Deutsche Bank
Research

Current Issues
Natural resources

June 2, 2016

German 'Energiewende': Many targets out of sight

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Original in German: May 12, 2016

Many of the environmental-performance targets of the German 'Energiewende' are in fact falling behind the time scale that is actually required – some of them are significantly behind schedule. Progress is largely achieved where major subsidies are provided via some form of support programme. Where there is no such support, or subsidies and incentives are small, or too small, targets are starting to be missed. One criticism is that no quantifiable targets have been drawn up in the areas of economics/efficiency and security of supply.

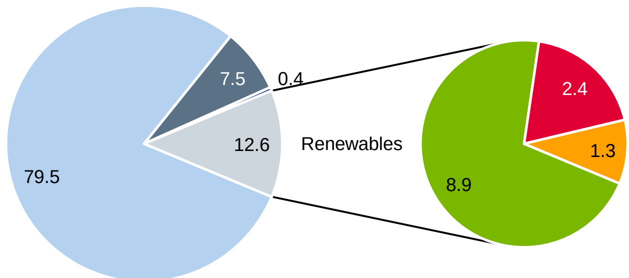
If the current status of the 'Energiewende' had to be described in one sentence, it might be that Germany has probably taken on too much in too short a time. We believe there are four main limiting factors: cost, physical limits, the available time budget and political feasibility.

To date, the 'Energiewende' in Germany has largely been a shift in electricity generation. The expansion in renewable energies in the power sector is progressing rapidly due to the Renewable Energy Sources Act (EEG), but this is associated with rising system costs, and there are stricter requirements in relation to security of supply. However, electricity only accounts for 21% per cent of final energy consumption in Germany. Outside the electricity sector (the heating market and transport sector), the 'new' renewables (wind power and photovoltaics) only play a minor role, with an aggregate share in primary energy consumption of 3.7% (2015). Bioenergy, the most important renewable energy form to date, has limited potential for expansion.

Until now, the government has relied on a mixture of government subsidies and regulatory law (prescriptions and prohibitions) to achieve the 'Energiewende'. These tools are often economically inefficient and/or lead to infringements of property rights or freedom of choice. Because the cost of energy transition is a limiting factor, the use of the resources available should create maximum benefit. A reformed European emissions trading system would be ideal.

Fossil fuels prevail – bioenergy is the mainstay of renewables 1

Proportion of individual energy sources to primary energy consumption in Germany, 2015, %



* Minus electricity exchange balance; deviations from 100% due to rounding.

Source: AG Energiebilanzen

1. Introduction

The migrant crisis is edging public attention away from energy transition

In recent months, energy transition in Germany – the so-called 'Energiewende' – has moved noticeably out of the focus of public-affairs reporting. Most notably, the migrant crisis has pushed many developments relating to energy policy (and other matters) out of the media spotlight. Yet the energy and climate-policy challenges that Germany faces in the coming years and decades are extremely significant. And there are few signs of any simple solutions. The question surrounding many of the political energy-transition targets is whether Germany can actually achieve its aims. To be clear, this does not mean the phasing out of nuclear energy, on which there was political consensus and which is not being called into question here.

In the following report, we analyse the progress made on selected energy and climate-policy targets set by the German government and investigate the question of which targets are likely to be achieved and where they are more likely to be missed.[1] In this context, selected energy and climate-policy instruments need to be analysed, including whether they achieve their environmental aims or are economically efficient. This applies to both the instruments currently in use and potential alternative instruments. In the case of alternative instruments, it is also interesting to discuss whether they are likely to be easy to implement politically, or whether resistance can be expected. Although regulatory instruments (prescriptions, prohibitions) are environmentally effective in many cases, they may be associated with high costs and/or represent infringements of property and civil rights, which makes them politically difficult to implement (and rightly so). In conclusion, we examine some fundamental arguments in favour of the shift in German energy policy.

Strong development support facilitates progress

Without wishing to prejudge the detailed findings of the report in advance, a fundamental trend is emerging in terms of German energy-transition targets and instruments. Wherever large direct or indirect subsidies and grants are provided via a (public) support programme, such as grants for certain technologies, the relevant targets are (very much) more likely to be achieved than in those cases where there is no such programme, or where grants and incentives are (too) small. It should also be stressed at the outset that the underlying tendency outlined above definitely does not lead us to the conclusion that the government ought to introduce even higher subsidies or other financial aids across the board so as to achieve its energy and climate policy goals. The government's financial capability is limited, which is why the resources available should be deployed in such a way as to create maximum benefit. Overall, the influence of government regulation on the energy sector – from generation to consumption – has grown significantly in recent years; this is particularly true of the electricity sector. It is obviously not easy to reconcile ambitious government energy and climate-change targets with the principles of a market economy.

2. Many energy-transition targets are off course

Energy policy is generally geared towards what is known as the energy-policy target triangle, which comprises targets for economics/efficiency, security of supply and environmental or climate compatibility, and which we will examine below. Over time, different levels of importance have been attached to the individual targets, despite the need for a long-term balance between targets because one-sided prioritisation of one target may be at the expense of the remaining targets.

[1] A major data source for this is: BMWi (2015). Die Energie der Zukunft. Vierter Monitoring-Bericht zur Energiewende. Berlin.

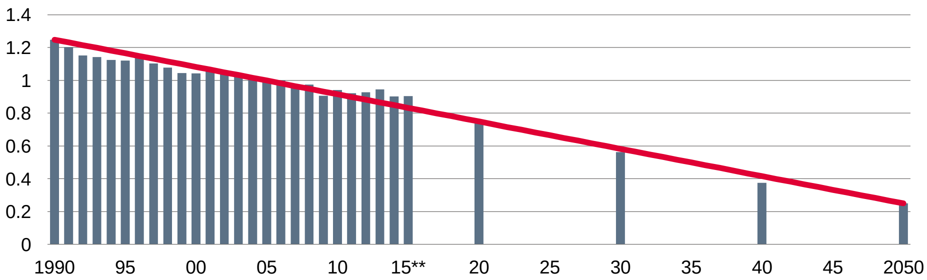
2.1 German government is pursuing many specific environmental targets

Aiming for up to 95% cut in greenhouse-gas emissions by 2050

Concerning the ‘Energiewende’, the German government has set specific quantities for a range of environmental-performance targets. One of the most important aims is to cut the emission of greenhouse gases (GHGs) – principally CO_2. By 2020, the German government wants greenhouse-gas emissions to be 40% lower than in 1990, the baseline year. By 2050, emissions are supposed to have fallen by as much as 80-95%. Is Germany on track to do so? Not really! Between 1990 and 2015[2], the emission of greenhouse gases in Germany fell by just under 28%. Because emissions plummeted in the first years after reunification, it is helpful to use 1995 as an additional basis for comparison. GHG emissions in 2015 were more than 19% lower than in 1995, so they would have to fall by 17% (!) in the next five years in order to achieve the aforementioned 40% target by 2020. This means that the cut in emissions within five years is intended to be almost as much as in the previous 20 years.

Medium-term climate targets may be missed 2

Greenhouse gas emissions in Germany*, CO_2 equivalents, billion tonnes



* The downward trend indicates a reduction of 80% (compared with 1990) in greenhouse gases in Germany in the period to 2050. The German government's official target is a reduction of 80% to 95% by 2050, but the least ambitious downward trend is shown.

** The value for 2015 is based on estimates from AG Energiebilanzen.

Sources: Federal Environment Agency, AG Energiebilanzen, BMWi, Deutsche Bank Research

Ageing lignite-fired power stations to go off-line

In recent months, the German government has announced a raft of measures to prevent the national climate-change target for 2020 being missed, including the plan to put ageing lignite-fired power stations into 'security standby' mode from 2016 onwards and to close them down after four years.[3] In return, the operators of the power stations concerned will receive compensation of EUR 230 million a year for seven years. A package of further measures is intended to ensure that the target for reducing GHGs is achieved by 2020. They include a higher subsidy for combined heat and power (CHP) plants and additional financial assistance for improving the energy efficiency of municipal and industrial buildings. Various measures are also planned or under way for the transport sector, such as broadening the scope of truck tolls, expanding rail and local public-transport infrastructure and subsidising electric vehicles.[4]

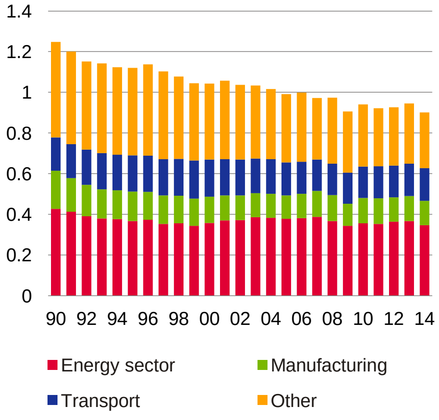
[2] Only estimates of greenhouse-gas emissions are available for 2015.

[3] Since the start of the third negotiation period for the EU emissions trading scheme (EU ETS) in early 2013, emissions in sectors subject to the EU ETS have (in effect) been removed from national emissions budgets. Instead, there is a cap at EU level, which principally affects electricity generation and some energy-intensive sectors. If, for example, national initiatives reduce CO_2 emissions in the electricity sector of one country, demand for CO_2 certificates will fall – along with their prices. But there has been no change in the predetermined cap for CO_2 emissions within the EU ETS, i.e. power stations in other EU countries can increase their emissions. However, the German government does include emissions from power stations in Germany in its calculation of German GHG emissions or the national climate-change target.

[4] For a summary of these measures, see: BMU (2014). Aktionsprogramm Klimaschutz 2020. Berlin. And: BMWi (2015). Energiejahr 2016: Neuerungen Anfang Januar. Press release dated

Greenhouse gas emissions are falling 3

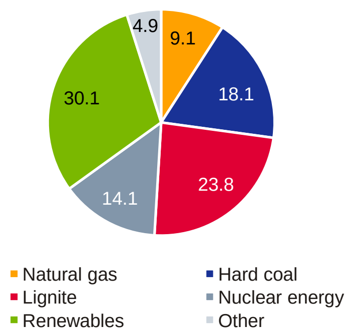
Greenhouse gas emissions in Germany*, CO_2 equivalents, billion tonnes



Source: Federal Environment Agency

Renewables top in electricity sector 4

Proportion* of individual energy sources to gross electricity generation in Germany in 2015, %



* Deviations from 100% due to rounding.

Source: AG Energiebilanzen

In this section, we investigate individual initiatives, such as those in the buildings or transport sectors. But it is already clear that the instruments deployed consist of a mix of (high-cost) government subsidies and regulatory law; in other words, the government is using a 'carrot and stick' approach. They obviously have little confidence in companies and private households choosing low-carbon or energy-efficient technologies to an extent that would meet climate-change targets based solely on economic considerations without any subsidies.

It remains to be seen whether the measures that have been agreed will meet the national climate-change target for 2020. For now, we are more than doubtful that this will actually succeed. We wonder, for example, whether the planned measures will be able to exert sufficient impact in the short time remaining, and whether the subsidies for individual measures are high enough. It is also worth bearing in mind that the weather and economic performance in Germany have a substantial impact on GHG and CO_2 emissions, but these factors cannot be influenced by energy and climate policies (or only marginally in the case of the economy). The reduction in energy consumption in Germany in 2014 was largely attributable to the mild temperatures, while the slightly colder weather in 2015 was responsible for the increase in energy use. The anticipated level of immigration to Germany in the next few years tends to suggest that energy consumption will be higher and that GHG emissions in Germany will rise, another factor that is difficult to influence.

Extremely ambitious long-term climate-change target

The long-term target for cutting German GHG emissions also remains ambitious. Assuming that emissions decline in a linear fashion, they would have to fall by 25% in the 2020s and by 33% in both of the two subsequent decades. If that were the case, GHG emissions in 2050 would be 80% lower than in 1990; thus 'only' achieving the minimum target, because a reduction of up to 95% is actually the official objective. Ultimately, there would have to be a sharper decade-on-decade percentage decline than in all previous decades. Although long-term forecasts are particularly fraught with uncertainty, such a trend – in which rates of decline accelerate over time – is counter intuitive and contradicts findings in other areas, where the easiest successes are achieved at the outset (ruling out any revolutionary technological breakthroughs). The data shows that substantial technical progress is needed in all areas of the economy and society if the long-term climate-change target is to be achieved.

Is there any sign of this technical advancement in 'just' 35 years? The German government is now largely relying on increases in energy efficiency and a further expansion in renewable energies, where the political focus is on wind power and photovoltaics. At the very least, the facts presented below are likely to raise the level of doubt as to whether the 2050 German climate-change target can be achieved by means of existing technologies and at an economically reasonable cost.

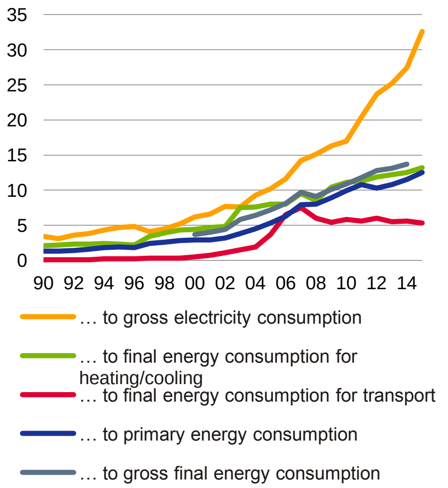
Expansion in renewables is progressing well in the power sector

One of the German government's key objectives is to expand renewable energies – particularly because their CO_2 intensity is low and they compensate for the phasing out of nuclear power. There are various subsidiary targets, such as increasing the proportion renewables to at least 35% of gross electricity consumption by 2020, with a further gradual increase in the proportion, taking it to a minimum of 80% by 2050. The target for 2020 is highly likely to be

December 23, 2015. Berlin. The BMWi's Vierter Monitoring-Bericht zur Energiewende quoted in footnote 1 also lists initiatives for cutting GHGs.

Renewables important for electricity, little progress in transport sector 5

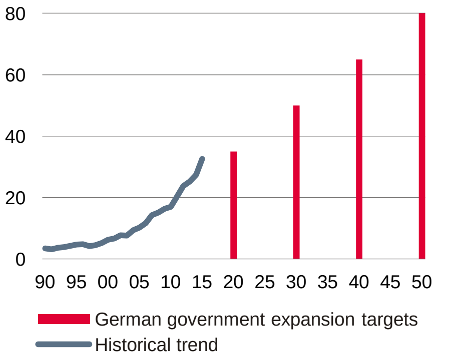
Proportion of renewable energies in Germany, %



Source: BMWi

EEG is creating rapid expansion in renewables for electricity 6

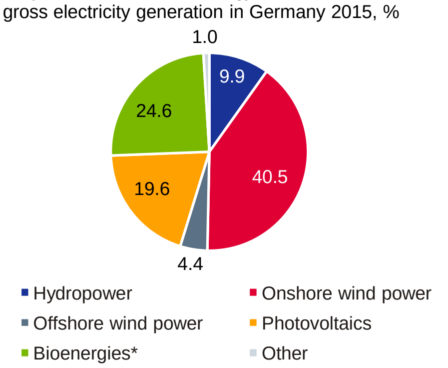
Proportion of renewable energies to gross electricity consumption in Germany, %



Sources: AG Energiebilanzen, BMWi

Wind is most important renewable energy source in the electricity sector 7

Proportion of individual energy sources to total renew. gross electricity generation in Germany 2015, %



* Solid, liquid and gaseous biogenic fuels and biogenic proportion of waste.

Source: AG Energiebilanzen

achieved. Renewable energies already accounted for 32.6% of gross electricity consumption in Germany in 2015, making them the main energy source for electricity. At the moment, it appears more than likely that the 35% target will be exceeded by 2020. In 2000, renewables accounted for just 6.2% of gross electricity consumption.

In terms of gross electricity generation, renewables were also ahead of all other energy sources, representing 30.1% of the total in 2015. Within renewable energies, on-shore wind power predominates, accounting for 40.5% of gross electricity generation, followed by bioenergy (24.6%). Photovoltaics come third with a share of 19.6%, ahead of hydroelectric power, which has been in the market for many years, and off-shore wind power, which is relatively new.

The Renewable Energy Sources Act (EEG) is a textbook example of an effective support programme

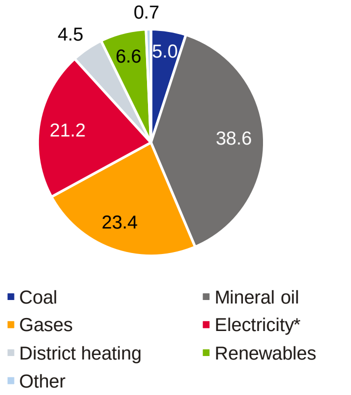
The gain in the share of renewable energies in the power sector is largely based on the Renewable Energy Sources Act (EEG) of 2000. The EEG is the ultimate textbook example of how a strong support programme can achieve the desired ecological aim. The principle on which the EEG works is that operators of plants generating electricity from renewable energies receive a fixed fee for each kilowatt hour of electricity fed into the grid for a period of (usually) 20 years. There is also priority feed-in and a purchase guarantee for the electricity generated, reducing both price and quantity risk, which is lucrative for investors and lenders (e.g. banks). Overall, investment in renewables and their share of the power market have grown significantly. The cost of this financial assistance is added to the price of electricity via the EEG surcharge. As a result, the subsidy is not the subject of annual budget debates (see section 2.2).

When the EEG was reformed in 2014, the system of incentives for selected newly built capacity was switched to a market premium. Since then, the power station operators concerned have been obliged to market their electricity themselves (direct marketing) and they receive a market premium. This is calculated as the difference between the fixed feed-in tariff and the average wholesale price of electricity. The next amendment to the EEG is currently under discussion. It specifies that the expansion of renewable energies in the electricity sector will be controlled by invitations to tender from 2017 onwards. This is essentially aimed at onshore and offshore wind power and large-scale photovoltaic arrays. Invitations to tender for predefined generating capacity should partly ensure that the expansion in renewables in the electricity sector takes place within a politically defined corridor. The ratio of renewable energies to gross electricity consumption in 2025 is intended to be between 40 and 45%, and between 55 and 60% in 2035 (see also section 2.2).

Despite the progress so far, there is no guarantee that the long-term energy-transition target – for 80% of electricity to be generated by renewables in 2050 – can be achieved. It depends on numerous uncertain factors, such as the speed of technical advancement in renewables, energy storage and efficiency technologies. Technical advancement will determine the fall in the cost of the technologies concerned. Any change in the demand for electricity is also crucial. The future energy supply in Germany in the areas of heating and transport is also likely to be increasingly based on electricity, so electricity consumption will probably be higher in 2050 than it is today, even if the huge potential for efficiency gains can be exploited. In 2014, electricity only accounted for 21% per cent of Germany's final energy consumption.

Oil dominates final energy consumption 8

Proportion of individual energy sources/forms to final energy consumption in Germany in 2014, %

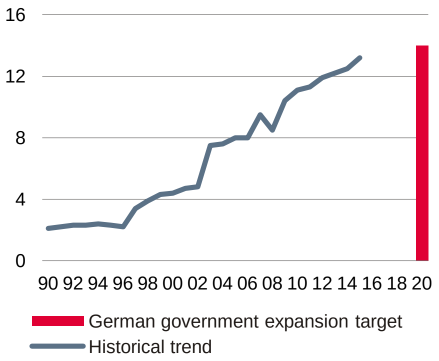


* Including electricity from renewables.

Source: AG Energiebilanzen

Renewables in heating market on course so far 9

Proportion of renewable energies to final electricity consumption for heating* in Germany, %

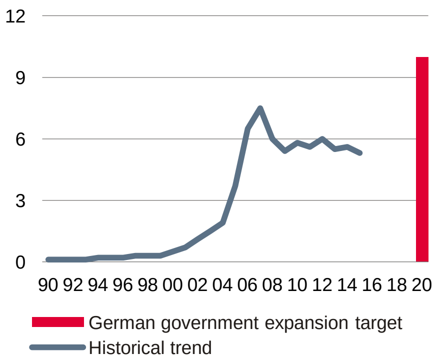


* And cooling.

Sources: AG Energiebilanzen, BMWi

Renewables no longer advancing in transport sector 10

Proportion of renewable energies to final energy consumption for transport in Germany, %



Sources: AG Energiebilanzen, BMWi

Renewables on track in the heating market, but insignificant in the transport sector

A glance at other indicators shows how ambitious the target is for significantly increasing the proportion of renewable energies (over the long term). The target is for renewables to account for 14% of final energy consumption in the area of heating and cooling by 2020. As they had already reached 13.2% in 2015, this target is highly likely to be met. Regulatory law and subsidies will provide the missing percentage points. The regulatory instruments include the Renewable Energies Heating Act (EEWärmeG), which includes targets for the proportion of renewables in the heating sector. The so-called market incentive programme (Marktanreizprogramm) is another aid programme that provides financial support for expanding renewables in the heating market. There are currently no long-term targets for the indicators mentioned.

The situation in the transport sector looks entirely different. Here, an EU directive specifies a target of 10% for increasing the ratio of renewables to final energy consumption in the sector by 2020. This target is likely to be missed because the proportion in 2015 was just 5.3% and no growth had been recorded in recent years. Nor are there currently any long-term targets for increasing the proportion of renewables in the transport sector.

In terms of primary energy consumption, 'new renewables' only account for 3.7%

Ultimately, for an energy supply that is as low-carbon as possible, the proportion of total primary or final energy consumption accounted for by renewable energies has to be as high as possible. The German government has one specific target for gross final energy consumption: raising the proportion of renewables to 18% by 2020. In 2014 (more recent figures are not available), the proportion was 13.7%. If the trend seen in recent years continues, this target is likely to be achieved. The government aims to increase the proportion of renewables to 60% by 2050.

At first glance, this is a less ambitious target than the plan to expand renewables in the electricity sector to 80% by 2050, but the importance of individual renewable energy sources varies from sector to sector: Wind power (on and off-shore) and photovoltaics together account for just under 65% of renewable power generation (2015). By contrast, they currently play virtually no role in the heating market and transport sector where bioenergy accounts for a large proportion of renewable final energy consumption. In both areas, bioenergy has a share of between 85 and 90% (as a reminder, the proportion for electricity was less than 25%). In the heating sector, wood (including pellets) is the dominant fuel, while biofuels dominate in transport.

The huge importance of bioenergy in the heating and transport sector, and the high level of energy consumption they represent in absolute terms, is also reflected in the total energy consumption mix. Although there are no statistics for final energy consumption that detail all renewable energy sources, these figures are available for primary energy consumption. In 2015, renewables accounted for 12.6% of primary energy consumption in Germany, of which 7.1% was attributable to bioenergy alone. By contrast, wind power only accounted for 2.4%, and photovoltaics for just 1.3%. The remaining 1.8% was spread across energy from waste, hydroelectric power and geothermal energy. Together, the 'new renewables', i.e. wind power and solar energy, only accounted for 3.7% of German primary energy consumption (see chart on first page), despite 15 years of EEG incentives. Fossil fuels continued to bear the brunt at 79.5%. In terms of final energy consumption, the overall situation is no different.

Limited potential for bioenergy

The energy mix outlined above shows the size of the challenge of increasing the proportion of renewable energies to 60% of final energy consumption in the long term, because bioenergy, by far the most important renewable energy form today, has limited potential. The German government has frequently indicated that it sees the greatest potential for expansion in wind power and solar energy, while it is much more cautious about bioenergy. In fact, bioenergy inevitably creates land-use conflicts because areas where energy crops are grown cannot be used for food production; as the global population grows, this conflict is becoming increasingly relevant. Wood that is burned to generate energy cannot be used as a material. Our intention here is not to examine problem areas in detail, such as forest clearance to create agricultural land for bioenergy crops or the emergence of monocultures that require the large-scale use of fertilisers and pesticides. Although bioenergies have numerous plus points, such as their use for a range of energy purposes and ability to be stored, the drawbacks cannot simply be dismissed. There are many studies that quantify the potential of bioenergy. In 2008, the German Advisory Council on Global Change (WBGU), a government agency, estimated that the long-term, sustainable use of bioenergy had the potential to meet a maximum of 10% of future global energy needs.[5]

This figure indicates that bioenergy – currently the mainstay of renewables – cannot bear the brunt if the proportion of renewable energy sources is to rise to 60% of final energy consumption in Germany by 2050. The modernisation of ageing hydroelectric stations and building a few new ones is likely to increase the quantity of hydroelectric power generated in Germany, but hydropower can only make a small contribution to achieving the aforementioned 60% target. The German Federal Environment Agency (UBA) actually describes its technical potential in Germany as "largely exhausted". Ultimately, all hopes currently rest on wind power and solar energy, which leads us to several conclusions:

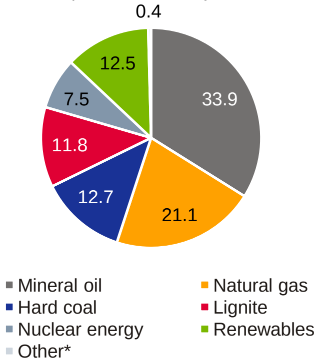
— In theory, the gap is widening between the current proportion of renewables in gross energy consumption (2014: 13.7%) and the target of increasing it to 60% by 2050, if the fact is taken into account that there is relatively little potential for expanding what are currently major sources of energy within the renewables mix. Moreover, a straight-line extrapolation of the current expansion trend in renewables shown in chart 13 arrives at a proportion of 40% of final energy consumption rather than 60% in 2050. This means that the future market share of renewables would have to increase more rapidly than in the past 15 years.

— If wind power and solar energy are to be the primary means of closing the gap, the expansion of power grids will be an issue in the short term and, looking forward, the question of power storage and its associated costs. There is no sign yet that these two renewable energy forms can meet the base load requirement (see sections 2.2 and 2.3).

— Ultimately, focusing on wind power and solar energy also means that the heating market and transport sector will increasingly need to be electrified in the next few years. This is indeed a declared political aim, but committing to achieve it is easier than putting it into practice. Two examples serve as an illustration. In 2015, heating was provided by electricity or electric heat pumps in just 4.5% of existing homes in Germany. The main sources were gas (49.3%), oil (26.5%) and district heating (13.6%). Although electric heat pumps accounted for as much as 20.9% of heating systems in new homes in 2015, the proportion in new builds has been slipping back for several years. Furthermore, the proportion of new homes in the total housing stock is just 0.7% (2015), which is why structural changes in housing stock take a

Oil remains most important energy source 11

Proportion of individual energy sources to primary energy consumption in Germany 2015, %

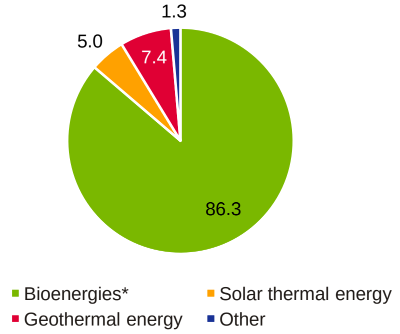


* Minus electricity exchange balance; deviations from 100% due to rounding.

Source: AG Energiebilanzen

Bioenergy is mainstay of renewables in the heating market 12

Proportion of energy sources/forms to renewable final consumption for heating in DE 2015,%

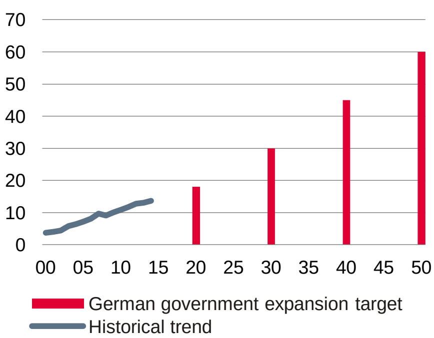


* Solid, liquid and gaseous biogenic fuels and biogenic proportion of waste.

Source: BMWi

Final energy consumption: ambitious expansion targets for renewables 13

Proportion of renewable energies to gross energy consumption in Germany, %

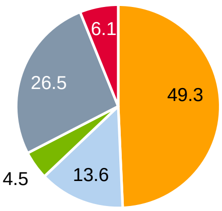


Sources: AG Energiebilanzen, BMWi

5 See WBGU (2008). Future bioenergy and sustainable land use. Berlin.

Natural gas most important heat source 14

Proportion of heating systems/energy sources in German housing stock in 2015, %



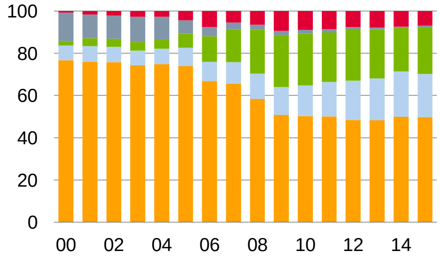
Gas (including methane and liquefied gas)
District heating
Electric heat pumps and electricity
Heating oil
Other*

* Including wood, wood pellets, other biomass, coke/coal.

Source: BDEW

Natural gas leads the market 15

Proportion of heating systems/energy sources in new homes in Germany, %



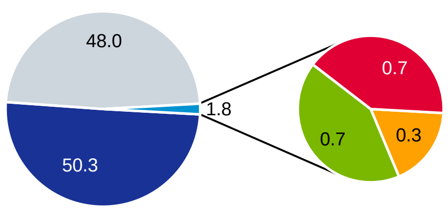
Natural gas (including methane)
District heating
Electric heat pumps and electricity
Heating oil
Other*

* Wood and wood pellets accounted for just under 75% of other heating systems in 2015.

Source: BDEW

Alternative drives still a niche sector 16

Proportion of fuel types/drive technologies to new car registrations in Germany in 2015, %



Petroleum
Diesel
LPG and natural gas
BEV and PHEV
Other

Source: Federal Motor Transport Authority (KBA)

long time – not least because buildings and heating systems have long lifespans. Gas continues to predominate in new buildings (49.8%), whereas heating oil is virtually irrelevant in the meantime (0.6%). District heating accounts for 20.4%.

The second example concerns the transport sector. In early 2016, 98.4% of all cars on Germany's roads were exclusively powered by petroleum or diesel. The remaining percentage is spread across alternative drive systems, including liquefied petroleum gas and natural gas, for which there is a tax advantage over petroleum and diesel. Even among recently registered cars in Germany, alternative drive systems do not yet play a major role, with a particularly high degree of reluctance among private customers. Electric vehicles have not yet won over German consumers, despite the increasing number of new models that are now available. The high purchase cost, short driving range and lack of battery charging infrastructure are the reasons for this reluctance.[6] The point about longevity is, of course, also relevant to motor vehicles (passenger cars and trucks), as well as ships, aircraft, and construction and agricultural machinery, most of which are currently powered by fossil fuels. Any structural change in the vehicle fleet and machinery population therefore takes time. There is only a significant level of electrification in German rail transport, where around 60% of the rail network operated by Deutsche Bahn had already been electrified in 2015.

The comprehensive transition to electricity in the energy supply for the heating and transport sector will only succeed if there is massive capital expenditure. Whether this capital investment will pay off for the decision-makers is not in itself guaranteed. So is additional government regulation required? Probably. An article in Die Zeit weekly newspaper on March 17, 2016 by Rainer Baake, Secretary of State at the BMWi explains what this could look like. In the article, Baake proposes that no heating systems based on fossil fuels should be allowed to be installed in German housing stock (including renovations) from 2030 onwards, nor should any cars powered by fossil fuels be permitted to be sold from 2030. This proposal is partly based on the long lifespans of heating systems and motor vehicles. If the aim is to have a carbon-neutral building stock and transport sector by 2050, the changeover to renewable energies needs to be started as soon as possible.[7]

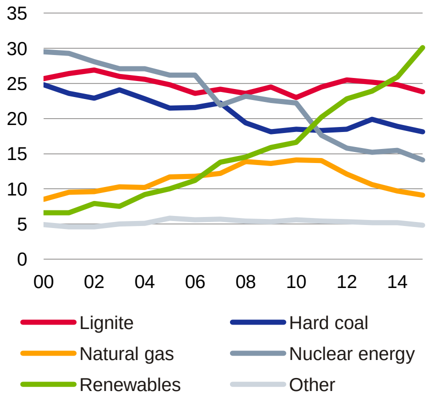
Regulatory measures of this sort would, of course, represent a massive infringement of property rights and consumers' freedom of choice, and a huge intervention in corporate decision-making. Because this would affect large swathes of the population and numerous companies, it raises the question of whether such proposals could be supported by a political majority. As things stand, we would answer this question in the negative. Given Germany's small share of global GHG emissions, we believe the introduction of this type of ban as a contribution to climate protection would be disproportionate (see section 4). Instead of using regulatory law, the government could, of course, also try to bring about this structural change by means of subsidies. However, in view of the size of the task (there are already over 40 million homes and around 55 million vehicles), such financial assistance would be likely to overstretch public finances. The possibility cannot be ruled out that technical advances will progress at such a pace in the next few years that climate-friendly technologies in the heating market and transport sector gain acceptance for purely financial considerations. In just a few years for example, even without financial incentives, electric cars are likely to rival cars with internal combustion engines

6 Outside Germany, electric cars also only account for a significant market share where purchases are heavily subsidised (e.g. Norway).

7 See Baake, Rainer (2016). Some like it hot. Wenn wir die Erderwärmung aufhalten wollen, müssen wir das billige Öl und Gas im Boden lassen. Article in German weekly Die Zeit, no 13/2016, March 17, 2016.

Renewables on the rise, nuclear energy falling, lignite very steady — 17

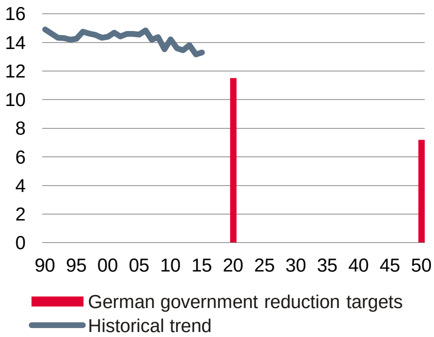
Proportion of individual energy sources to gross electricity generation in Germany, %



Source: AG Energiebilanzen

Primary energy consumption to fall by 50% by 2050 — 18

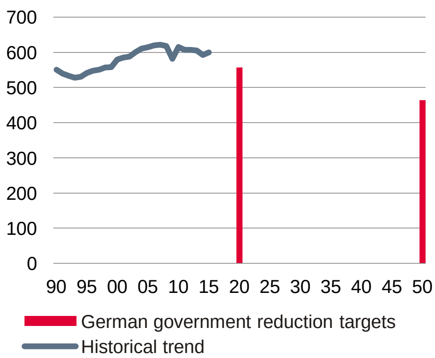
Primary energy consumption in Germany, exajoules



Sources: AG Energiebilanzen, BMWi, Deutsche Bank Research

Recent slight downward trend in electricity consumption — 19

Gross electricity consumption in Germany, billion terawatt hours



Sources: AG Energiebilanzen, BMWi, Deutsche Bank Research

in some vehicle categories or for certain customer groups and purposes. However, it looks unlikely from the current perspective that the pace of large-scale progress in technical advances (e.g. upgrading the housing stock, replacing fossil fuels in heavy goods transport) will be fast enough.

Our first preliminary conclusion is that the 'Energiewende' to date has largely been a switch in electricity sources.

If any preliminary conclusion is to be drawn from the proportion of renewables in energy consumption in Germany, it is that the 'Energiewende' in Germany has so far been a switch in electricity sources; renewables in the power sector are currently ahead of target. Although the 2020 expansion target for renewables is also likely to be achieved in the heating market, the role of the 'new renewables' (wind power and solar energy) here and in the transport sector remains minor, which ultimately also applies to primary and final energy consumption. Outside the power sector, bioenergies continue to predominate, but their potential for expansion is limited. The focus of some political statements and parts of public-affairs reporting on the large proportion of renewables in the power sector therefore provides a distorted image of the overall importance of renewables.

Without a surge in energy efficiency, the energy transition will fail

The basic requirements for the success of the 'Energiewende' are a fall in energy consumption and a surge in energy efficiency in Germany. The German government has also drawn up various quantitative targets in these areas, which we will examine at the end of this section.

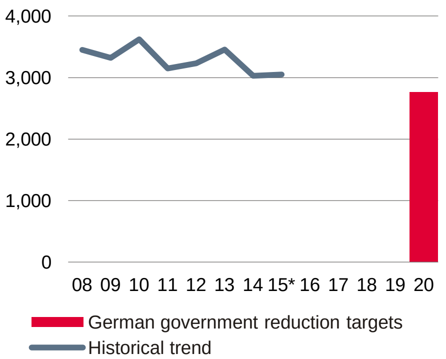
— The aim is for primary energy consumption Germany to be 20% lower by 2020 and 50% lower by 2050 (compared with 2008 in each case). In 2015, primary energy consumption was just 7.5% below the 2008 level. By 2020, there would have to be a further reduction of 13.5% in order to meet the target, but it is likely to be missed if weather conditions remain average and the economy performs as normal. Whether a 50% cut in primary energy consumption by 2050 is actually possible is, of course, difficult to say from today's perspective. It depends partly on technical advances, the future economic structure (e.g. the importance of energy-intensive industries) and average temperatures (i.e. climate change). The decline in Germany's population in the period to 2050 will be favourable for reducing primary energy consumption. The following figures show how ambitious the long-term target is. In the past 20 years, primary energy consumption in Germany has declined by just under 1,100 petajoules in absolute terms.[8] By 2050, i.e. in the next 35 years, primary energy consumption would have to fall by 6,100 petajoules in order to achieve the aforementioned 50% target, which means that it would have to contract three times more quickly in every year to 2050 than it has in the previous 20 years.

— One of the German government's other targets relates to gross domestic electricity consumption, which is supposed to be 10% lower by 2020 and 25% lower by 2050 (compared with 2008). This target also looks likely to be missed, because gross electricity consumption had only fallen by just under 3% between 2008 and 2015. The missing 7% or so would therefore have to be cut in the coming five years. It is doubtful whether the long-term target for gross electricity consumption can be achieved, or whether it can still be considered in any way reasonable. If a relatively large proportion of the energy supply in Germany is switched to electricity – as described above –

[8] Primary energy requirement in 2015 compared with the mean for 1994 to 1996. This period was selected so as to exclude the effect of German reunification.

Gradual decline in building heating requirement 20

Building-related final energy consumption for heating in Germany, petajoules

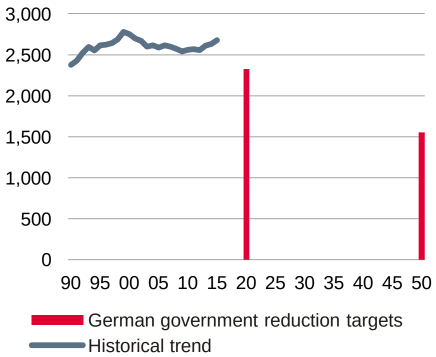


* Estimated value for 2015.

Sources: BMWi, Deutsche Bank Research

No reversal in energy consumption trend yet in sight for transport sector 21

Final energy consumption in transport sector in Germany, petajoules



Sources: AG Energiebilanzen, BMWi, Deutsche Bank Research

the additional number of users is more likely to push up total electricity consumption in the long term. This applies even if potential energy savings can be exploited.

— There are also energy-saving targets in the buildings sector and heating market[9]. The aim is for final energy consumption for heating buildings, which accounts for over one third of [10] final energy consumption in Germany, to be 20% lower in 2020 than in 2008, as well as reducing non-renewable primary energy consumption for buildings by 80% by 2050. The first goal was already more than halfway towards being achieved by 2015. In order to close the gap, politicians are (still) focusing on the familiar mix of regulatory law and subsidies. One regulatory measure is the Energy Saving Regulation (EnEV), which imposes greater requirements for energy efficiency in new buildings. There are also numerous subsidy programmes that support energy-efficient home improvements and the replacement of heating systems.[11] It is not unrealistic for the energy-saving targets mentioned above to be achieved by 2020, even though the regulatory measures and subsidies only affect a small proportion of all buildings at any time. Within the very short 2020 deadline, the weather is likely to remain the key factor. As an example, the year-on-year decline in final energy consumption relevant to buildings in Germany was over 12% in 2014 (high average temperatures). For the long-term target to be achieved, a large proportion of the building stock will have to be upgraded (heating systems and outer shells). In recent years, the rate at which the building stock has been upgraded was below 1%.[12] If this continues at the same pace, the long-term target will probably be missed. Ultimately, parallels can be seen here with the proposed switch to renewable energies in the heating market and buildings sector (discussed above). The energy-saving target also raises questions about the regulatory measures that building owners will be expected to comply with, and what is therefore (financially) proportionate and able to gain majority political support, as well as the state's capacity for subsidising the upgrade of the buildings sector. In a recent article, the ifo Institute of Economic Research pointed out that the tighter regulations imposed by the Energy Saving Regulation (EnEV) in 2009 and 2014 have contributed to the very sharp rise in average house-building costs. The authors also come to the conclusion that building projects may be postponed due to rising ancillary building costs and more stringent building regulations arising from government measures.[13]

— In the transport sector, the aim is to cut final energy consumption in absolute terms, by 10% by 2020 and by 40% by 2050 (compared with 2005 in each case). The short-term target is highly likely to be missed because final energy consumption in 2015 was 3.6% above (!) the 2005 value. As yet, there is no sign of a reversal in the trend in absolute energy consumption in the transport sector. Although the energy consumption per unit of transport has declined by 32% since the mid-1990s, this has been more than offset by the increasing transport volume (rebound effect). Added

[9] At the BMWi, there are various energy-consumption time series for heating, which stems from differing demarcations (e.g. inclusion of process heating).

[10] If final energy consumption for the areas of space heating, hot water and other process heating are included, the proportion of total final energy consumption rises to just under 54% (2014).

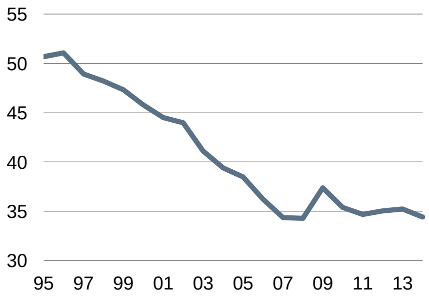
[11] For further measures, see: BMWi (2015). Die Energie der Zukunft. Vierter Monitoring-Bericht zur Energiewende. Berlin.

[12] See BMVBS (2013). Maßnahmen zur Umsetzung der Ziele des Energiekonzepts im Gebäudebereich – Zielerreichungsszenario. Berlin. The report points out the uncertainties involved in determining the upgrade rate. In February 2016, the BMWi reported that, in the past ten years, more than 4.1 million homes were either new builds or had been upgraded to improve their energy efficiency. This is equivalent to an annual rate of 1% of the housing stock in Germany.

[13] See Dorffmeister, Ludwig und Matijas Kocijan (2016). Auswirkungen der Energieeinsparverordnung auf die Baukosten im Wohnungsneubau. ifo Schnelldienst 6/2016. Munich.

Energy consumption per transport unit is falling (more slowly recently) 22

Energy consumption per unit in transport sector in Germany, megajoules per passenger kilometre*

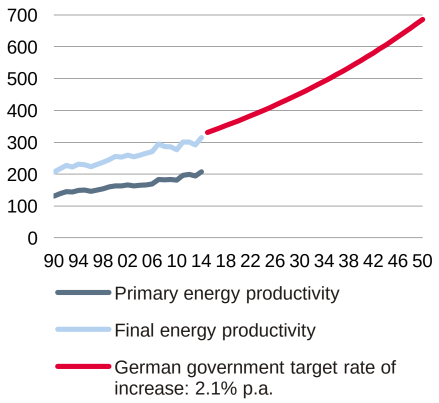


* These figures include both freight and passenger transport, assuming that one tonne kilometre is equivalent to ten passenger kilometres.

Source: AG Energiebilanzen

Very steady increase in energy productivity 23

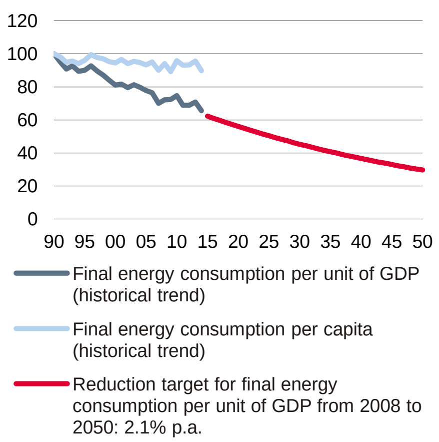
Energy productivity in Germany, real GDP per gigajoule of energy use, EUR



Source: AG Energiebilanzen

Specific energy consumption to fall sharply 24

Final energy consumption per unit of GDP/per capita in Germany, 1990=100



Sources: AG Energiebilanzen, BMWi, Deutsche Bank Research

to which, the progress in reducing energy intensity has slowed down in recent years. The findings of the past 20 years show that enhancing the efficiency of the vehicles concerned will not be enough to reduce energy consumption in the transport sector by 40% by 2050. The absolute transport volume in Germany would also have to decline at the same time. While this does not appear unrealistic for passenger transport – for reasons such as demographic change or future increases in travel costs – a move in this direction runs counter to all established traffic forecasts in freight transport. On balance, it is extremely doubtful that the long-term target can be achieved. The methods currently favoured by politicians concentrate on fuels (e.g. subsidising electric vehicles). EU-level CO_2 limits for cars will ensure that the average fuel requirement for the vehicle fleet will be lower. Extreme measures for reducing the absolute transport volume are even conceivable, such as regional restrictions (e.g. bans on certain vehicles driving in city centres) or making private travel more expensive, by increasing fuel taxes, charging tolls for cars or abolishing tax benefits for travel to work, for example. Again, this immediately raises the questions of (financial) acceptability and majority political support.

— To conclude this section, we are also looking at the political objective of increasing final energy productivity in Germany, which is the ratio of economic output to final energy consumption, or inversely, final energy consumption per unit of GDP (final energy intensity). The aim is for final energy productivity to rise by 2.1% per annum in the period to 2050. This would be a substantial increase compared with the improvements in productivity in recent decades, as annual growth in final energy productivity has 'only' been around 1.7% since the mid-1990s. The National Action Plan on Energy Efficiency (NAPE) comprises a number of measures intended to help to achieve the efficiency target. Here too, the range of measures includes regulatory components and specific subsidies, most of which focus on 2020.

Second preliminary conclusion: Many environmental and climate targets are likely to be missed

The information in this section has shown that many of the aforementioned environmental and climate-change targets set by the German government are unlikely to be achieved. In most cases, (significantly) greater efforts need to be made than in the past 20 to 25 years. Both the regulatory instruments and the specific subsidies, which have been the primary focus of politicians to date, present an obvious dilemma. Energy and climate-specific targets that are weak (or too weak) will fail to achieve the speed required to meet the targets, whereas regulatory law that is stringent (or too stringent) runs the risk of financially overburdening private households and companies. Applied to potential subsidies, this means that financial incentives that are too low will fail to produce the (full) desired effect, while significantly higher subsidies will be thwarted by the limited public budget.

Overall – measured by the intended targets – there are too few financially sustainable measures that would be cost-effective for private households and companies without subsidies. Generally, large-scale expenditure or capital investment, on energy-efficiency technologies for example, is only carried out when the equipment/machinery/buildings etc. hitherto in use is being modernised or replaced anyway. This is generally a rational decision from the perspective of the individuals concerned because they have the total costs in mind, not just the energy costs. As a result, the requirement for existing capital assets that have been used for years or decades to be upgraded presents an obstacle to the long-term energy-related restructuring of the economy, calling to mind the example of the building-stock upgrade. However, the issue of property-rights and freedom-of-choice infringements then quickly becomes relevant. With particular regard to long-term environmental-performance targets, it is quite possible that technical advances will result in certain developments much sooner than might be expected today, but we are currently very doubtful.

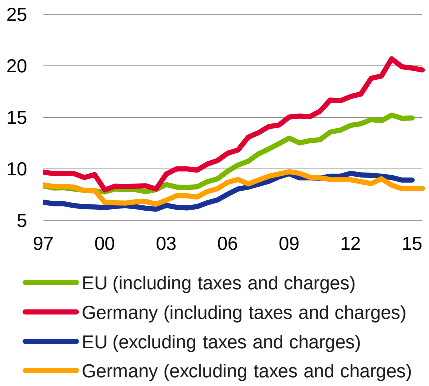
2.2 No quantitative targets for economics/efficiency

We have seen that the German government is pursuing many specific and quantifiable environmental performance targets. In the sections below we now take a look at the other two sides of the energy-policy target triangle, starting with economics/efficiency.

Unlike the environmental-performance targets, the economic targets are conspicuously worded much more vaguely and they cannot really be quantified. Ultimately, they state that energy prices must remain 'affordable' and that the competitiveness of German industry must not be jeopardised, but it is not clear what this means in detail. There is no quantitative target for the permitted levels that the price of electricity for private or commercial customers, the EEG surcharge, absolute EEG payouts or network charges can reach while still deemed to be 'affordable'. Nor is there a target for the level of public funds that can be earmarked each year to subsidise energy and climate-change policy measures. Targets for the maximum costs to households or companies created by regulatory law are also absent, but targets that are not specified or not designed to be measurable are liable to be ignored by decision-makers.[14]

Taxes and charges are the main drivers of electricity prices in Germany 25

Electricity price for industrial customers*, cents per kilowatt hour



* Annual electricity consumption between 500 and 2,000 MWh.

Source: Eurostat

Energy transition is raising electricity prices for (most) end customers

How have energy prices in Germany performed in recent years? Unlike the prices of internationally traded energy commodities (e.g. oil or coal), energy prices for end customers are heavily dependent on national regulation and consequently vary from country to country, sometimes significantly; this applies to petroleum and diesel, gas and electricity. The biggest impact of the 'Energiewende' on energy prices can be seen in the case of electricity. The EEG and the accelerated expansion of renewable energies resulting from it are having different effects on prices.

Wholesale electricity price is falling 26

Producer price index for wholesale electricity in Germany, 2010=100

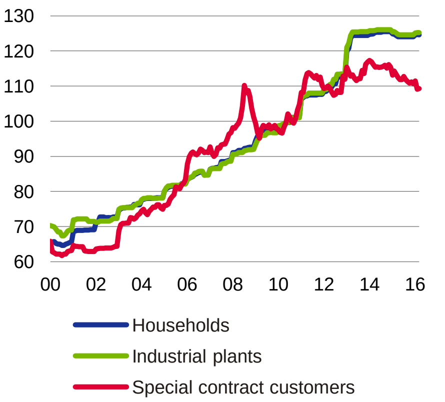
Source: German Federal Statistical Office

— The wholesale price of electricity is based on the marginal cost-pricing principle, i.e. the cost of the last kilowatt hour generated determines the price. The marginal costs of wind power and photovoltaics are virtually zero (the cost of an additional turn of a wind farm's rotor blade is practically non-existent), so they keep the wholesale electricity price down. The more electricity from wind power and photovoltaics is fed into the grid, the greater the effect, because more and more power stations with higher marginal costs are displaced from the market (merit-order effect). Ironically, relatively low-carbon gas-fired power stations, whose marginal costs are (currently) higher than those of coal-fired or nuclear power stations, have been hit hardest in recent years. Due to their greater CO_2-intensity per kilowatt hour, more EU ETS emissions certificates are required for the operation of coal-fired power stations than gas-fired power stations. Because certificate prices have recently been very low, coal-fired power stations have benefited more in relative terms than gas-fired power stations. Coal prices in the global market are also currently low. As a result, the wholesale price of electricity in Germany has followed a downward trend since about mid-2008 and in early 2016 it was almost 60% below the average level of 2011. This is also attributable to the expansion in wind power and photovoltaics, although

[14] See Kronberger Kreis (2014). Neustart in der Energiewende jetzt! Stiftung Marktwirtschaft. Berlin.

Sharp, long-term rise in electricity price 27

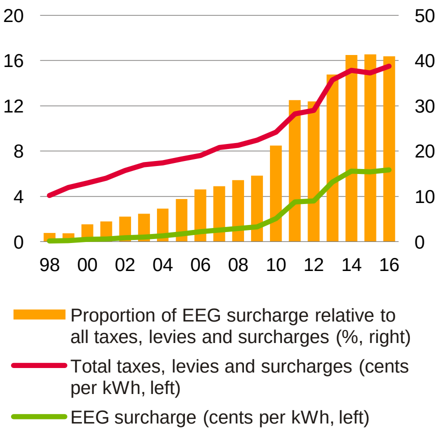
Producer price index, electricity for different customer groups, 2010=100



Source: German Federal Statistical Office

EEG surcharge is a major cost factor 28

Taxes, levies and surcharges on electricity price for households in Germany



Source: BDEW

other factors have been instrumental (such as the low prices for coal and natural gas and overcapacity in the electricity market).

— By contrast, the prices of electricity for private and (most) commercial end customers have risen sharply in the past few years. At the beginning of 2016, for example, the price for private households was more than 90% above the average level of 2000. Even for special contract customers, the electricity price rose by 74% during this period. The capital costs of installing equipment in the renewable energy sector is added to the price of electricity via the EEG surcharge. In 2016, the EEG surcharge amounts to 6.35 cents per kilowatt hour, which means that it accounts for more than 40% of all electricity taxes, levies and charges for private households. Other costs are also added to the price of electricity that are connected, partly at least, with the increase in the proportion generated from renewables. They include the costs of expanding electricity grids, 'redispatching' operations[15], subsidising CHP power stations and providing the capacity reserve. The Association of German Chambers of Industry and Commerce (DHIK) puts the total cost of expanding the total grid (including connecting offshore wind farms and the cost of laying underground cables) from 2016 to 2025 alone at EUR 50 billion. The cost of redispatching is estimated to be EUR 30 billion for the same period.[16]

By international standards, German electricity prices are high

The increase in electricity prices for end consumers in Germany has put them among the highest in the EU. Only in Denmark are prices slightly above the German level. Depending on statistical differentiation, the proportion of the electricity price paid by households in Germany that is attributable to taxes, levies and surcharges is between 48% (Eurostat, 2015) and 54% (German Association of Energy and Water Industries (BDEW), 2016). Excluding taxes and levies, German electricity prices would be in the mid-range for EU countries. Of course, not all taxes and levies are due to the 'Energiewende', but the EEG surcharge has been the biggest cost driver in the past. According to BDEW statistics, the recent slight fall in electricity prices is largely due to lower procurement and operating costs.

Energy-intensive companies benefit from exemptions

It must, of course, be mentioned that particularly energy-intensive companies in Germany enjoy exemptions (e.g. from the EEG surcharge or network charges) and receive special compensation. This is intended to safeguard the international competitiveness of the companies concerned, which is an understandable reason given the high electricity prices in Germany. Because the beneficiaries are companies that consume a great deal of electricity, the EEG surcharge and other levies mean that their absolute costs are considerable – despite the reduced rates. However, the highest percentage of costs incurred by these electricity consumers are for procurement and distribution and they are closely correlated with the wholesale electricity price. As a result, the downward pressure on the wholesale electricity price from the low marginal costs for wind

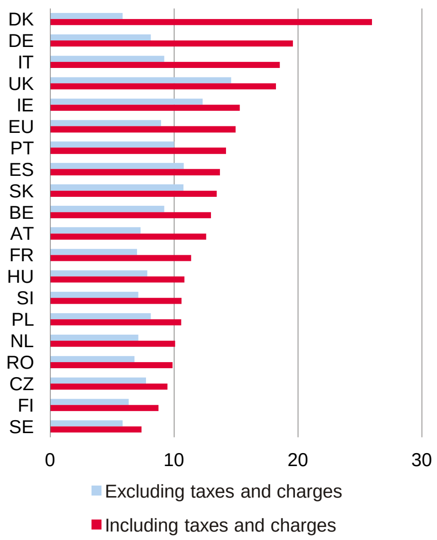
[15] The German Federal Network Agency explains redispatching as follows: Redispatching describes an intervention in the market-based operating schedule of generating units in order to shift feed-ins from power stations. Based on the contractual obligations of TSOs [transmission system operators], power stations are instructed to reduce their feed-in power, while other power stations are simultaneously instructed to increase their feed-in power. […] Redispatching is used by network operators to ensure the safe, reliable operation of electricity supply networks. It is carried out to prevent power lines becoming overloaded (preventive redispatching) or to relieve overloading on power lines (curative redispatching). The network operator must reimburse the power stations participating in the redispatch for the costs they incur. Federal Network Agency (2016). 2. Quartalsbericht 2015 zu Netz- und Systemsicherheitsmaßnahmen. Drittes Quartal 2015. Bonn.

[16] See DIHK (2016). Faktenpapier Strompreise in Deutschland 2016. Berlin.

power and photovoltaics has an positive impact on certain energy-intensive operations.

Prices of industrial electricity in Germany among the highest in Europe 29

Electricity price for industrial customers*, in second half of 2015, cents per kilowatt hour

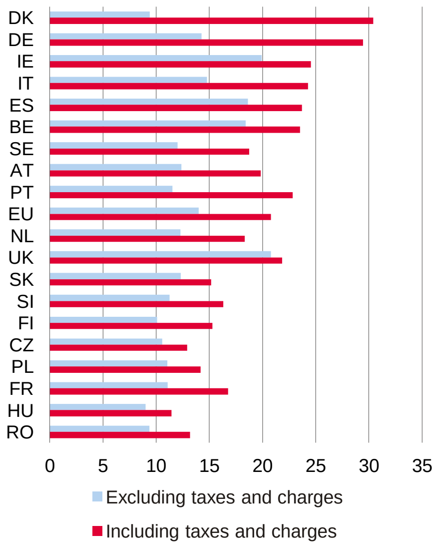


* Annual electricity consumption between 500 and 2,000 MWh.

Source: Eurostat

Electricity price (incl. taxes) particularly high in Denmark and Germany 30

Electricity price for households* in second half of 2015, cents per kilowatt hour

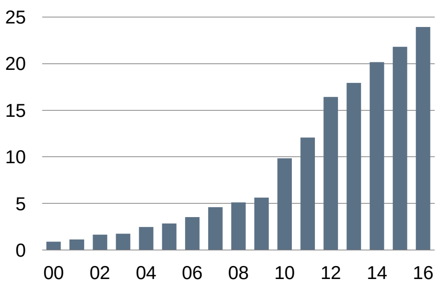


* Annual electricity consumption between 2,500 and 5,000 kWh.

Source: Eurostat

Steady rise in EEG differential costs* 31

EEG differential costs in Germany; EUR bn



* The EEG differential costs are calculated based on the remuneration and bonus payments to the operators of renewable-energy plants minus network operators' revenue from selling the electricity generated by those plants.

Figures for 2015 and 2016 based on forecasts.

Source: BDEW

Nonetheless, it should be borne in mind that these companies buy the bulk of their power requirements in advance in the forward markets. Low wholesale electricity prices in Germany are also keeping prices down in neighbouring European countries due to a degree of market coupling; as a result, companies located in Germany do not have a unique competitive advantage.[17] Furthermore, according to the BDEW, 96% of all industrial corporations in Germany pay the full EEG surcharge. It is particularly problematic for the companies concerned that they cannot be certain about how long they will benefit from the exemptions. This uncertainty is having a negative impact on investing activities in Germany.[18] Politicians will never be able to fully meet companies' demands for reliable parameters, but there is currently little to suggest that the conflict between uncertainties in energy policy and capital investment in energy-intensive sectors in Germany is about to be resolved.

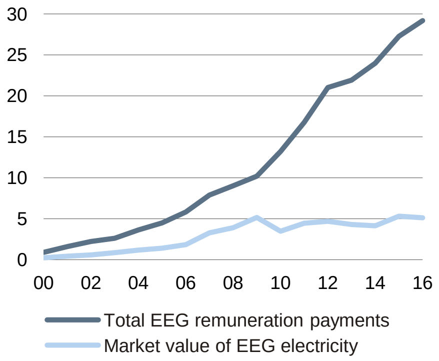
Absolute EEG costs are in excess of EUR 20 billion a year

According to the BDEW, EEG 'differential costs' – remuneration and bonus payments to the operators of renewable-energy plants minus network operators' revenue from selling the electricity generated by those plants – amounted to EUR 24 billion in 2016. The gap between the total EEG remuneration payments and the market value of the electricity fed into the grid has become wider in recent years. Remember that these costs only cover one part of the ‘Energiewende’, i.e. 'just' the electricity generated by renewables. They do not include the costs of network expansion, redispatching etc. The same applies to those costs resulting from the fact that the capacity utilisation of existing (fossil-

[17] See DIHK (2016). 2016 paper on electricity prices in Germany, Berlin.
[18] See Heymann, Eric (2013). Carbon Leakage: A barely perceptible process. Deutsche Bank Research. Current Issues. Frankfurt am Main.

The gap is widening 32

Total EEG remuneration payments and market value of EEG electricity in Germany, EUR bn



Source: BMWi

fuel) power stations is lower because renewables have priority feed-in (they are partly displaced because of higher marginal costs). As a result, the number of full-load hours for relatively low-CO_2 gas-fired power stations in Germany fell by almost 42% between 2010 and 2014, which significantly reduced their efficiency. Overall, the notional capacity utilisation (ratio of actual full-load hours per annum to maximum possible full-load hours) of gas-fired power stations was only around 23%. The costs of the 'Energiewende', which are (overwhelmingly) incurred in the heating market and the transport sector, are also left out of the EEG payments.

In 2012, we estimated that at least EUR 30 billion needed to be invested in Germany in order to achieve German energy and climate-policy targets.[19] If the annual EEG costs are interpreted as repayments of the capital invested in previous years, it is clear that our previous estimate was (much) too cautious. The following figure from the BMWi's Fourth Monitoring Report on energy transition shows how much capital has been invested in areas such as the building stock. It states that: *The cost of investment in the building stock that is relevant to energy is estimated at EUR 52.3 billion [in 2014].*[20] And in the transport sector, the German automotive industry alone invests tens of billions every year, a large proportion of which goes into researching alternative drive technologies and improving the energy efficiency of vehicles.[21] Clearly, this capital investment is not initiated by government regulation (alone), it would partly be carried out by the companies involved as a matter of course (because existing buildings are due to be renovated in any case, or because fuel consumption is becoming a more important factor for car buyers).

Are the costs of energy transition still within reason?

Energy transition is costing households more per month than the now infamously quoted cost of a scoop of ice cream

At the beginning of this section, we said that there is no specific energy-transition target for the economic components of the energy-policy triangle of objectives. So, in the first instance, it is impossible to make a generally applicable statement as to whether the costs of the 'Energiewende' are still within the limits of what politicians consider financially appropriate. When the EEG was introduced, though, its supporters certainly believed that the costs for consumers would be lower. It is an interesting question, but ultimately one that cannot be answered, whether there would have been widespread approval of the EEG if it had been clear to the decision-makers at the time of its introduction that the costs would run to more than EUR 20 billion a year. In 2015, the EEG costs would have been one of the biggest items in the German federal budget, ahead even of spending on education and research or healthcare. Nor has a quantitative target, such as a cap, been set for spending on energy and climate-change policy, which is decided by the federal budget (and additionally by regional and municipal budgets). Clearly, these funds are always competing with alternative uses.

EEG reformed in part due to rising costs

Despite the lack of specific objectives, the costs of the 'Energiewende' is the subject of political discussion as well as attracting the attention of both consumer-protection organisations and trade associations. The comment in 2013 from former German environment minister Peter Altmaier, who said that the costs of the 'Energiewende' could amount to EUR 1 trillion by the end of the 2030s, caused something of a stir. One of the aims of reforming the EEG is indeed to limit the rise in costs (by establishing expansion corridors, reducing the average remuneration, etc.). This was a step in the right direction, but the

[19] See Auer, Josef and Eric Heymann (2012). Germany's energy turnaround: Challenging for municipalities and municipal utilities. Deutsche Bank Research. Current Issues. Frankfurt am Main.
[20] BMWi (2015). Die Energie der Zukunft. Vierter Monitoring-Bericht zur Energiewende. Berlin.
[21] See German Association of the Automotive Industry (VDA, 2015). Jahresbericht 2015. Berlin.

outcome so far has still been a steady rise in EEG payments in absolute terms. For many other costs associated with the 'Energiewende', there are no authoritative or uniformly demarcated time series.

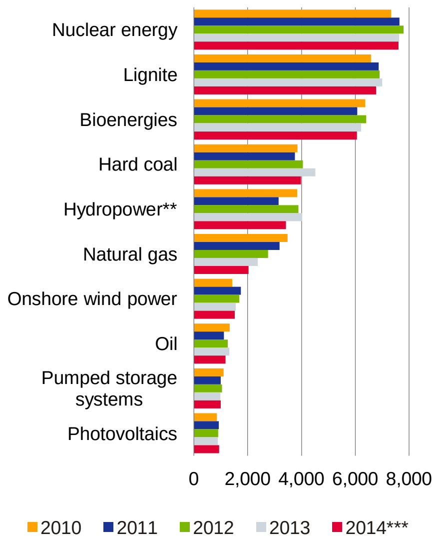
Reduced costs, e.g. for energy imports

Of course, the overall picture includes the fact that the costs of the 'Energiewende' are also offset by savings, such as lower energy consumption or fewer imports of energy commodities. The BMU points out that imports of fuel costing EUR 36 billion were avoided in 2012 due to the expansion of renewable energies and energy-efficiency measures. Of that amount, EUR 26 billion was attributable to greater energy efficiency[22], but these figures were not explained in further detail. It is not entirely clear, therefore, how these statements made by the BMU tally with statistics from AG Energiebilanzen (Energy Balances Group) showing a 2% rise in imports of both coal and mineral oil in 2012 (measured in energy units rather than monetary quantities). The only imports that declined were those of natural gas (down by 1.4%) and nuclear fuel (down by 7.9%). To date, fluctuations in world market prices for energy commodities based on fossil fuels are likely to have had the greatest impact on the German energy import bill.

We will re-examine the aspect of reduced energy imports resulting from the 'Energiewende' in section 4, but we would stress here that the deciding factor for companies and households is their own energy bill rather than the bill for the economy as a whole. In recent years, the (government-induced) rise in the cost of electricity has been a particularly dominant issue.

Substantial differences 33

Full-load hours per annum* in the electricity industry in Germany by power station type



* Significant output fluctuations during the course of the year have been taken into account.
** Running and stored water.
*** Preliminary figures.

Source: BDEW

Costs expected to rise further in near future

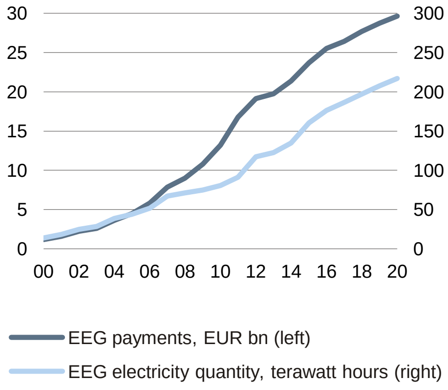
Despite the reforms to the EEG mentioned above, there will continue to be a fundamental 'problem', particularly with the new renewables (wind power and photovoltaics). They incur high up-front capital costs for installing the equipment concerned, although their marginal costs are extremely low once they are in operation because the actual 'fuel' – wind and solar energy – costs nothing. In contrast, fossil-fuel-fired power stations incur running costs for their energy sources (coal or gas) in addition to their initial investment costs, so their marginal costs depend partly on the prices for these fuels. As already mentioned, the low marginal costs for renewables depress the wholesale price of electricity as it is based on the marginal cost-pricing principle. Ultimately, the opportunities for wind power and photovoltaics to fund their up-front investment costs via the wholesale electricity price are diminished by their own low marginal costs. In a market based on marginal costs, the new renewables will (probably) always need to be subsidised. If these subsidies were to be removed, there would be a dramatic decline in capital spending on wind power and photovoltaics.[23] The speed and extent at which it is possible to reduce these subsidies will therefore be crucial for overall costs. Again, this is highly dependent on technical advances, but the quantity of electricity fed into the grid is also relevant to the total amount of the subsidy.

A further underlying problem for the new renewables is their low level of capacity utilisation. In 2014, the full-load hours for onshore wind power accounted for just 17% of the maximum possible full-load hours – despite priority feed-in. The figure for photovoltaics was barely 11%. Low levels of

[22] See BMU (2015). Klimaschutz in Zahlen. Fakten, Trends und Impulse deutscher Klimapolitik. Ausgabe 2015. Berlin.
[23] See Agora Energiewende (2012). 12 Thesen zur Energiewende. Berlin.

Rising in step 34

EEG electricity quantities and EEG payments in Germany

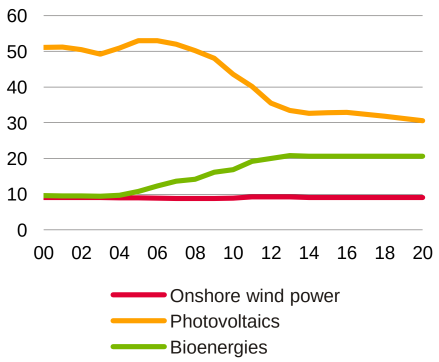


* From 2015: forecast by transmission system operators.

Source: BDEW

EEG remuneration is relatively stable for wind; for photovoltaics it is decreasing steadily 35

Average EEG fixed remuneration* for all EEG plants, cents per kWh

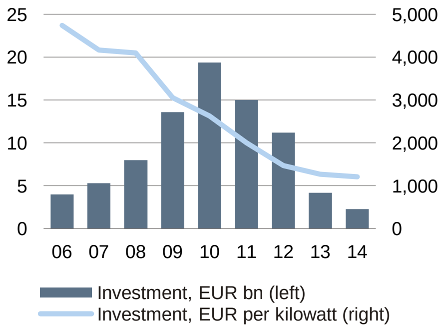


* From 2015: forecast by transmission system operators.

Source: BDEW

Photovoltaics: Specific capital investment costs are falling 36

Capital investment in photovoltaics in Germany



Source: BDEW

capacity utilisation are expensive. In terms of capacity utilisation, the hydropower (39%) and bioenergy (69%) perform much better.

What lies ahead in the coming years? The BDEW quotes forecasts from the transmission system operators, according to which the electricity quantities and payments under the EEG will continue to rise – at least until 2020 – so costs are expected to rise in absolute terms. A study into the future direction of the EEG surcharge per kilowatt hour commissioned by Agora Energiewende and carried out by the Institute for Applied Ecology (Öko-Institut) comes to the conclusion that the cost of the EEG surcharge will decline from 2023 onwards. This is because ageing power stations that receive relatively large EEG subsidies will no longer be subsidised from that point, and will be replaced by power stations for which lower subsidy rates apply. By 2023, the total of the EEG surcharge and the wholesale electricity price would increase by around 1 to 2 cents per kilowatt hour and would fall again thereafter – despite the further expansion of renewables. The study does not examine any other cost components of the electricity price in detail. In absolute terms, the remuneration entitlements of power station operators relating to renewable energies, would be almost EUR 30 billion a year in 2035 (at today's prices). The forecasts/scenarios are partly based on the assumption that net electricity consumption will remain constant until 2035.[24] Here too, it should be emphasised that 'only' the electricity generated by renewables is included.

Detailed economic targets are needed

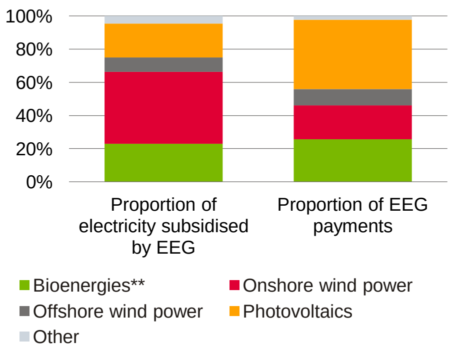
The longer the prediction horizon, the greater the uncertainty. This obviously applies equally to forecasts for the future costs of the 'Energiewende'. A democratic debate about the maximum permitted level for these costs would be helpful for acceptance of the project. To date, key blocks of costs in the 'Energiewende' (e.g. EEG payments) have been treated as a residual figure. There has been significantly less political negotiation about the level of the absolute costs than the distribution of the costs across different customer groups/electricity consumers etc. One outcome of this has been the lower EEG surcharge for energy-intensive companies. A politically tangible statement about the intended (approximate) direction of the total level of cost that is controlled by the government (e.g. a cap on taxes, levies and surcharges on electricity) would be useful for corporate investment decisions. Nor should the socio-political dimension be ignored, because energy and electricity costs account for a higher proportion of the disposable income of low-income households than they do for higher-income consumers. Expenditures on energy and climate-policy subsidy programmes are at least decided by democratic budget debates.

To make energy transition as affordable as possible, it would be necessary to deploy the resources available where they create the maximum benefit (whatever that may actually be). This is not currently the case. According to the BDEW, the remuneration in line with the EEG for a kilowatt hour of electricity generated by a photovoltaic array (almost 33 cents in 2015) is, on average, more than three times higher than if it were generated by an onshore wind farm.[25] It is true that photovoltaics are reporting immense technical advances, with the result that, according to the German Solar Industry Association, the feed-in tariff for new plants is currently between 8.5 and 12.3 cents per kilowatt hour. Based on existing plants, however, there will only be a slight narrowing of the gap between the average remuneration for electricity from photovoltaics and onshore wind power in the next few years (see chart 35). Furthermore, chart 37 shows that photovoltaics account for just under 42% of EEG payments in 2016,

[24] See Agora Energiewende (Commissioner, 2015). Die Entwicklung der EEG-Kosten bis 2035. Durchgeführt durch das Öko-Institut. Berlin, Freiburg.
[25] The data/statements refer to all installed wind/solar plants.

Expensive photovoltaics – wind power relatively cheap 37

Proportion of electricity subsidised by the EEG and EEG payments by energy source in DE in 2016*



* Preliminary estimation.
** Solid, liquid and gaseous biogenic fuels.

Source: BDEW

but they are only likely to account for just over 20% of the electricity subsidised by the EEG. Overall, it is clear that the performance of photovoltaics from a financial perspective is worse than that of sources such as onshore wind power (currently much worse). There are other political initiatives that are not cost effective and also not beneficial in terms of climate protection, such as the recently approved direct bonuses for buyers' of electric vehicles.[26] In the case of the EEG, politicians have responded by cutting the average subsidy rates. In the future, they are likely to pay more attention to the cost-effectiveness of the energy and climate-change policy. This not only applies to the electricity sector, which has been the focus of this section, but also of course to the buildings and heating market as well as the transport sector.

2.3 Security of supply is non-negotiable, but it is becoming more expensive

For Germany with its innovative and technologically advanced industrial companies and service providers, a reliable energy supply is essential and, consequently is non-negotiable. Politicians (naturally) share this view. So does this mean that further targets are needed? From an economic perspective, at least, the question that arises is the cost of security of supply.

The 'Energiewende' (primarily the shift in electricity generation) is accompanied by new challenges for a secure energy/electricity supply. Ensuring that grids operate more safely requires different measures when the power supply is switched from major power stations (with base-load capacity) to numerous distributed plants that feed in power intermittently depending on the weather (but are guaranteed priority by law).

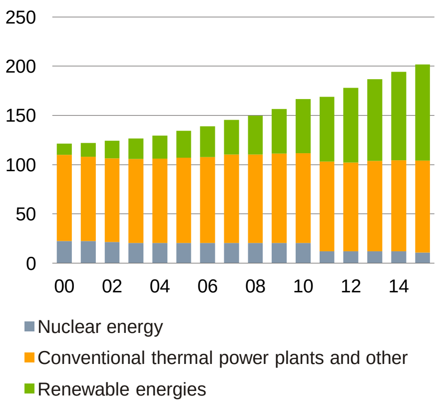
Fewer power failures

So far, this transition has clearly worked well overall: the BMWi has determined that the downtime in 2014, i.e. the period within one year in which the power supply for end users was interrupted, was only about 12 minutes or so. This was the lowest it had been since it was first recorded (2006).

This means that there has been guaranteed security of supply for electricity in Germany to date[27], but security of supply comes at a price in the new electricity market. We have already mentioned the cost of redispatching that ultimately must be attributable to the objective of security of supply. In recent years, redispatching has increased in frequency. The Federal Network Agency reports that incidences of intervention totalled 8,453 hours in 2014, compared with just 1,588 hours in 2000. In the first half of 2015, intervention incidences already totalled 5,690 hours. The costs of expanding the grid also contribute to security of supply. One criticism in this respect is the fact that the operators of power generation plants choose their location with relatively little regard for the grid expansion costs that will then be required.[28] Of course, it is also clear that not all investment in the electricity grid is attributable to the process of the 'Energiewende'.

Increasing capacity 38

Electricity generation capacity installed in Germany, gigawatts



Source: BDEW

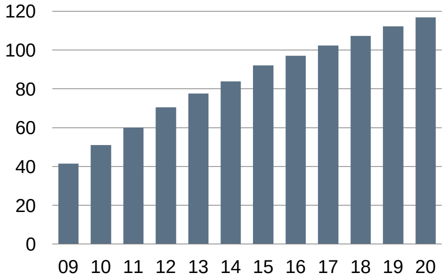
Capacity reserve versus capacity market

The capacity of renewables in the German electricity sector will be further expanded in the next few years. According to transmission system operators' forecasts, the installed capacity in 2020 of renewable-energy plants alone (around 117 gigawatts by then) is likely to be more than 40% (around 35

[26] See Heymann, Eric (2016). Cash incentives to purchase electric cars are not the ideal solution. Deutsche Bank Research. Talking Point. Frankfurt am Main.
[27] This also applies to the supply using oil, coal and gas as energy sources that can be purchased in the global market.
[28] See Haucap, Justus and Beatrice Pagel (2014). Haucap, Justus und Beatrice Pagel (2014). Ausbau der Stromnetze im Rahmen der Energiewende: Effizienter Netzausbau und effiziente Struktur der Netznutzungsentgelte. Düsseldorf Institute for Competition Economics. Düsseldorf.

Expansion of renewables continues 39

Installed capacity of the EEG plants* installed in Germany, gigawatts



* From 2015: forecast by transmission system operators.

Source: BDEW

gigawatts) higher than the current peak load (i.e. the maximum output required at a specified time); after 2020, the installed capacity of renewables will increase further. At the same time, the electricity generated from the new renewable energy sources (wind power and photovoltaics) will remain dependent on the prevailing weather conditions and it will not be possible to ramp it up quickly at will. Overall, situations are increasingly likely to arise in which renewable energies temporarily meet (virtually) all the demand for electricity. However, in order to guarantee security of supply, sufficient capacity must be reserved for times it is dark and calm, i.e. when there is little wind or sunshine.

In this situation, all other things being equal, the capacity utilisation of the power stations required to close the gap as necessary is lower, and so is their profitability. In fact, many 'traditional' power stations have ceased to operate at a profit in recent years and companies have applied to the Federal Network Agency to close them. In the past few years, there has been increasing discussion about whether a market for providing or maintaining capacity for security of supply needs to be created (capacity market) or whether it would be sufficient to change the design of the electricity market to secure supply.

Disagreement on the issue of whether Electricity Market 2.0 plus capacity reserve can ensure security of supply

To this end, the BMWi published a White Paper during the summer of 2015[29] making the case for a mechanism known as Electricity Market 2.0. Among other things, this is intended to enable power plants to be operated profitably (even if capacity utilisation is low) by allowing temporary price peaks to cover peak load demand. A capacity reserve is also intended to safeguard the supply of power. Unlike a capacity market, the capacity reserve includes *only power plants that do not participate in the electricity market and […] are only used if, contrary to expectations, the supply cannot satisfy the demand despite unrestricted pricing on the wholesale market*.[30] An initial response to the White Paper from the German Energy and Water Industries Association (BDEW) indicated that there was some disagreement about this issue: the BDEW stated it was *not convinced* that an energy-only market *could be set up adequately to ensure, together with a modest capacity reserve, permanent security of supply at a high level*.[31]

Falling capacity utilisation in the electricity sector is relevant to costs

We do not intend to go into the discussion surrounding Electricity Market 2.0 in greater detail here, but would highlight once again that security of supply in an electricity market shaped by renewable energies gives rise to costs that are frequently overlooked in the public discussion. We have explained that the use of the new renewable energies is generally associated with low capacity utilisation (low number of full-load hours). As the proportion of the energy mix accounted for by renewables rises, capacity utilisation in the remaining fossil-fuel-based power plants will tend to fall because these plants are only intended in the future to make up for the shortfalls that the renewables are unable to cover. Other conditions remaining the same, this will lead to a fall in average capacity utilisation across the entire electricity sector and therefore to lower profitability.[32] Under the laws of economics, a corresponding price will need to be paid somewhere along the line.

[29] See BMWi (2015). Ein Strommarkt für die Energiewende. Ergebnispapier des Bundes-ministeriums für Wirtschaft und Energie (Weißbuch). Berlin. See also: Connect (2015): Endbericht Leitstudie Strommarkt 2015. Im Auftrag des Bundesministeriums für Wirtschaft und Energie. Berlin. And: Cologne Institute for Economic Research (2015). Ein Strommarkt für die Energiewende – Leitlinien für die Zukunft? Stellungnahme zum Ergebnispapier des Bundesministeriums für Wirtschaft und Energie (Weißbuch) Cologne.

[30] BMWi (2015). Ein Strommarkt für die Energiewende. Ergebnispapier des Bundesministeriums für Wirtschaft und Energie (Weißbuch). Berlin.

[31] BDEW (2015). Stellungnahme zum Ergebnispapier des Bundesministeriums für Wirtschaft und Energie (Weißbuch). Ein Strommarkt für die Energiewende. Berlin.

[32] The think tank Agora Energiewende pointed out in 2012 that there will no longer be any base load power plants in the future. See Agora Energiewende (2012). 12 Thesen zur Energiewende. Berlin.

Storage technologies required in the long term

Excess supply can lead to negative prices on energy exchanges

Rising compensation payments for unused surplus capacity

The discussion about capacity reserves and capacity markets arises because there will be many times when renewable energies are unable to meet the required level of supply. The other extreme, in which renewables produce more electricity than is required to meet the prevailing level of demand, is likely to occur more often in the future. This is also related with higher costs because the electricity generated from renewables is generally paid for and should therefore be used. Oversupply of electricity can lead to negative prices on energy exchanges, with the result that the customer has to be paid to take the surplus electricity. Even if the electricity production from renewables has to be temporarily limited (and is therefore also not fed into the grid), the operators of the plant currently receive compensation for this unused surplus capacity; by way of example, in Schleswig-Holstein in 2014, this compensation is likely to have amounted to approximately 10 cents per kilowatt hour.[33] The unused surplus capacity and the associated compensation payments have risen sharply in the last few years. According to the Federal Network Agency, the total for the whole of 2014 was EUR 83 million. For just the first three quarters of 2015, the compensation payments are estimated at EUR 276 million.[34] It is obvious that this type of system is extremely inefficient and expensive. The greater the gap between the installed renewables capacity and the peak load in Germany, the more frequent the questions about what to do with the temporary excess of electricity.

Many studies have agreed that, in the short to medium terms, the expansion of electricity grids including greater European grid integration combined with flexibility options across all power plants and on the demand side (load management) could be sufficient to absorb any temporary oversupply. In the medium to longer terms however, high-performance electricity storage technologies are likely to be necessary. It is hoped this will contribute to the security of supply and enable the excess supply to be used economically.

Pumped hydroelectric energy storage is currently the only usable large

We have not carried out a detailed examination of different measures on the demand side or various storage technologies because this would be outside the scope of this report.[35] However, we will address some aspects of the storage issue. Currently, only pumped hydroelectric energy storage facilities are used for large-scale storage in Germany.[36] According to the BMWi, pumped storage is the sole storage technology available at present that can be used on sizeable scale. At the moment, batteries and other storage technologies are of little significance other than in private applications or in specific niche markets (such as electric vehicles). The conversion of (surplus) electricity into gas or liquid fuels (power-to-gas and power-to-liquid conversion) looks like a highly promising technology over the long term, but this will require huge technological advances. Currently, the power-to-gas technology is still expensive (for example because

33 See Schleswig Holstein Ministry of Energy, Agriculture, the Environment and Rural Areas (2015). Abregelung von Strom aus Erneuerbaren Energien und daraus resultierende Entschädigungsansprüche in den Jahren 2010 bis 2014. Kiel.

34 See Federal Network Agency (2016). Federal Network Agency (2016). 2. Quartalsbericht 2015 zu Netz- und Systemsicherheitsmaßnahmen. Drittes Quartal 2015. Bonn. And: Federal Network Agency (2016). Monitoringbericht 2015. Bonn. Also: Fraunhofer Institute for Wind Energy and Energy System Technology (2015). Windenergie Report Deutschland 2014. Kassel.

35 Comprehensive information on energy storage can be found in: Fraunhofer (2014). Abschlussbericht Metastudie "Energiespeicher". Studie im Auftrag des Bundesministeriums für Wirtschaft und Energie (BMWi). Kassel, Oberhausen. See also: Agora Energiewende (2014). Stromspeicher in der Energiewende. Untersuchung zum Bedarf an neuen Stromspeichern in Deutschland für den Erzeugungsausgleich, Systemdienstleistungen und im Verteilnetz. Berlin.

36 A pumped storage hydroelectric plant requires two linked reservoirs (or natural lakes) at different altitudes. Low-cost power is used to pump water from the lower to the upper reservoir. The electrical energy used in this process is converted to the potential energy of the stored water. The water is then released from the upper reservoir to the lower reservoir (for example, when electricity is expensive or in short supply) and is directed through a turbine to generate electricity, which can then be fed into the grid.

of the required capital investment and conversion losses). It will be many years yet before we see profitable large-scale use.[37]

Pumped storage capacity in Germany (too) small

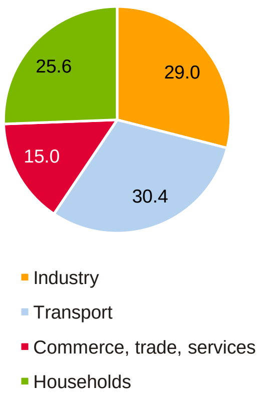
Returning to pumped hydroelectric energy storage, Deutsche Bank Research published a paper in 2012 in which the total pumped storage capacity in Germany was estimated at 40 gigawatt hours.[38] A further study in 2012 calculated a similar figure (44 gigawatt hours).[39] In the meantime, storage capacity is likely to have risen slightly. The two studies referred to above indicate that storage capacity could increase over the medium to long terms to around 65 to 90 gigawatt hours, even though new construction projects frequently attract protests and, if nothing else, can be delayed as a result. We have created a theoretical calculation to illustrate the extent to which pumped storage could help to absorb the excess output (from renewables). The calculation assumes that all pumped storage capacity in Germany (estimated at 45 gigawatt hours) is available (i.e. all upper reservoirs are assumed to be empty). It is also assumed that the excess output is 5 gigawatts. If this excess output were used exclusively to pump water to the upper reservoirs, these reservoirs would be full again after 9 hours. In the future however, the actual excess output is likely to be significantly higher, which is why pumped storage in Germany only offers a small buffer, even if capacity were to be doubled. For the time being therefore, it is reasonable to assume that the output from renewable energy power plants will frequently (or more frequently) have to be regulated in the event of excess production. One possible solution would be to use storage capacity in countries such as Norway, Austria or Switzerland, which have landscapes better suited to pumped hydroelectric storage facilities.[40] We do not intend to discuss here the extent to which this possible solution is realistic.

Pumped storage can only provide a small buffer

The theoretical calculation can be looked at in a different way by posing the question as to how long full pumped storage facilities would allow Germany to cope with a period in which its renewables-based generating capacity were 'becalmed'. Let us assume there were a feed-in shortfall of (just) 10 gigawatts. The current pumped storage capacity could only cover this shortfall for 4.5 hours. Even in this case, doubling the capacity would still only provide a small degree of extra cover. Until other storage technologies become available and unless electricity can be imported in the requisite volumes when required, flexible power plants that are capable of covering the base load will probably continue to play a key role in the German energy market, even over the longer term.

Transport and industry consume the largest amount of energy 40

Proportion of the sectors to final energy consumption* in Germany in 2014, %



* Total final energy consumption: 8,647.9 petajoules.

Source: BMWi

The simple calculations aim to show that the storage issue is relevant not only because of the associated costs[41] (which we have not discussed here in any detail at all) but also because of the absolute physical capacity limits involved. This applies in particular when large-scale use is considered. However, as

[37] See German Energy Agency (2015). Systemlösung Power to Gas. Chancen, Herausforderungen und Stellschrauben auf dem Weg zur Marktreife. Berlin. See also: Ganteför, Gerd (2015). Wir drehen am Klima – na und? Wiley-VCH. Weinheim. Also: Auer, Josef (2014). Germany's 'Energiewende' driving power-to-gas. From an idea to market launch. Deutsche Bank Research. Current Issues. Frankfurt am Main.

[38] See Auer, Josef (2012). State-of-the-art electricity storage systems. Indispensable elements of the energy revolution. Deutsche Bank Research. Current Issues. Frankfurt am Main.

[39] Energy Research Center Stuttgart (2012). Stromspeicherpotenziale für Deutschland. Stuttgart.

[40] See German Advisory Council on the Environment (2011). Wege zur 100 % erneuerbaren Stromversorgung. Sondergutachten. Berlin.

[41] A critical factor in the profitability of pumped hydroelectric plants is the extent to which the electricity used by the plants is subject to taxes and other levies. Various energy industry associations, together with the German Engineering Federation (VDMA) and the German Association of Local Utilities (VKU), together issued a request at the beginning of 2016 that energy storage facilities not be classified as an end consumer, because otherwise the power they generate would be subject to double charges, for example in respect of grid fees.

regards the use of storage technologies in private households, we generally agree with the proposition put forward by Agora Energiewende, for example, that a combination of local photovoltaic installations and local energy storage facilities could prove to be economic at micro level (but not necessarily at macro level) in the near future if the conditions were right. There would still need to be a great deal of technical progress before this statement were also true for systems used by major local electricity consumers, such as steel or chemical plants.

Interim summary: Many hidden costs and technological challenges

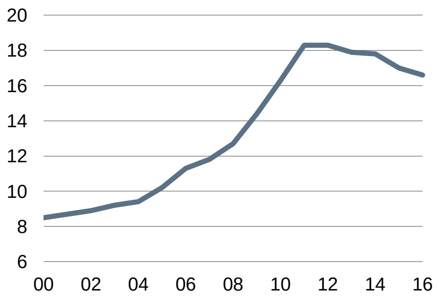
This section has demonstrated that the issue of security of supply is generally manageable from a technical perspective. However, there are many hidden costs and enormous technical challenges. From a political viewpoint, the creation of individual economic performance targets ought to be considered to support the overall objective of security of supply. At the very least, the total costs associated with ensuring security of supply ought to be communicated in a more transparent manner.

2.4 Cost scenarios

To conclude this section we have tried to combine the environmental and economic targets described above and draw up a highly simplified cost estimate (without a specific target date). Our starting point is primary energy consumption[42] in Germany, which was just under 3,700 billion kilowatt hours in 2015.

Average remuneration has been falling for several years 41

Average EEG remuneration, cents per kWh



Source: BMWi

— Let us suppose that primary energy consumption is successfully cut by 15% and the proportion of renewables in the energy mix is increased to 30%. Let us also assume that the average payment for energy based on renewables is 15 cents per kilowatt hour (under the EEG it is currently just under 17 cents). In this scenario, the costs 'just' for the 30% accounted for by renewables would come to more than EUR 140 billion per year. On top of this, there would be the costs for the other fuels, energy infrastructure, networks, etc.

— In a more challenging scenario, primary energy consumption is cut by 25%; the renewables proportion rises to 40%. We have also assumed faster technical progress, with the result that the average cost per kilowatt hour is 'just' 12 cents. The overall annual costs in this case would then be just under EU 125 billion. In this scenario, the costs of reducing primary energy consumption, which are not included in the amount of EU 125 billion referred to above, are likely to be considerable. As in the first scenario, the costs for other energy sources, networks etc. would need to be added on top.

— The third scenario comes very close to the long-term target set by the German government: a 50% reduction in primary energy consumption and an increase in the renewables proportion to 60%. As in the other scenarios, the average payment per kilowatt hour is an important lever: if this could be successfully lowered to 8 cents, the costs (just) for the energy from renewables would amount to just under EUR 90 billion p.a. The capital investment costs to reduce energy consumption in this case would probably be very high indeed. Of course, there would be lower ongoing energy costs on the other side of the equation; the overall outcome in economic terms

[42] We are not using final energy consumption as a reference value because there will still be conversion losses, even in the case of renewable energies, especially if the energy is subject to interim storage and used in the heating market and transport sector.

would depend on many factors, such as energy prices, technical progress, etc. Furthermore, in this scenario, the costs of upgrading vast sections of the heating market (more than 40 million homes in the housing stock) and of the transport sector to electricity would be particularly significant. In a world in which 60% of the total energy supply were based on renewables, there would then also be a further very high level of costs for storage, capacity reserves and load management to be added to the other blocks of costs (networks, other energy sources and infrastructure).

The scenarios are only intended as food for thought. It is useful to compare the absolute figures against other reference values. This gives you a sense of the approximate orders of magnitude involved. For example, the entire German federal budget for 2016 provides for expenditure totalling EUR 316.9 billion. The gross value added in the German energy supply sector in 2014 amounted to EUR 49.6 billion. The costs issue could be summarised by saying that the 'Energiewende' only stands any chance of being affordable (without a serious loss of prosperity) if dramatic technical progress (and thereby a fall in prices) is achieved in energy-efficient technologies and renewable energies. If unit costs do not fall significantly in either of these two factors, the energy transition would probably turn out to be much too expensive and would therefore fail. An additional critical factor affecting the necessary technological progress is the timeframe, because there are now 'only' 35 years remaining until the middle of the century.

Dramatic technical advances required in renewable energies and energy

3. Policy instruments: less is more – writing on the wall for the EEG approach?

We have seen how the government relies on a broad mix of mechanisms to shape the switch to renewable energy sources. To date, it has focused mainly on regulatory measures and subsidies, and we are likely to see further measures in the next few years.[43] Many taxes and levies also include environment-related components. The EU ETS is a key mechanism at European level.

EEG vigorously debated

For some years, there has been a vigorous debate about mechanisms other than the EEG that could be used to encourage expansion in the use of renewables. Some market players and academics (including many economists) are critical of the EEG[44], although it is broadly recognised that the EEG has enabled the use of renewables to be ramped up and has fostered advances in technology. Other countries involved in the renewables sector are also benefiting from the fall in costs. However, the high costs associated with the EEG are coming under increasing criticism, especially as renewables no longer occupy just a niche in the power market. Differences between the levels of subsidy available for the various technologies (such as wind power and photovoltaics) are also creating a situation in which the focus is not necessarily on the least expensive forms of renewable energy. Another criticism is that the EEG is felt to conflict with, and weaken, the EU ETS.[45]

[43] The following comprehensive compilation of potential measures concerning energy and climate policy illustrates the mechanisms under discussion by various policymakers: BMU (2016). Maßnahmenkatalog. Ergebnis des Dialogprozesses zum Klimaschutzplan 2050 der Bundesregierung.
[44] By way of example, see: Weimann, Joachim (2013). Rettet die Energiewende? Warum eigentlich? Wirtschaftsdienst. Issue 11. November 2013. Hamburg.
[45] A consequence of the provision of support for renewable energies through the EEG is that demand for fossil fuels in Germany is falling. This means that the demand for, and the price of, emissions certificates in the EU ETS is dropping too. Power station operators in other countries are benefiting from the lower price and can make use of the certificates that have become available. At European level, there have been no changes to the cap on CO_2 emissions covered by the ETS.

To date, changes have been made primarily to the existing system

Modifications to the existing system are the preferred method of preventing undesirable side-effects from the EEG – strategy has only had limited success

So far, policymakers have only modified individual aspects of the existing system of incentives. As soon as undesirable effects have been observed in particular areas, policymakers have tried to eliminate or mitigate these effects by tweaking the system. In most cases, these corrective measures have then had a negative impact at other points in the system. One example is the issue of independent power generation and own consumption. Previously, independent power generation and own consumption was exempted from many of the levies in connection with the EEG. Consequently, many companies then focused on expanding their own power generation; generally speaking however, they still remained connected to the German electricity grid. The more players were able to withdraw from the financing of the entire system costs by using their own power generation, the greater the costs that had to be borne by the remaining electricity customers. Policymakers responded to this trend by ensuring that the EEG reforms in 2014 included new independent power generation plant built primarily for own consumption in the EEG levy, although there were exemptions for smaller facilities. It is little wonder that this decision met with opposition from those players contemplating an increase in the use of independent power generation. Another example is the speed of expansion in renewables: the corridors for renewables expansion referred to above also represent a response by policymakers to the sharp growth in installed renewables capacity, especially in the years 2010 to 2012. The limitation on the creation of additional capacity associated with the expansion corridors was criticised by businesses and associations in the renewables segment.

System changeover perhaps possible or probable only in the longer term

Alternatives: more direct marketing, invitations to tender ...

In the last EEG reforms, policymakers departed somewhat from the previously prevailing approach, which had largely isolated the operators of renewables-based power plant from demand risk (priority feed-in and guaranteed purchase at fixed rates). With the transition to compulsory direct marketing, operators must pay much closer attention to the demand side. The aim of issuing invitations to tender for specific output volumes in a competitive market is to leverage potential cost savings. The change is also intended to prevent the installed renewables capacity from permanently expanding faster than the network or load management capability for example. The rise in compensation payments for unused surplus capacity (see section 2.3) demonstrates that this change is a necessary requirement.

… or a quota system

A quota model would offer another way of increasing the proportion of renewables in the energy mix. In this model, power plant operators (or other players involved) would have to feed a specific quota of electricity from renewable energy sources into the network; this quota would rise over time. One advantage of the quota model is that it allows installed capacity to be managed. Market players would also aim to market low-cost renewable energies as far as possible, opening up the possibility of cost savings compared with the current system.[46]

Emissions trading, (theoretically) the ideal solution

The best solution from a theoretical perspective (at least according to the textbooks) and the one preferred by many economists would be to integrate renewable energies into emissions trading. This mainly applies if the primary objective of energy and climate policy is to limit CO_2 emissions to a particular

[46] A detailed discussion of different systems can be found, for example, in: Kronberger Kreis (2014). Neustart in der Energiewende jetzt! Stiftung Marktwirtschaft. Berlin.

level. Although the EU ETS has been criticised in recent years (oversupply of CO_2 certificates and consequent fall in prices), this instrument will nevertheless reduce CO_2 emissions in the sectors involved within the EU by 21% (compared with 2005) by 2020, as intended. The success rates of many other approaches to energy and climate policy are significantly worse than this. Furthermore, the (actual) shortcomings of the current EU ETS can all be remedied in the medium term.

Emissions trading is environmentally effective and economically efficient

In an emissions trading system, the number of emissions certificates (for example for CO_2) is capped in advance. These certificates are allocated to the individual market players (by means of an auction for example) and can then be traded. Businesses able to reduce their emissions at low cost sell surplus certificates to businesses with higher CO_2 reduction costs. The bottom line is that emissions are reduced where the least cost is incurred. This approach is therefore effective, because the carbon reduction objective is attained, and also efficient, because the costs incurred are low. Emissions trading produces a uniform price for CO_2. In contrast, the current mix of instrument gives rise to a very large number of different CO_2 prices, which is a clear indicator that the system is both economically and environmentally inefficient.

If renewables were integrated into the EU ETS, power plant operators (or other players involved in the system) would analyse where they could achieve the greatest reduction in emissions based on a given allocation of resources. Capital investment in renewables would therefore be in competition with other action to reduce emissions. If this alternative action were less expensive, there would be no capital investment in renewables (in the absence of other subsidies). The more challenging the overarching CO_2 reduction targets, the greater the increase in the price for emissions certificates. As soon as the cost of the investment in renewable energies to avoid CO_2 emissions were the same as or lower than the certificate price, the investment would become cost-effective. Naturally enough, businesses would then focus on the least expensive technologies and the most favourable locations (i.e. at present on onshore wind energy rather than photovoltaics). Given the current price of CO_2, capital investment in renewables would currently (largely) be rejected in this type of system. Any economist looking at the situation objectively would judge this to be an outcome of market forces rather than a disaster.[47]

EU ETS could be combined with other emissions trading systems

A scenario of this nature – which would effectively mean the end of the EEG – is currently purely hypothetical. At the moment, there is practically no discussion among policymakers about this kind of radical change in the system – let alone the prospect of a political majority. However, over the medium to longer term, there are good reasons for including other sectors of the economy (such as the transport sector and heating market) in the EU ETS in addition to renewable energies.[48] The EU ETS would have to be comprehensively reformed, but the basic idea outlined above would still remain in place. In the future, the EU ETS could then be combined with similar trading systems that emerge, for example, in the US or China. Another advantage would be that these changes would reduce the significant number of instrument currently used to implement energy and climate policy in detail. The principle of 'less is more' would apply. The author is well aware that this kind of system transformation is a (very) distant dream. Nevertheless, most economists agree that CO_2 needs to have a price so

[47] Whether emissions trading would be adequate by itself to sufficiently encourage development of the dynamic efficiency of green technologies is a matter of hot debate. Thus, the question arises as to whether an emissions trading system would provide sufficient incentive for R&D effort in those technologies only likely to come to fruition over many years or even decades.

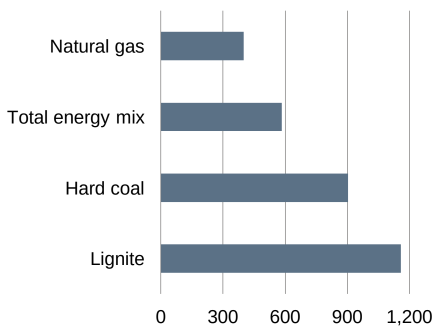
[48] See Heymann, Eric (2014). CO_2 emissions from cars. Regulation via EU Emissions Trading System better than stricter CO_2 limits. Deutsche Bank Research. Current Issues. Frankfurt am Main. The transport sector and heating market could be integrated into emissions trading using an upstream approach in which fuel producers and importers, rather than homeowners or car drivers for example, would participate in the trading.

that the external effects of CO_2 emissions can be internalised. An emissions trading system with the greatest possible global reach would be a good way of achieving this – and at the same time would be highly likely to meet the environmental aims.

Even more government?

Natural gas has low CO_2 intensity 42

CO_2 emissions factors in the German energy mix* in 2012, grams per kilowatt hour



* By energy source, based on electricity consumption.

Source: Federal Environment Agency

The last few years have seen an increase in government influence in the energy market (especially in the electricity sector). One extreme – and also politically unlikely – option for restructuring energy supply would be for the state to take on a much greater role and even act as a provider (in some segments). Ultimately, the German government aims to reduce CO_2 emissions in the country, end the use of nuclear power and increase the proportion of renewable energy sources in the energy mix; from the perspective of CO_2 emissions, gas-fired power stations (ideally with a high proportion of CHP), which emit low levels of CO_2, offer the best option for plugging the gap that cannot be covered by the use of renewables. Structural change of this nature – involving a move towards combining renewables and gas-fired power plants with a high CHP component – will not be brought about by market forces alone. Therefore, the government could (for example, by using invitations to tender) 'order' exactly the power generation capacity needed to achieve its specified objectives. If no companies could be found to provide the particular capacity required, the government could itself become a provider. This restructuring (or most of it) would then not be financed through electricity or energy prices, but from the general public finances, i.e. through taxes. An advantage would be that the expenditure would be authorised year after year through the democratic process and would be transparent. The costs of the 'Energiewende' would then have to compete with social security, education and research, healthcare, homeland security and defence for a share of the budget. The notion of even greater government influence in the energy sector initially sounds far-fetched (and we expressly argue against such a development). Nevertheless, a quick glance at many areas of public services (such as local public transport or water supply) shows that a similar model is not uncommon. It should also be noted, however, that a transformation of the system as described above would not bring about the necessary upgrading in the heating market or transport sector.

Strengthen mechanisms at European level – costs are the limiting factor

Cost-effectiveness should have a greater priority when selecting mechanisms

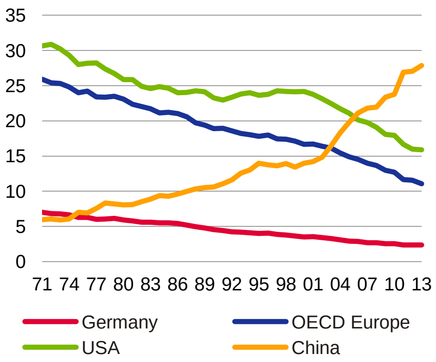
In summary, it can be stated that the switch to renewable energy sources will become more expensive by using the current mix of mechanisms than it would be, for example, by strengthening the EU ETS. As funding is a limiting factor of course, cost-effectiveness should therefore be taken into consideration when selecting suitable instruments. Otherwise, the 'Energiewende' will fail to gain acceptance among businesses and consumers. Furthermore, other countries will not follow suit if the 'Energiewende' is seen to be expensive. Despite this, it is unlikely in the short to medium term that German policymakers will rely predominantly on emissions trading as a mechanism for implementing energy and climate policy. It would therefore be a good idea if, at the very least, these policymakers did not introduce any additional national instruments that would weaken the emissions trading system. As the 'Energiewende' will only succeed in the European context, European mechanisms should be reinforced. This also applies to the provision of subsidies for renewables because the climate and topography in Europe mean that conditions for the use of renewable energy sources vary from one place to another.

4. Fundamental rationale concerning the German 'Energiewende'

The German 'Energiewende' frequently gives rise to highly charged debate with an ideological slant. On one side stand the ardent proponents of the 'Energiewende'. They are fiercely opposed by a varied group that includes both climate change sceptics, who deny that human activity has any appreciable impact on climate, and also many critics, who may well accept the argument that climate change is predominantly man-made, but who, at the very least, do not agree with the methods being used to implement the 'Energiewende' in practice. Economic interests may play a significant role in the respective arguments of both advocates and opponents of the 'Energiewende'. You often have the impression that both sides are only interested in their own arguments, tolerating practically no criticism of their respective positions. In the section below, we have therefore examined from both sides some of the arguments in connection with the 'Energiewende' in Germany.

China produces highest level of global CO_2 emissions 43

Proportion of individual countries/regions to global energy-related CO_2 emissions, %



Source: IEA

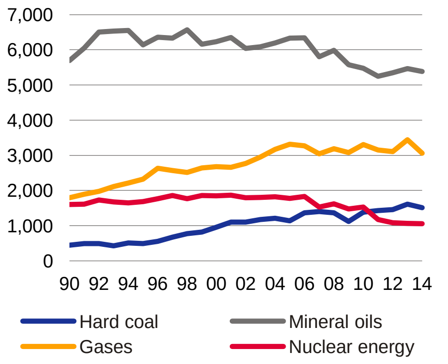
— A key argument put forward by the advocates of the 'Energiewende' is that efforts must be made to combat climate change as quickly as possible. They maintain that Germany is a relatively rich country with historically high greenhouse gas emissions, but also enormous innovative capability, and therefore meets the preconditions, and has a responsibility, to be the trailblazer in the 'Energiewende'. Although this argument is valid, it comes up against the counter-argument that Germany alone cannot prevent climate change. Germany only accounts for 2.4% of global CO_2 emissions and this figure is declining. Since 2000, China alone has been responsible for a volume of additional CO_2 emissions greater than the total emitted by Germany within every two years on average. To date, there have been too few countries not only officially pursuing ambitious climate protection targets similar to those in Germany but also implementing similarly serious corrective measures in practice. Few countries have been willing to follow the example, although many are monitoring Germany's approach. We do not believe that the Paris Agreement at the end of 2015 represented any real breakthrough either, contrary to the hopes of a number of market observers. Ultimately, the action agreed at the conference – measured against the scale of global correction actually required – was not very ambitious and not binding.[49] Even in the most optimistic scenario in the World Energy Outlook published by the International Energy Agency (IEA) at the end of 2015, all renewable energies together will account for a proportion of 'barely' 30% of primary energy consumption in 2040; in the most probable scenario, the figure is just 18%. Within the renewables segment, most of the figure in both scenarios is accounted for by bioenergy (rather than wind or solar power). Even the divestment movement[50] is unlikely to be sufficient to bring about a turnaround at global level. Although the growth in capital investment in renewables will probably be much faster almost everywhere in the next few decades compared with investment in traditional forms of energy, emerging markets and developing countries in particular will still also rely (or will still have to rely) on fossil fuels to meet their growing energy needs. If no private investors can be found for this purpose, state enterprises are likely to step into the breach.

[49] See Heymann, Eric (2016). Pariser Klimaabkommen: Kleiner gemeinsamer Nenner. VIK-Mitteilungen 1/2016. Berlin.

[50] Divestment is defined as the withdrawal of investors from businesses or types of investment in which the business model or investment focus is based partially or wholly on fossil fuels. The prices of many energy commodities have fallen in recent years and the profits of many companies in this segment have therefore also declined. In view of these trends, a corresponding strategy of investment withdrawal has been rational, even from a purely economic perspective. At the same time, many alternative forms of energy or efficiency technologies have received government subsidies, which can make these segments attractive to investors.

Varied picture 44

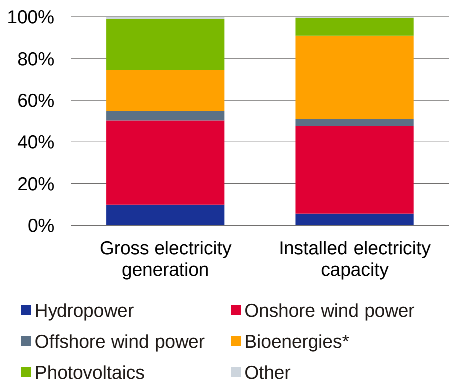
Imports of different energy sources to Germany, petajoules



Source: AG Energiebilanzen

Bioenergies: Relative efficiency higher than for other renewables 45

Proportion of renewable energy sources to gross electricity generation and installed electricity capacity in Germany in 2015, %



* Solid, liquid and gaseous biogenic fuels and biogenic proportion of waste.

Sources: AG Energiebilanzen, BMWi

— One generally valid argument put forward by the advocates of the 'Energiewende' is that it could reduce dependency on energy imports and cut the energy bill payable to other countries. Foreign trade is not a zero-sum game, however. For example, in 2015, Germany exported goods with a value of almost EUR 71 billion to traditional oil-exporting countries.[51] So far, the effect of the 'Energiewende' on energy commodity imports has been quite small. Absolute energy imports (measured in petajoules) were higher in 2015 than at the beginning of the 1990s. Imports of coal and gas have been rising in a long-term comparison but there is a downward trend in the case of mineral oil and nuclear fuels. Possible reasons for the fall in oil imports include the long-term decline in the importance of oil in the heating market and the fall in the average fuel consumption of vehicles. In the case of nuclear fuels, Germany's decision to end its use of nuclear power is probably the key factor in the drop in imports.

— As a positive argument, supporters of the 'Energiewende' maintain that the supply of energy has become more locally based and more compartmentalised. This is true. Small-scale, distributed power generation structures are not ends in themselves, however. They need to make sense from an economic perspective. This cannot be automatically assumed because economies of scale also play a key role in the energy market. On the other hand, no one is advocating a return to the monopolistic supply structures that were the norm prior to the liberalisation of the energy market at the end of the 1990s.

— A classic argument presented as one of the benefits of the 'Energiewende' is that the switch creates new jobs. This is a weak argument in our view. If the government provides financial assistance for the development of certain technologies, this does of course also lead to the creation of jobs in the segments concerned. But these jobs are then jeopardised if the support is withdrawn. The jobs argument would thus only hold if the employment could be maintained or expanded without government subsidies. Even then, there is still a question as to whether more jobs could have been created if the resources used had been redirected elsewhere. Furthermore, it is always advisable to carry out a net analysis, i.e. an analysis showing how many jobs are being lost elsewhere as a result of political action. Overall, if more jobs are needed to produce a certain volume of a product (such as electricity) than was the case in the previous circumstances, then this is an indicator of lower productivity. Finally, past experience has shown that jobs and businesses in segments such as photovoltaics are in competition with businesses in other countries such as China. If the products concerned can be manufactured in other countries with the same quality but at lower cost, then jobs in Germany are at risk.

— According to the proponents of the 'Energiewende', the levelised cost of producing electricity based on renewable energy sources is so low that renewables are now (largely) competitive compared with fossil fuels. The pure levelised cost of electricity based on renewables has actually fallen and this trend is likely to continue.[52] However, an isolated analysis of the levelised cost of electricity is inadequate because the expansion in the use of renewable energies also involves system costs (such as expansion of the grid), as we have discussed in this report. System costs vary from energy source to energy source; although the end product (electricity) is always the same, the generation and the systems required in each case are very different. The variances in full-load hours and ability to control generating

[51] See Heymann, Eric and Heiko Peters (2016). The end of the golden era for oil states continues to curb German export growth in 2016. Deutsche Bank Research. Talking Point. Frankfurt am Main.
[52] See Fraunhofer Institute for Solar Energy Systems (2013). Stromgestehungskosten erneubare Energien. Freiburg.

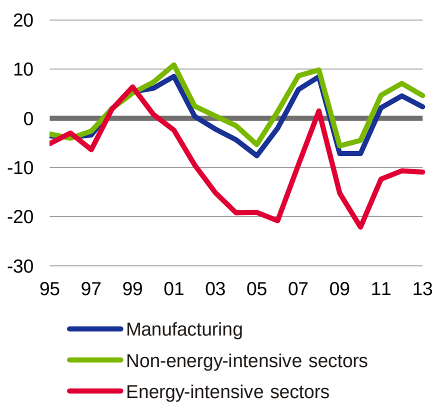
activity also need to be taken into account. One example illustrates the nature of the differences: the levelised cost of electricity for onshore wind power is lower than that for offshore wind power; this is also reflected in the different energy payments under the EEG. Does this mean that onshore wind power is 'better' per se? Not necessarily, because offshore wind power generally has higher full-load hours than onshore wind power. In turn, the grid connection costs for offshore wind power are generally higher. These and other aspects have to be factored into the equation. When a comparison is made between renewables and traditional power plant technologies, the conventional approaches have the advantage in terms of ability to meet the base load requirement and level of control, which is generally good. Put another way, a controllable kilowatt hour of electricity is more valuable than a kilowatt hour of electricity that cannot be controlled.

Subsidies for fossil fuels should be reduced

— Renewable energy sources would be more competitive compared with fossil fuels if the external costs were better internalised. This argument is valid. A quantification is difficult of course because it is no small matter to put figures on the external costs of burning fossil fuels. For decades, as part of the UN climate change conferences, the international community has been trying to find suitable mechanisms to internalise the external effects – so far without (any great) success. Europe 'at least' has the EU ETS, which goes some way to internalising the external costs; taxes and levies on energy have a similar impact. It would be an important step in the right direction if every country that still subsidises fossil fuels were to reduce these subsidies; this primarily affects those countries that have extensive fossil fuel resources. In view of the low prices for oil, coal, etc., now would be a good time to cut these subsidies. It should be added that all forms of energy have external effects that can only be partially internalised or cannot be internalised at all. In the case of fossil fuels, the main effect is climate change. Effects arising from renewables include, for example, the impact on the countryside. Protests against the installation of wind turbines or power lines may also be counted as external effects.

Energy-intensive industries invest less 46

Nominal net capital expenditure as a percentage of nominal gross capital expenditure in Germany, %



Source: German Federal Statistical Office

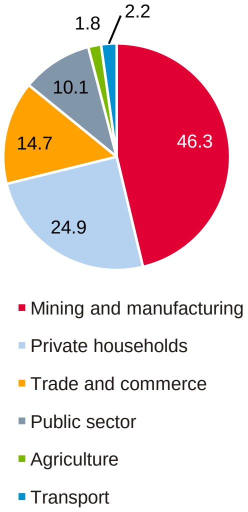
— Another valid argument put forward by the advocates of the 'Energiewende' is that the average renewable energy levy under the EEG would be lower if there were no exemptions for energy-intensive businesses. However, special arrangements for energy-intensive businesses are necessary because their international competitiveness would otherwise be badly hit; production facilities in Germany would find themselves in financial difficulty as a result of the high level of special charges imposed in the country. There would be no climate protection benefit if some or all of the production concerned were to be relocated outside Germany in the future. As it is, the uncertainty surrounding the energy transition in the last few years has already led to a situation in which energy-intensive businesses are restricting capital investment in Germany, but at the same time increasing investment abroad. Ultimately, this investment leakage means that CO_2 emissions are also shifted abroad. For now, industry remains the largest consumer of electricity in Germany.

— Some market observers believe that the payment of subsidies for renewable energies should not be viewed too critically because, after all, many conventional forms of energy also received subsidies in Germany in the past. It is doubtless unwise to justify less-than-efficient changes in an area of activity (for example, to the nature and scope of subsidies for renewables) by referring to the fact that similar undesirable developments were permitted elsewhere and/or in previous times.

The arguments demonstrate that there are often no simple cast-iron truths when it comes to the German 'Energiewende'. It would be productive if all the players involved in the switch could discuss the pros and cons of the individual

Industry is largest energy consumer 47

Proportion of net electricity consumption in Germany in 2015, %



* Net electricity consumption: 530.6 billion kWh.

Source: AG Energiebilanzen

measures openly and without bias and were prepared to correct their own mistakes. A debate shaped by ideological prejudices is detrimental to the whole process.

5. Summary and outlook

The German 'Energiewende' is a once-in-a-lifetime project. It is tying up a huge amount of capacity among policymakers, businesses, research institutes and universities, trade associations, NGOs and other market players. There are widely differing assessments in the academic literature as to whether and how this energy transition can succeed. This is understandable given the many uncertainties regarding, for example, future technical advances, differing political priorities and trends in energy demand and prices.

In view of the current rate of progress in relation to the individual performance targets in the German 'Energiewende' and the challenges that still lie ahead in the coming years, there is a prevailing scepticism – at least on the part of the author of this report – as to whether the 'Energiewende' will broadly succeed. Progress is being made almost only where there is a robust system of subsidies or the imposition of stringent conditions. If this paper had to be summarised in a single sentence, it would be that Germany has probably taken on too much in too short a time. This is not a conclusion to be reached lightly because the fundamental idea of the 'Energiewende' is compelling faced with climate change and also the finite nature of fossil fuels. However, the task of the economist is to make a sober analysis of the figures or the effect of political action (and, naturally enough, there are differing assessments of the German 'Energiewende', even among economists). Essentially, we believe that the German 'Energiewende' is affected by four limiting factors.

— Costs: In this report, we have primarily explored the costs of the 'Energiewende' in the electricity sector – and mainly the costs of generating electricity from renewable energy sources. This represents just a small segment of the entire energy market. Although the benefit from renewables of low marginal production costs will be maintained over the long term, these sources of energy still require significant capital investment, which means that (without integration of renewables into the EU ETS) subsidies will be necessary for the foreseeable future. From a cost perspective, it is particularly significant that a huge level of expenditure will be required in connection with the necessary upgrading in the heating market (building stock) and transport sector in the next few years. This also applies to those energy-efficiency technologies that would be necessary to enable Germany to attain its targets. In this regard, we are only at the beginning of the 'Energiewende' and therefore also of the debate about costs. The issue of the competitiveness of Germany as an industrial base is closely linked with the issue of costs.

Absolute efficiency of the new renewables is currently still quite low

— Physical limitations: The proportion of primary energy consumption in Germany accounted for by the new renewables (wind power, photovoltaics) was just 3.7% in 2015; the figure at global level was around 1%. Despite the immense technical advances, these figures illustrate how the performance of these technologies is still limited at the moment. One disadvantage of the new renewables is the low capacity utilisation (full-load hours). A further expansion in the fluctuating power generation derived from renewable energy sources means that it will be necessary in the future to store the electricity for longer periods and less expensively than is currently possible. Present storage technologies are unable to meet these requirements. Although alternative storage technologies are available, they are still too expensive as things stand (costs). We will still need to wait for a number of years before these technologies are ready for the market. The significant land or sea area required by renewables could also be classified as a physical limitation.[53]

— Available time scale: The long-term targets set by the German government relate to the year 2050. Many of the performance targets are falling behind the time scale that is actually required – some of them are significantly behind schedule. Particularly in those areas where large parts of the existing structures would have to be modified, the remaining 35 years represent a really short timeframe; this applies for example to the upgrading of the building stock to the required energy efficiency standards. In terms of renewable energies, an example calculation can be used to illustrate the time scale as a limiting factor. In 2015, primary energy consumption in Germany based on renewables was 1,669 petajoules. Since 2000, the average annual growth has been over 83 petajoules. If the aim is to halve primary energy consumption in Germany by 2050 (which is already an ambitious target) and increase the proportion accounted for by renewables to 60%, the energy required from renewables would be just under 4,000 petajoules. If the rate of expansion over the last few years is extrapolated, it would take 28 years to close the gap. This would therefore be within the time limit purely on the basis of this calculation. However, consideration needs to be given to the fact that the bulk of today's primary energy consumption based on renewables is derived from bioenergies, which offer only limited scope for further expansion.

Not much time left until 2050

— Political feasibility: In the coming years, policymakers are increasingly likely to turn to regulatory instruments (such as regulations on energy supply and on energy consumption in buildings) to meet the energy transition targets for the heating market, transport sector and energy-efficient technologies. For private households and businesses involved, this would initially mean incurring higher costs as well as infringements of property rights and restrictions on freedom of choice. The EEG costs are already the subject of political debate. The greater the costs caused by specific requirements and the more unpopular the regulatory measures, the greater the likely opposition in the population, among trade associations, trade unions and some politicians. Particularly those parties that claim to represent broad sections of the population and/or the socially disadvantaged will probably pay much closer attention over the medium to longer term to the financial consequences of regulatory measures or taxes on both households and businesses.

Greater focus on costs incurred by the electorate likely

History is littered with basic inaccurate forecasts regarding long-term economic and technological trends. Technical progress has frequently defied such forecasts. The author of this report would like to be more optimistic about the prospects of the German 'Energiewende' but the limiting factors outlined above prevent him from doing so.

So what can be done? It would be advisable to integrate the German 'Energiewende' to a greater extent with European energy and climate policy. Germany would then have to accept (for better or for worse) generally less demanding, but more realistic, climate change targets than is currently the case. Because the cost and funding of the 'Energiewende' are limiting factors, the available resources should be used in a manner that maximises benefits. If the limitation of CO_2 emissions were given the highest priority, the EU ETS would offer a mechanism that could produce a uniform price for CO_2 and could be combined in the future with emissions trading systems in other countries. Emissions trading could be expanded to cover the heating market and the transport sector. As a system changeover of this nature is politically unlikely in Germany in the short to medium terms, policymakers ought to investigate the

[53] See Ganteför, Gerd (2015). Wir drehen am Klima – na und? Wiley-VCH. Weinheim.

advantages and disadvantages of the options for a possible withdrawal from the EEG and strengthen market forces. A democratic debate on what the ‘Energiewende’ ought to cost overall would go some way to encouraging acceptance of the switch.

When formulating long-term climate protection targets, Germany and the EU should pay attention to the aims being pursued by other countries. Officially, all the talk is about a long-term decarbonisation of the global economy. However, it is pretty easy for the current policymakers to draw up these long-term targets because they will no longer be in office in 2050. In practice, there is as yet no sign that policymakers have set the necessary course for this decarbonisation. This is still true, even after the Paris Agreement. Equally, the long-term forecasts published by the IEA give no indication that it will be the end of the line for fossil fuels any time soon. At global level, the following points should be at the top of the energy and climate policy agenda: pricing of CO_2, reduction in subsidies for fossil fuels, more research into alternative energy systems and energy efficiency, more forestry protection and more adaptation to climate change, particularly in the poorest countries.

This report undoubtedly has a deficiency in that it does not present any solution for a challenging energy transition that is affordable, permits economic growth, avoids massive infringements of property rights and freedom of choice, and (largely) excludes the foregoing of consumption. Would this be squaring the circle? Or can this only be achieved with technologies that still lie beyond our knowledge or capabilities?

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Printed by: HST Offsetdruck Schadt & Tetzlaff GbR, Dieburg

Print: ISSN 1612-314X / Internet/E-mail: ISSN 1612-3158