical unclarities and practical problems in these calculations, there is currently no general capacity shortage recognizable in Germany. However, electricity supply has also shifted on the regional level. Conventional as well as renewable electricity is to a larger extent generated in the north of Germany. With the planned shutdown of the remaining nuclear power plants south of the River Main the risk of a local capacity shortage arises and regional imbalances between generation and consumption are appearing. The foreseeable supply shortages in southern Germany are exacerbated by the backlogs in the expansion of the transmission systems. Looking at the original 24 grid expansion projects cited in the Power Grid Expansion Act (Energieleitungsausbaugesetz – EnLAG) of 2009 it becomes clear that the grid expansion is lagging behind the needs of the energy transition. At the end of 2014, only 367 km had been finished, more than 100 km less than forecast in 2013, and more than 450 km less than originally planned. Although annual investment by the transmission system operators has tripled since 2011, at the present pace of expansion many of projects are unlikely to be completed before the end of the decade, not to mention the planned direct-current transmission lines between northern and southern Germany, which are facing substantial political opposition. As a result, the transmission grid operators are increasingly forced to resort to redispatch interventions.

Exhibit 1 provides a brief summary of the development so far and of the changes in selected variables required if the targets are to be attained. This shows that, with certain exceptions in renewable energy, electricity consumption and final energy consumption for space heating, there are more or less sizable deviations between the emissions and efficiency target paths and the changes achieved so far. This mainly refers to the greenhouse gas emissions, power grid expansion, primary

Exhibit 1

Past changes and changes needed to meet selected targets up to 2020/2050



Source: Löschel *et al.* (2015).

energy consumption, final energy productivity and final energy consumption in the transport sector.

AFFORDABILITY OF THE ENERGY TRANSITION

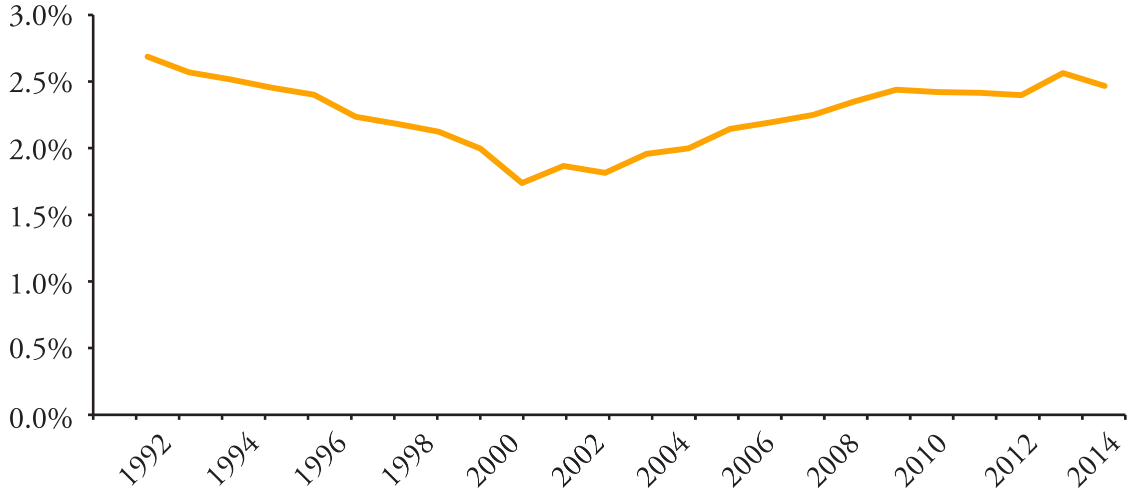
The costs of the Energy Transformation have been heavily discussed in the last years especially with ever-increasing expenses for the support of renewable. However, the costs of the Energy Transformation are difficult to assess. It requires the comparison of the *status quo* with contra-factual scenarios. Rather it is proposed to look at the aggregate expenses for energy to evaluate the affordability of the energy supply. To be able to properly assess the evolution of the costs of the energy supply and the additional costs incurred as a result of the Energiewende, annual aggregated total energy expenditure of final consumers for the sectors of electricity, heat and transportation should be collected and analysed. The figures for total final consumer expenditure and the individual total expenditure components provide meaningful indications as to the economic viability of the energy supply. This indicative instrument leaves distribution problems – the subject of much political debate – unaddressed for the time being, also because distribution problems are fundamentally diffused or easier to solve if final user expenditure does not develop disproportionally to nominal gross domestic product (GDP). As long as total expenditure tends to be proportional to GDP or rises at a lower rate, the general affordability of energy as a whole can scarcely seriously be called into question.

Final consumer spending on fuels and heating depends to a large degree on the international development of oil and gas prices and the procurement expenditure this entails. In contrast to electricity, the government-induced and regulated price components play a secondary role. Final consumer spending on electricity increased sharply in the last years, in fact it almost doubled in the last 15 years to about 70 bn Euro per year. In 2014, absolute end-user expenditure dropped slightly. This means that, at present, the energy transition is developing in a slightly positive way in the eyes of private, commercial and industrial consumers. However, a closer look shows that whilst the shares spent on government-induced elements (taxes, levies and surcharges) as well as the government-regulated grid charges have increased significantly, the share accounted for by market-driven elements has decreased. The most important cost drivers are increases in grid charges and the costs driven by the Renewable Energy Sources Act. The overall decline in final consumer spending on electricity is chiefly due to the drastic fall in spending on "generation and sales", which has almost halved since 2010. The causes of this are to be found in the sales of non-renewable electricity, which have fallen by over a fifth, and the ongoing fall in wholesale prices for electric power. The collapse in wholesale prices is only partly due to the "merit order" effect, *i.e.* only partly driven by the energy transition. The wholesale prices are largely determined by the development of international prices for primary energy sources (coal and gas) and the carbon price.

In terms of nominal GDP final user expenditure on electricity remained largely constant at approximately 2.5% (see Exhibit 2). The increase in aggregate electricity spending to date is not as dramatic as often publicly claimed. End-user spending on heat and transport has mainly fallen due to the international development in oil and gas prices. This amounted to 3.5% for heat in 2013 (€100 billion), and around 2.8% for transport in 2014 (€83 billion). For 2013, the

Exhibit 2

Share of final consumption expenses on electrical power in total GDP



Source: Löschel *et al.* (2015).

total proportion of end-user spending on energy amounted to about 9.0% (€255 billion). The overall cost situation of the German energy transition seems to be still under control.

IMPACTS ON COMPETITIVENESS

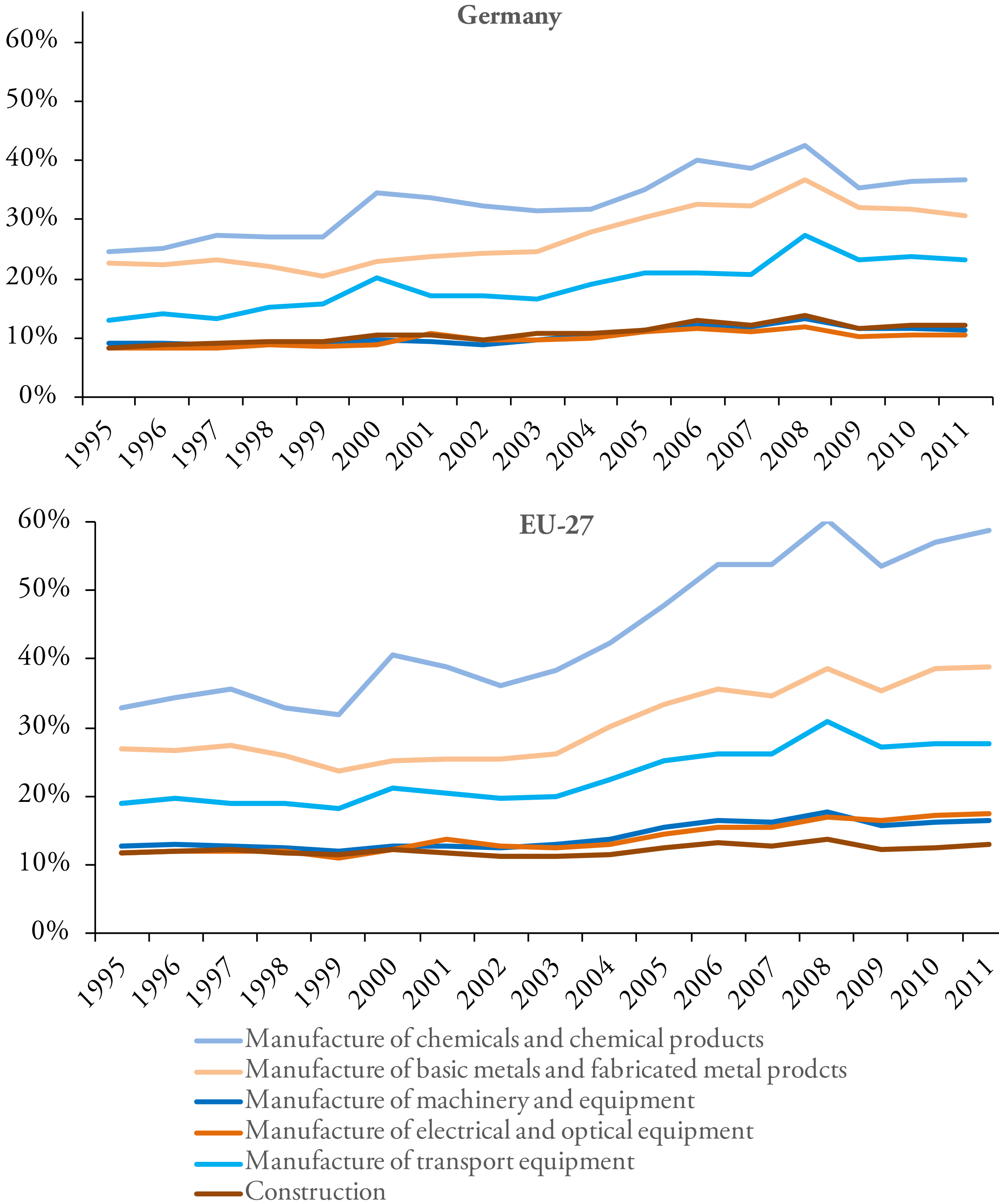
In addition to general affordability, differences in the energy prices paid by the various consumers must also be noted. Distributional consequences of the Energy Transformation concerns, for instance, the distribution of the surcharge pursuant to the EEG across final electricity consumers and in this context the special equalisation scheme for energy-intensive industry. A mere comparison of energy prices is not sufficient in this case. Rather, broader energy costs should be taken into account. These costs are also relatively moderate for households. Yet, the Energy Transformation puts a larger burden on low income households. Around 10 to 12% of households could be seen to be at risk of energy poverty.

For industry, a company's actual energy cost also needs to be taken into account in terms of the share of the energy cost in the gross value added for the sector in question. If aggregate energy costs are available for other countries, the economic viability of the energy supply can also be assessed well in terms of a broader international context. Energy per unit costs – the aggregated energy costs per unit of value added – are then a better indicator of international competitiveness. In order to monitor the burden on companies caused by energy costs, the unit energy costs indicator should not only include direct costs, but also "indirect", *i.e.* upstream, energy costs. These have been increasing on a very broad basis for years, and are (now) much more significant for most sectors than "direct" energy costs in Germany. This is true, for example, of the goods-producing sectors. The indirect energy costs in the six key goods-producing sectors studied in greater depth amount to between €5 and 11 billion per sector, and are thus in some cases higher than the direct energy costs, which only amount to €2 to 8 billion per sector. The comparison of the total German unit energy costs with the European average in Exhibit 3 illustrates three things here: total domestic unit energy costs in the relevant sectors are structurally at a lower level than in Europe. Secondly, total unit energy costs in Europe have seen a more dynamic upward development over the period than in Germany. And, thirdly, Germany easily outperformed the European average following the last economic crisis in terms of reducing total unit energy costs. The reason for the latter factor is that the relevant sectors of the German goods-producing industry were generally able to expand their added value between 2008 and 2011, and at the same time to reduce total energy costs. In the European average, in contrast, total energy costs fell by less in some cases, and in particular the added value by industry did not develop as well as in Germany. "Total energy costs", or the yardstick of "total unit energy costs", are thus more favourable for German goods-producing sectors than for the European average.

It becomes clear that energy per unit costs are on aggregate still relatively low in the German manufacturing sector – although that might not true for some individual sub-sectors. The various sectors within manufacturing industry are very heterogeneous. Thus the unit cost of energy is not moderate in an international comparison in all sectors and especially not within some sub-sectors. A more detailed examination is recommended. To be able to draw conclusions as to the competitiveness of businesses, further factors need to be taken into consideration additionally to energy cost. These include differences in national regulatory

Exhibit 3

Total unit energy costs in selected sectors of the German and European goods-producing industry between 1995 and 2011



Source: Löschel *et al.* (2015).

frameworks and classical location factors, such as the (business) tax system, wage levels and the quality of the workforce on the local labor market. Another decisive factor is the level of competition, above all how easy it is to access the local market. This is because a rising cost of energy will have little impact on (industrial) competitiveness if the increase can be passed on to consumers in the long term. It is difficult to ascertain this and thus to evaluate the effects of cost increases by describing and comparing energy costs alone. Thus, in addition to purely fact-based monitoring, more in-depth analyses are needed to obtain a more comprehensive picture of the cost of energy *(cf.* the discussion on the merit-order effect), distinguish it by sectors, trace its time history and make international comparisons.

PROBLEMS WITH THE CURRENT RENEWABLE SUPPORT SCHEME

The Renewable Energy Sources Act[4] has enabled a large-scale introduction of electricity generation from renewable energy sources. Especially electricity generation from wind and solar energy has increased extensively. The current support scheme guarantees investors the sales of their electricity at a fixed price, minimises risk and hence costs of their investment. By now, renewable energies have ceased to be a niche technology and became an important part of the electricity mix in Germany. The market design has to be adapted to this new situation. This is the consensus of the current discussion. Given fixed compensations for electricity fed into the grid, investors and operators of renewable power plants do not have incentives to adapt their behaviour to the actual scarcity of electricity. Market prices indicate the (potential) electricity producers if and when their supply is needed. If market prices are high, electricity is scarce and high revenues can be yielded. Accordingly, it is profitable to generate additional electricity and to build up further capacities. If the revenues are decoupled from the market prices and therefore the scarcities, as it is the case in the current EEG, production, investment, and decommissioning decisions are not made in a cost-efficient way. As long as the compensation is independent of scarcities, the investor only

4 The next two sections are based on the Discussion Paper: Löschel *et al.*, 2013a.

cares about the overall fed-in quantities, but not the time dimension. This is the greatest obstacle for the cost-efficient development of renewable energies. The actual scarcity of electricity has to be reflected to foster market-oriented investment and production decisions. The added value of a market integration of renewables lies in avoiding unnecessary costs.

On top of this, electricity generation has gradually shifted and will continue to shift into the north, while consumption mostly takes place in the west and south of Germany. Finding ways to deal with this shift will be a challenge for the electricity market in the future. If the grid is not congested, it is irrelevant for a consumer whether electricity was generated at the coast or in the mountains. Feed-in tariffs for renewables are not spatially differentiated and distort the choice of location. Wind mills are set up where most of the wind blows. Solar panels are set up where the sun shines the most. However, costs caused by network congestion are not considered in the choice of location. Not taking into consideration network congestion has similar effects as fixed compensations, but it concerns operators of conventional plants alike. With a single pricing zone, electricity producers do not notice costs caused by the transport of their electricity. This is why it is efficient, for example, for operators of coal-fired power plants to build them near the shore to be able to deliver the primary energy source at low costs. Network congestion is not perceptible through market signals and therefore not integrated into production and investment decisions. The lack of adaptation to the availability of electricity occurs then time wise, in the short and long-term, as well as spatially. If the future development of conventional and renewable power plants does not follow the actual scarcity of electricity, there is a risk of regular regional over- and underproduction. This goes along with unnecessary costs, on the one hand, for additional measures to ensure the supply in case of underproduction, on the other hand, due to unnecessary overproduction elsewhere. In order to align the reaction of investors and producers to actual scarcities, an isolated reform of the EEG is not sufficient, but congestion in the transmission grid also has to be taken into consideration.

PROPOSAL FOR A NEW ENERGY MARKET DESIGN

A better response of fluctuating renewable energies to scarcities can be achieved by linking the compensation of renewable energies to prices at the electricity exchange which reflect the time-specific scarcity of electricity. There are different options to achieve this linkage. In a quota system for renewables with tradable green certificates policy makers determine the amount or share of electricity that is supposed to come from renewables. With the possibility to trade green certificates, an efficient allocation of renewables production is reached theoretically. Capacity to produce energy from renewables is expanded in locations where it is most cost-efficient. Producers at the most cost-effective sites sell green certificates, producers at sites where renewable energies are more expensive buy certificates, respectively. Moreover, investment and production are decided upon taking into account the scarcity of electricity. A major shortcoming of the quota system is the price volatility of green certificates and hence high risk premiums for investments in renewables. Moreover, the political implementation of a quota system is difficult. It represents a fundamental change of the previous promotion mechanism for renewable energy. Another option to make the investment in and the production of renewables more sensitive to the scarcity of electricity is to introduce a market premium for renewable energy. This premium is paid additionally to the exchange price for electricity for a fixed time period. Ideally, the premium reflects the positive externalities of renewable energies. Hence, the premium would reward the positive side-effects of renewable energy, while the exchange price for electricity remunerates the electricity production given the current scarcity. In the long-term, renewable and conventional energy would compete sustainably and the entire electricity production would be demand driven. Long-term overproduction would not occur. Uncertainties are reduced by the fixed premium; therefore smaller risk premiums for investors than in the quota system are to be expected. The risks are distributed in the premium system and those investing in renewable energy only bear the risk on the electricity market.

The market premium is very flexible and can be developed from the EEG as a starting point. By contrast with the quota system, the promotion of renewables does not have to be restructured fundamentally. For instance, it is possible to grant technology-specific premia in the beginning and to let them converge gradually into a system with a single market premium.

To recognise scarcities in electricity networks, network congestion has to be priced. However, the current system assumes Germany as a copper plate. The marginal power plant sets the price for the entire electricity market without considering transmission cost of the traded electricity. There are different options to price for scarce transmission capacities. Under Nodal Pricing, the price which reflects the costs for generation as well as for the transport of electricity is determined at different nodes of the network. However, introducing such a system in Germany would necessitate major reorganisation of the electricity sector. For instance, a single network operator (Independent System Operator, ISO) would be needed. Moreover, Nodal Pricing generally involves a trading system in which all transactions are carried out compulsory (Pool). The introduction of Nodal Pricing is likely to be time-consuming and cost-intensive. Other approaches that interfere less with the current market design lie between the two extremes of fixed network use of system charges in a single pricing zone *(i.e.* todays framework) and the flexible Nodal Pricing. The most relevant approaches are regionally differentiated network charges and market splitting.

With regionally differentiated network charges network users receive price signals which are supposed to have effects on the choice of location. In a practical implementation in Germany, higher charges for producers and lower charges for consumers could be set in the north. In the south, there would be lower producers' and higher consumers' charges. The producers would include the different network charges in their investment decisions. If the investment conditions were identical apart from that, it would make sense for the producer to invest in the region with the lower network charges. Another possibility is market splitting. In this system, the market area is divided into several pricing zones. The borders are determined according to bottlenecks of the grid. If capacity constraints are not binding, the same prices will emerge. Only in situations, where the transmission capacities are limited, the market participants are faced with different prices. A key aspect of market splitting is that the scarcity prices are directly generated at the spot market and therefore congestion is reflected in the electricity price. The price differences between the pricing zones stimulate investment incentives that contribute to eliminating them. In the short-term, diverging prices can prevent the decommissioning of conventional power plants in regions with scarce capacities which cannot be operated economically anymore in a single price zone. In the long-term, the undistorted investment incentives contribute to efficient and sufficient investments and reduce additional measures ensuring sufficient capacities. If there are enough transmission capacities available in the system, no diverging prices are realised. In contrast, redispatch measures eliminate the congestion only after the pricing on the spot market by altering utilisation of power plants. Market splitting prevents fundamental changes of the electricity market and is easily compatible with a joint European electricity market. A division into north and south would be an option for Germany.

OUTLOOK

The German energy transition is making progress, albeit not so quickly across the board as initially planned and necessary. In certain areas, such as renewables-based electricity generation, the 2020 targets will probably be met or overshot, the progress made so far in other areas is still insufficient. The latter applies in particular to the goal of cutting greenhouse gas emissions by 40% by 2020. In the transport sector, the development is actually pointing in the wrong direction. Potential failures to attain specific targets in the Energy Concept should not be deemed the fault of policymakers alone. In addition to economic and social conflicts, exogenous causes such as the low international market prices for fossil fuels and CO_2 emissions rights are making it more difficult to attain the energy transition targets. While these developments will keep the energy costs low, electricity prices are most likely going to increase for the years to come due to the continued expansion of renewables, especially in the offshore area; the urgently required expansion of grids to link up offshore wind parks and for distribution and transmission, especially with priority for underground cables as the ultra-high voltage grid; the funding of new backup power plants and storage facilities etc. Distributional conflicts are reduced if these cost increases are dampened. An efficient implementation of the Energy Transformation is more important than ever. Political decision-makers should not lose sight of the aspect of affordability, particularly in view of the innumerable wishes and demands which would entail further expenditure.

The German government is currently discussing recommendations by different institutions concerning reforms of the EEG to take effect in 2017. Most likely, an auction system for most renewable technologies will be implemented which would tender a specific amount of capacity volume each year. As described above, this proposal is economically problematic as it i) perpetuates technology-specific support that hinges on political decisions, ii) suppresses market signal for electricity suppliers on whether electricity is currently demanded, and iii) ignores the spatial interactions of renewable penetration and grid development. It has been argued that a combination of the market integration of renewables with a premium on the exchange price and market splitting to price network congestion establishes a better coordination of the regional and temporal demand of renewables as well as conventional power plants. Moreover, it yields better incentives to eliminate congestion through short and long-term measures like investment in network expansion, power plant construction, demand management, or storage. The market premium can be developed based on the current EEG. Technology-specific subsidies are possible at the very beginning, but in the medium term a technology-neutral scheme should be aimed for.

Given the negative trend in the transport sector, a new policy approach seems necessary also in this sector. The European Union legislation sets mandatory CO_2 emissions reduction targets for new cars. However, it is unlikely that the standards alone would be sufficient to achieve the long term targets for emission reduction in road transport. The effectiveness of minimum energy efficiency standards is negatively impacted by rebound effects. Pricing instruments reduce rebound effect: Including the road transport sector in the EU ETS is likely to act as a small carbon price add-on on fuel and as such raises the costs for the end consumers. By increasing the cost of driving, the potential rebound effects from improved fuel economy in cars can be reduced. An emissions trading system in which the absolute amount of input is regulated also does not leave any room for rebound effects to develop. There are other advantages as well: By sending a price signal, the ETS simultaneously incentivizes adjustment of carbon-emitting activities along all margins of substitution, *i.e.* fuel carbon intensity, fuel economy in cars, driving behavior and demand for vehicle miles travelled. The ETS guarantees no emissions above the cap and puts a binding long-term ceiling on relevant emissions. It is technology neutral, and a cost-efficient instrument because abatement occurs in the sectors that face the lowest marginal abatement cost. Moreover, the abatement costs are revealed by the allowance price so policy makers can observe the cost of the policy implemented directly. The marginal abatement costs for road transport are widely held to be higher than the marginal abatement costs faced in many other sectors covered by the ETS. This implies that including the road transport sector in the ETS – regulating upstream, *i.e.* fuel providers – would increase the cost efficiency of EU climate policy although abatement may take place in other sectors of the economy under ETS rather than in road transport.[5] It is likely that the inclusion would lead to an increase in the ETS price, although recent analysis suggests that such an increase could be very moderate. The strong permit demand from the transport sector in the medium term would also solve the problem of excess certificates. Instead of discussing this proposal, the government considers introducing a subsidy for electric car buyers. It becomes apparent that whilst almost all stakeholders in government, industry and society would like to support the challenging greenhouse gas reduction targets, there is virtually no willingness to accept the measures needed to achieve this if they apparently involve personal sacrifices. Everyone knows that climate change mitigation does not come free of charge; despite this, behaviour is often targeted to secure a direct economic advantage from the process. Such a model cannot work.

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5 See for this proposal Achtnicht *et al.*, 2015.

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