Note de l'Ifri

Year 2 of Germany's Energy Transition

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Center for Energy

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Summary

After a decade characterised by the take-off of renewable energies, Germany decided in 2010 to make them the top priority. At the same time, it decided to make exemplary efforts in terms of energy efficiency and the reduction of greenhouse gases. The audacious nature of this policy was strengthened by the "turn" taken in 2011 to give up nuclear energy in the wake of the Fukushima accident.

Given the initial results for 2012, Germany seems to be on target for reaching its national objective, of 18% renewable energy within total consumption by 2020. Germany is also well placed to reduce its planned cut in electricity consumption of 10%. The country will also meet its commitments, both international and European, concerning greenhouse gas emissions. In contrast, recent trends suggest it will be increasingly difficult for Germany to meet its own, domestic goal of cutting emissions by 40%, by 2020. Furthermore, it is hard to see how Germany will be able to bring down total energy consumption by 20% by 2020 (from 2008 levels), or increase the share of renewables in electricity production above 35%.

Success with this latter objective is largely dependent on reinforcing networks, both for transmission over long distances and for local distribution. It is not sure that the delays accumulated in both areas will be made up for by 2020, despite the rapid legislative adjustments that have already been made. By favouring intermittent energy sources – wind and solar power – Germany also faces problems of managing frequent production fluctuations. The long term solution to this lies in storing electricity. However, despite the considerable efforts in research and development, the technologies necessary for this will doubtless not be available on a large scale before the end of the present decade. These efforts could nevertheless provide German industry with interesting advantages in sectors of high potential, such as electric vehicles.

Measures to promote renewable energies are also costly, and constitute another threat slowing down their development. Until now, this cost has been born by household consumers and small firms, with large industries being sheltered from such costs. Yet these rising costs are being increasingly criticised. Changes are likely of follow in the wake of the national elections which took place on the 22 September 2013, and their impact on the future pace of renewable electricity production remains unknown. Yet so far the sector has a positive image due to the jobs it creates. The latter are

going to depend more and more on foreign outlets, though the misadventures of photovoltaic solar energy indicate the uncertainties hanging over the sector. Renewable energies however do have a major advantage in that they have been able to set up financial sources that are both solid and not very costly.

Such financing facilities do not seem to be available to most European countries. This illustrates a specific characteristic of German renewables, namely that their development in Germany also depends on the reaction of other European states. The latter are affected physically by the massive arrival of electricity from wind and solar power being produced in Germany, and economically by the disruptions this leads to in wholesale markets. So far, the response of other countries has been poorly coordinated by the European Commission which seems to have been caught on the wrong foot by the implementation of capacity mechanisms, in some countries, or by the demands to reconstruct the market model.

Content

Introduction

On 30 June 2011, an overwhelming majority in Germany’s federal Parliament passed a law confirming the accelerated closure of the country’s fleet of nuclear power stations, by reinforcing previous legislation concerning the reduction of energy consumption, the reduction of greenhouse gas emissions and the development of renewable energy sources. It will only really be possible to evaluate the evolution underway in the future, given the inertia inherent in large energy systems and the changes underway. The major deadline for quantified objectives is 2020.

However, several factors require the first consequences of the “energy turnaround” to be followed closely. To begin with is Germany’s insolent economic health with a Europe struck by a deep crisis, as well as the political weight the country has acquired given the problems affecting its neighbours. These make re-examining the question raised in 2011 about whether the energy policy will weaken the country or lead Germany to find a new stimulus to growth all the more pertinent. Secondly, several European countries have started their “energy transition” for different reasons to Germany, but also involving equally profound changes. It thus seems useful to examine work in progress on the other side of the Rhine, and draw lessons from it. Lastly, the re-composition of energy in Germany has an influence on the functioning of the energy sectors in neighbouring countries. Analysing the trends at work therefore will facilitate the adjustments of these countries, via coordination under the auspices of the European Union.

The present study opens by recalling the objectives of Germany’s “energy turnaround”, and an overview of the quantitative results known so far. The rest of this study focuses on electricity. This choice is justified by the fact that the integration of Europe’s electricity system means that the impact of any decision spreads rapidly in the system, even if it appears isolated. The German government has been prudent about putting forward figures relating to other energies, but it has retained ambitious objectives concerning electricity generated by renewable sources. The consequences for neighbouring countries thus require examination of changes happening in Germany. The second chapter looks at technical issues and the third chapter discusses problems encountered, measures put into place to deal with them and expected benefits, if the obstacles are overcome. The conclusion sketches out some of the broader lessons for any energy transition.

This study of course refers to a very short period of time: less than two years. Its comments must therefore be viewed with caution: they should be seen as elements to be taken into account in further analysis, rather than as definitive results. Further study may complete, challenge or support the contribution of the following pages, and will be precious. Here, official sources have been favoured, so that the indications and especially the quantitative data can be verified and discussed according to need. A large range of material has been examined in order to favour cross-cutting comparisons and an expansion of the range of subjects examined.

The author would like to thank all readers wishing to put forward remarks about the present text.

The Objectives and Present Path

A Historical Outline

Germany's energy landscape has been shaped by three major legislative trends, each reflecting the balance of power of its time.

The "ecological modernisation" of the energy sector was promoted by the "red-green" coalition government of the Social Democratic Party (SPD) and the Green party. It includes:

- The law on renewable energies, known as the EEG (*Erneuerbare Energien Gesetz,* 29 March 2000), creates a framework favourable to electricity generation from renewable sources, by providing investments with secure, guaranteed purchase rates for 15 to 20 years, with prices posted in advance. The additional costs in production are transmitted to the final consumer.

- The law introducing an environmental tax on energy imposes a tax on electricity consumption (*Stromsteuer Gesetz*, 24 March 1999).

- The law on exiting from nuclear power (*Atomausstieg,* 22 April 2002) amends the framework law on nuclear energy, the *Atomgesetz*. It fixes a ceiling on the accumulated production of the 19 working reactors, and states that the last reactor will stop working in 2021.

The Christian Democrat party (CDU) has deplored this precipitated shutdown. It came to power in 2005 within a Grand Coalition with the SPD, which tied its hands on the issue. The success of the Liberal Party (FDP) in 2009 allowed for a switch in coalitions. But Chancellor Angela Merkel is conscious of the popularity of the Green Party, which obtained remarkable scores in regional elections. Accordingly, she came out in favour of an overall plan, an "energy concept" (*Energiekonzept,* approved by the Bundestag[1] on 29 October 2010). This law sets out very ambitious goals through to 2050, in terms of reducing greenhouse gas emissions and developing renewable energies. To reach these objectives, the operating life of nuclear power stations is to be extended by 8 to 14 years, according to their age, beyond 2021. This results in:

- A source of income via a tax on nuclear fuel and a contribution to the "Energy and Climate" fund, which will be used to stimulate development of renewable energies.
- Decarbonised electricity production, which needs to be conserved until renewable energies have become mature.

But opinion polls showed that prolonging the life of nuclear power stations was unpopular. As soon as early 2011, the Chancellor understood that this decision would make forming a coalition with the SPD or the Greens very difficult after the 2013 elections. In March 2011, the Fukushima accident allowed her to reverse her decision. Drawing on the emotions triggered by this catastrophe, Ms Merkel announced the immediate closure of 8 of the oldest nuclear reactors, and early closure of the 9 others by 2022. In spite of this, the objectives decided in 2010 have not been modified: the target concerning the share of renewable energies has even been made tougher for the federal government. The accelerated scrapping of nuclear energy requires overhauling numerous legislative texts or regulations relating to the energy sector: this "legislative package" (*Gesetzpaket*) was dealt with in a few months. 2011 was thus characterised by a real "energy turning point" (*Energiewende*).

This historical overview shows why Germany's new energy policy is sometimes described as a huge bet. Indeed, the laws of 2000 and 2002 did indeed favour the take-off of renewables. But they did not really prepare for the exit from nuclear power. The 2011 turning point involves renouncing decarbonised electricity production before other, non-CO_2 emitting sources are ready, and giving up on income to facilitate the transition, as the earnings from the nuclear power station fleet are cut. Germany's new energy policy still aims at the objectives set out in October 2010, and which are summarised in Table 1:

[1] Bundestag: Germany's lower parliamentary chamber.

Table 1 – The Aims of German Energy Policy [i]

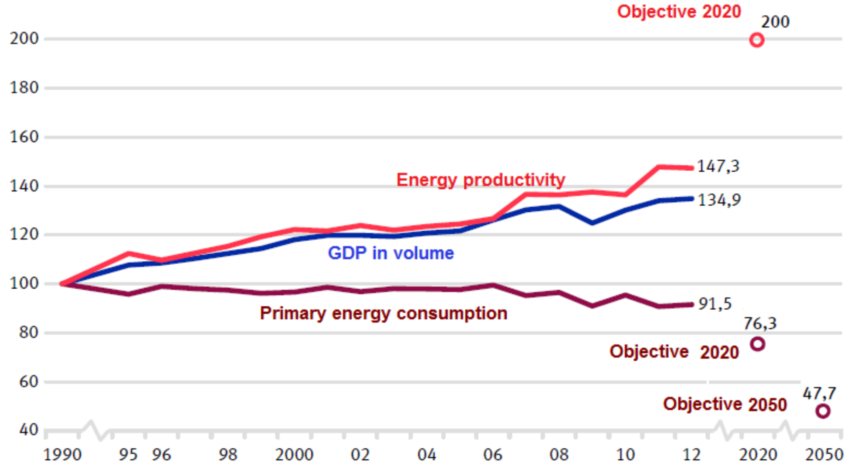
	2020	2030	2040	2050
Cutting the consumption of primary energy (relative to 2008)	- 20 %			- 50 %
Cutting the consumption of raw electricity (relative to 2008)	- 10 %			- 25 %
Cutting the consumption of final energy in the transport sector (relative to 2008)	- 10 %			- 40%
Cutting CO_2 emissions (relative to 1990)	- 40 %	- 55 %	- 70 %	- 80 - 95 %
The share of renewables in final energy consumption	18 %	30 %	45 %	60 %
The share of renewables in the consumption of raw electricity	35 %	50 %	65 %	80 %

The Reduction of Primary Energy Consumption

All official presentations stress the importance given to the goal of reducing consumption, and federal government representatives often recall that success in this area conditions meeting other objectives. The following diagram highlights the proactive nature of the policy goals in reducing primary energy consumption. To reach the objective in 2020, primary energy consumption has to fall by 2.2% per year, whereas the observed trend for 2006 to 2012 was about 1.5% per year. Furthermore, if GDP growth continues at the pace recorded since 2006, namely an annual average of 2.4%, then energy productivity will have to rise by 3.9% per year from 2012 to 2020, compared to the 2.4% observed between 2006 and 2012.[2]

[2] Energy productivity measures the volume of GDP generated by each unit of energy consumed. This is the opposite of energy intensity, which evaluates energy consumed per unit of GDP.

Figure 1 – Trends in Primary Energy Consumption[ii]



Beyond 2020, demographic change will likely play a role in bringing about the desired evolution in energy use. But this role will be modest. Demographic forecasts for the years 2020 to 2050 indicate a fall in the population of 0.4% per year, equivalent to -9.3 million inhabitants. However, primary energy consumption has to fall by 1.6% per year from 2020 on, for the goal to be met.

Overall, there is a target to reduce primary energy consumption by -20% over 12 years. The planned rate of decline in electricity use and in the transport sector is weaker (a fall in 10% over the same period). The main reductions therefore fall on construction and industry. However, an analysis of trends in these two sectors, as recently undertaken by the IDDRI,[iii] call for a degree of scepticism about this target actually being attained.

For construction, the standards applied to new buildings are severe and well respected. However, the renewal rate of buildings is very slow (less than 1% per year). As a result, existing buildings are the main source of potential savings, but this source can only be exploited with the help of massive financial support. The German government is striving for substantial renovation of 2% of existing buildings each year, through to 2050. This is twice the present rate. Despite the remarkable efficiency of current measures involving the KfW, and the significant sensitisation of households, such an achievement would require a near, quasi-doubling of aid granted.[3] Doubts concern the possibility of acquiring financial contributions for partial renovation that leads to the "cream skimming" of operations

[3] In the rest of this text, the acronym KfW relates to the *Kreditanstalt für Wiederaufbau Bankengruppe*, or Bank of Reconstruction. This is a public bank, 80% of whose capital is held by the federal government, and 20 % by the *Länder*. It is similar to France's *Caisse des Dépôts*.

which are immediately profitable, whereas other sources of savings are lost, since when taken separately the time lags of their returns on investment are too long. From a comparative perspective, consumption by Germany's residential sector fell by 21% over 17 years (1991-2008), as this period benefitted from substantial investment in renovating housing in former East Germany. As a result, the International Energy Agency estimates that attaining the 2020 objective is unlikely.[iv] It should be noted that 75% of heat energy used in buildings comes from gas and oil products that are used directly, and 11% is from urban heating, which in turn partly follows from the use of fossil fuels. Electricity provides 6% of heating and the production of warm water in the residential and tertiary sectors.[v]

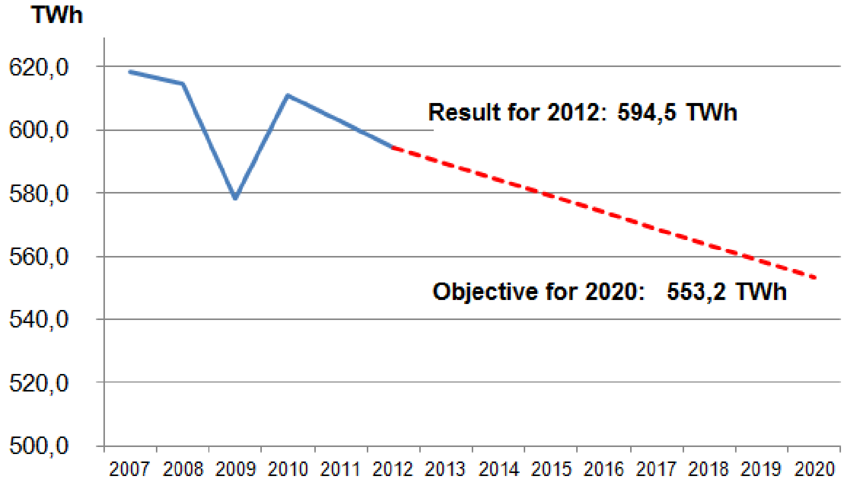
In industry, energy efficiency increased by 24% between 1991 and 2008. This positive result follows essentially from spontaneous actions by business leaders in cutting their energy costs. The latter have increased due to significant environmental taxes since 2000, and the introduction of CO_2 quotas since 2005. Public policies appear to have had little impact on business decisions. In the future, low quota prices and tax waivers granted by companies in the name of competitiveness are likely to reduce incentives to invest in saving energy.

To stimulate progress in two sectors, Germany could soon implement a programme of Energy Saving Certificates (or white certificates) that have been tested with some success in France. The launching of Energy Service Companies (ESCOs), acting as a third investor, has met with more success in Germany than in France, but their influence remains modest.

The Reduction of Raw Electricity Consumption

Raw electricity consumption peaked in Germany in 2007, at 618.1TWh. If 2009 is ignored, given the 4% fall in GDP, then the linear decline between 2007 and 2012 has been 0.8% per year. This is much in line with declines required to reach a level of consumption in 2020: i.e. 10% less than the 2008 level.

Figure 2 – The Evolution of Raw Electricity Consumption[vi]



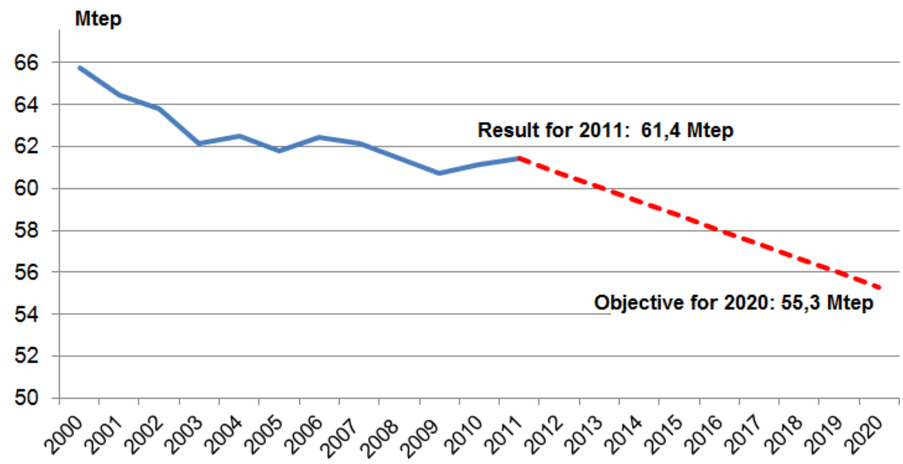
If Germany's total primary energy consumption does indeed fall by 20% by 2020, then the relative share of electricity will rise within total energy balances, as its reduction target is only 10%. Official statistics on the structure of final consumption do not yet provide precise data beyond 2010, so that it is difficult to predict in which areas cuts will mainly occur. In the last decade, final electricity demand experienced marked growth between 2001 and 2007, followed by a stabilisation, so that final consumption in 2011 was about 521TWh, similar to the 526TWh in 2007.[vii]

The International Energy Agency has pointed out the risk of inconsistencies between the goal assigned to electricity and that concerning all primary energies. While the latter stresses heating, the former could discourage the development of heat pumps, which are nevertheless a very effective tool. The German association of heat pumps supports this observation in a study it published in August 2011, emphasising that present sales (about 50,000 per year since 2007) lie very much below the market potential, which it estimates to be between 100,000 and 300,000 per year.[viii]

The Reduction of Energy Consumption in Transport

The fall in consumption in the transport sector between 2020 and 2050 also appears less ambitious than the total cut in energy. However, the trend in the last decade raises concerns that the 2020 goal will be difficult to meet. Indeed, after a spectacular fall between 2000 and 2003, energy consumption in this sector has remained relatively stable, only slipping from 62.1 Mtep to 61.4 Mtep.

Figure 3 – The Evolution of Energy Consumption in the Transport Sector[ix]



The German transport sector does not seem to have been subject to a proactive public policy, above and beyond European measures transposed into German law. These impose ceilings on CO_2 emissions per kilometre for personal vehicles and light commercial vehicles. For both these texts, the German government also sought to water down the initial proposals by the European Commission… The reduction observed between 2000 and 2003 is generally attributed to the introduction of an environmental tax on fuels in 2000. But its effects have been blunted and it has remained unchanged over the years.

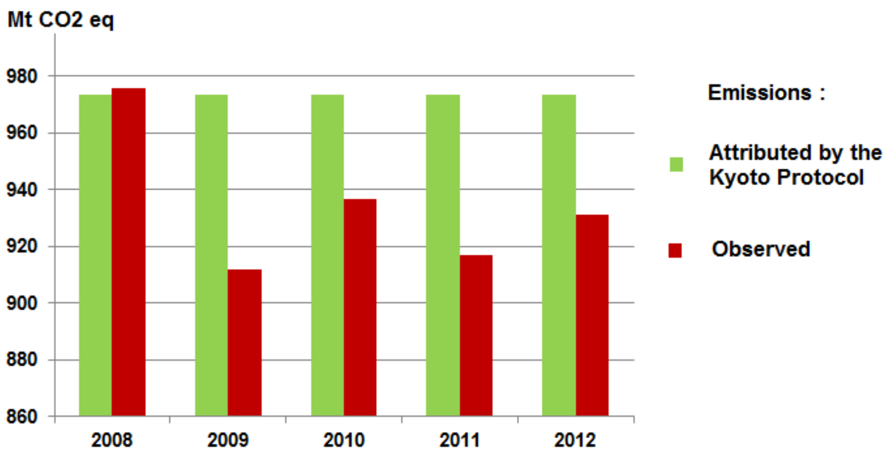
There were hardly any measures throughout the decade to support the modal transfer, i.e., a shift away from road transport to other, less energy-hungry forms of transport (rail or waterways). In contrast, Germany's car industry has made considerable efforts to improve the energy efficiency of vehicles, efforts also supported by significant public programmes. Public policy thus appears to be oriented towards waiting for the development of very efficient, marketable models all over the world, prior to imposing its own constraints, in order to pull the market towards such products, which could use various technologies (thermal electricity or hybrid power). In the meantime, reaching the -10% target by 2020 will certainly remain of secondary concern to the federal government. Local authorities, however, often lend great importance to issues of mobility and are multiplying initiatives both to favour modal transfer and to change citizens' behaviour.

Reducing CO_2 Emissions

Germany is bound by two commitments:

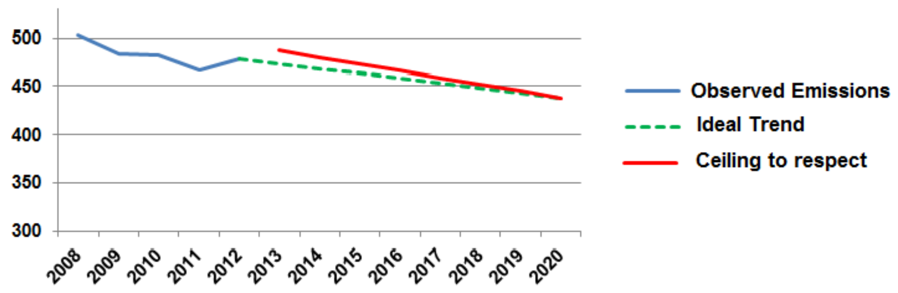
The first commitment is related to overall emissions; the objective was taken within the framework of the Kyoto Protocol. It covers the years 2008-2012 and imposes a 21% reduction in emissions below the 1990 level. According to the first results available, this goal has been respected. Such a 21% reduction is equivalent to a "carbon budget" of 4,868 $MtCO_2eq$ over 5 years, while recorded emissions are 4,672 $MtCO_2eq$.

Figure 4 – Respecting the Kyoto Protocol[x]



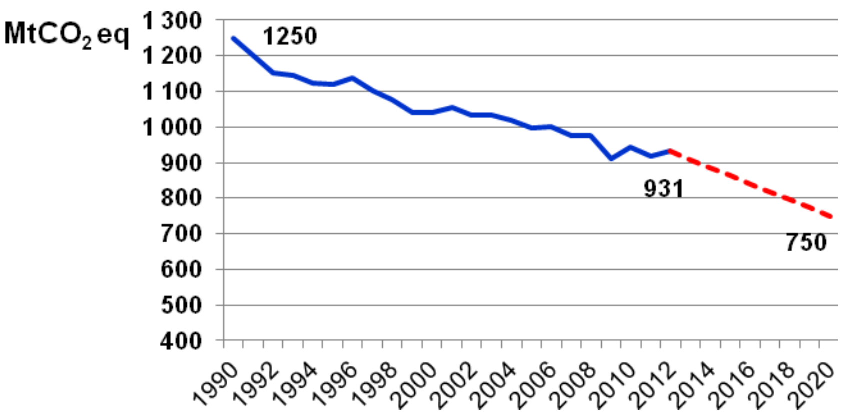
The second objective has been attributed within the framework of the European Union's Energy Climate Package at the end of 2008. The corresponding target only concerns emissions stemming from sectors not covered by the European Trading Scheme (ETS) market for trading in quotas. Germany is required to reduce emissions from these sectors by 14% by 2020, compared to 2005. Figure 5 shows that despite the renewed rise of emissions in 2012 above their level in 2011, the objective could be met. The Federal Environment Agency explains the rise in 2012 by the very cold winter that year, which led to higher consumption of gas and heating oil. This was a one-off event which should not affect the general trend.

Figure 5 - Emissions Outside the ETS Sector[xi]



Apart from its European and international commitments, Germany has announced plans to cut emissions by 40% from their 1990 levels, by 2020. This objective seems very ambitious given past achievements. Indeed, while Germany did cut emissions by 26% between 1990 and 2012, 17% of the reduction occurred between 1990 and 2000. This most likely took place due to the updating of installations in former East Germany, which in 1987 had the highest per capita energy consumption in the world. From 1990 to 2000, the annual pace of reduction stood at 1.8%. It then fell to 0.9% between 2000 and 2012. For the -40% target to be met by 2020, the rate of annual cuts has to rise to 2.7% per year, between 2012 and 2020. It is hard to see how such a spectacular rate of reduction can be achieved.

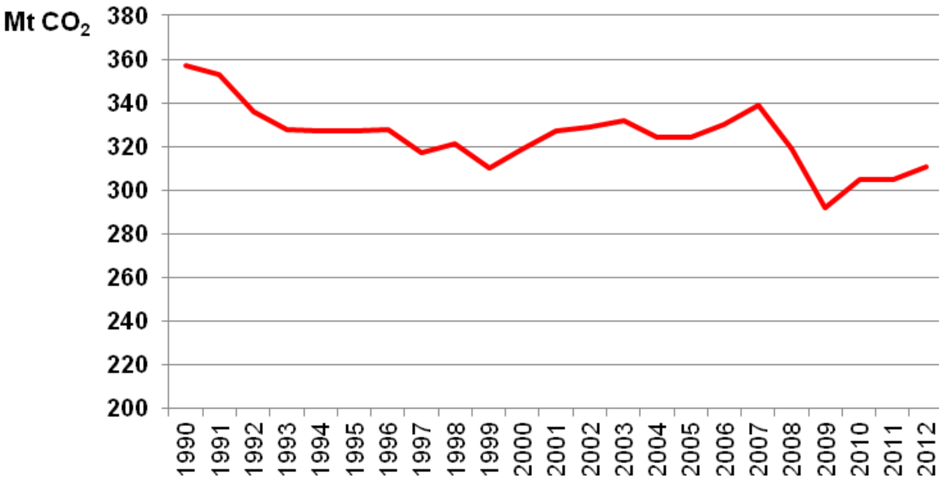
Figure 6 – Greenhouse Gas Emissions[xii]



This reduction should affect primarily the electricity sector, which is a large emitter of CO_2, the main greenhouse gas. It may be observed incidentally that the share of CO_2 within all greenhouse gas emissions in Germany rose from 83.3% in 1990 to 87.0% in 2011.

Within CO_2 emissions, the share of the electricity sector expanded from 34.3% to 44.2% during the same period.[xiii] This can be seen quite clearly in Figure 6 above and Figure 7 below. While greenhouse gas emissions fell strongly by 26% between 1990 and 2012, CO_2 emissions in the electricity sector only fell by 13% in the same period.

Figure 7 - CO_2 Emissions Linked to Electricity Generation[xiv]

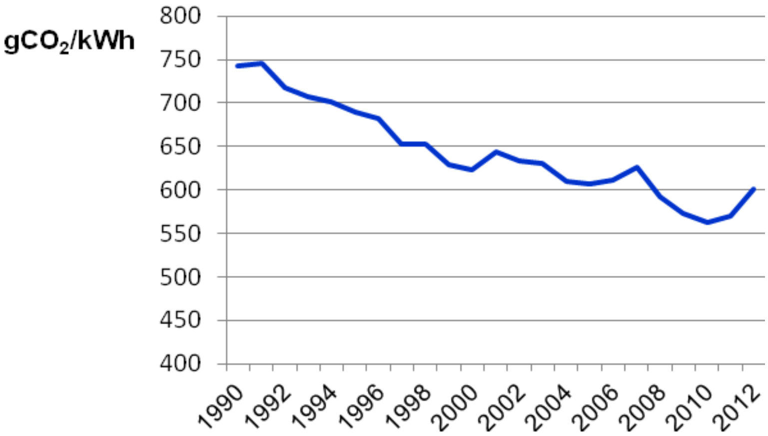


We have seen that Germany reduced its greenhouse gas emissions by 26% between 1990 and 2012. To reach the -40% goal by 2020, a further -14% cut has to be achieved in eight years. If it is assumed that this effort is to be distributed equitably across all sectors of activity, then the electricity sector needs to obtain a greater reduction in 8 years than it did in 22 years.

Given the data presented in Section 1.2, there is good reason to believe that gross electricity consumption will meet the specific objective assigned to it, i.e., a 7% reduction between 2012 and 2020. Cuts in consumption will therefore not be enough by themselves to reach the 14% overall reduction.

As a result, action needs to be undertaken on another aspect of CO_2 emission, namely the amount generated with each kWh. The latter fell rapidly between 1990 and 2000 (-16.2%), but then more slowly between 2000 and 2010 (-9.6%). It then experienced a rise from 2010 to 2012 (+6.7%).

Figure 8 - CO_2 Content per kWh Produced in Germany[14]



With gross consumption calculated for 2020, the CO_2 content per kWh should fall from 601g (the level in 2012) to 483g by 2020, i.e., an annual average fall of 2.7%. In 2011, presentations of the energy turnaround put forward three likely trends to attain such a strong cut:

- The penetration of renewable energies in electricity production.
- The greater use of natural gas instead of solid fuels.
- The replacement of some of the older thermal power stations by more modern plants with higher yields.

The first point is discussed in Chapter 2 below. The two other forecasts seem unlikely to be met.

Despite its technical and environmental qualities, natural gas has been declining for several months in electricity production in Europe. It has indeed suffered from competition from coal, whose average price has fallen due to exports from the United States, where the arrival of shale gas has pushed coal out of power stations. Studies by the International Energy Agency indicate that the development of shale gas is likely to proceed. Arbitration between gas and coal also depends on the CO_2 quota price within the European Union. This price has now become too low to favour gas. This low level is due to several factors: i) an excessive allocation of free quotas between 2008 and 2012; ii) the slowing down of economic growth; and iii) the possibility of converting into ETS quotas credits obtained within the framework of the Kyoto Protocol, especially via the "clean development mechanism". These factors will have an impact over several years.

Thus, electricity production in Germany using natural gas experienced regular growth, rising from 71 TWh to 87 TWh between

2005 and 2010, before falling to 70 TWh in 2012, i.e., -16.8 TWh. In contrast, coal (hard coal and brown coal) developed in the opposite direction: its use fell through to 2010, before rebounding by 14.1 TWh between 2010 and 2012. It must be reminded that the Northstream gas pipeline gives Germany a gas price that is lower than in other continental European countries. The gas companies would like to bring down prices even further, by building a liquefied natural gas terminal receiving gas in Wilhelmshaven. But the project was scrapped due to opposition from the local population. The use of shale gas which exists underground in Germany has yet to be decided by the government.

It thus appears fairly unlikely that the price of gas will fall sufficiently to catch up with the competitiveness of coal in the coming years. Furthermore, efforts by the European Commission to raise the price of CO_2 quotas on the ETS market by "backloading" (i.e. holding up the auction sale of quotas) has run into strong reticence. This was overcome in the European Parliament with the vote in plenary session on 3 July 2013. Furthermore backloading was finally accepted in the Council of Ministers at its meeting on 8 November 2013. Nevertheless, the economy supremacy of coal seems set to continue for some years still.

Germany's oldest thermal power stations are being replaced. But the rate of replacement is being spread out over time. For lignite stations, the Federal Network Agency (*Bundes Netz Agentur*, or BNA) is basing itself on its B scenario.[xv] Under this intermediate scenario, 5.5 GW is set to be cut between 2012 and 2024, but only 2.8 GW is likely to be brought in, according to the Enerlytics consultancy.[xvi] According to these same two sources, coal-fired power output will remain constant at 25.1GW, between 2012 and 2024, with 7.4 GW to 8.5 GW set to be replaced. In other words, about a third of the lignite fleet will be shut down and less than 20% will be replaced. At the same time, the output potential from coal plants will remain constant, while 30% of plants will be replaced. It will therefore be hard to obtain an improvement in average yields, sufficient enough to reduce CO_2 emissions by 20%, by 2020. As an aside, it should be noted that the opening up of new power stations often runs up against strong opposition from nearby residents. The BUND association (*Bund für Umwelt und Natur*) lists eight construction sites on its Internet site that it has been able to hold up for at least two years, and 21 projects it has been able get frozen.[xvii]

Investment in building a coal-fired power station (hard coal or lignite) is substantial, and can only be offset through regular operation over a period of at least 20 years. As a result, power stations currently under construction, or planned, will be operating beyond 2035… and emitting CO_2. In 2011, Germany was the world's largest lignite producer, and its resources are substantial: dropping this source of energy is not on the agenda of any of the main political parties. The probability of being locked-in to this technology is all the greater as legislation to favour carbon capture and sequestration has been turned down: both the government and industry seem to have lost interest.

One possibility being explored to improve returns on plants involves co-generation, a technique which consists of producing heat and electricity simultaneously. Heat created in traditional power stations is lost, but with co-generation it is exploited either by nearby companies for industrial purposes, or in nearby towns for domestic heating, via heat networks ("district heating"). Up to 20% to 30% of fuel (gas or coal) can thus be saved, reducing CO_2 emissions accordingly. But such technology is expensive, and all heat must be used to make it profitable. In the cold season, heating requirements do guarantee good use. But to make the systems work in the summer, the excess heat needs to be stored until the autumn. Technologies to do this are generally known, and usually involve heating underground water tables. But it must be doubted whether co-generation will be enough to significantly shift the CO_2 emissions curve before 2020.

Lastly, another issue complicates the problem, namely the fact that thermal power plants are used as back-up installations for electricity coming from intermittent, renewable sources (wind and solar power). This means that plants have to be started frequently, working for some hours in which overall output is running below capacity. According to a study by Eurelectric, such operating conditions reduce yields from gas-fired plants by about 20%, and by between 5% and 10% in coal-fired plants.

This overview leads to the conclusion that it will be very difficult for the fleet of power stations fired by fossil fuels to contribute fully to the objective of cutting CO_2 emissions by -40%, as set out by the government. So, could renewable sources compensate for this insufficient result?

The Share of Renewable Energies

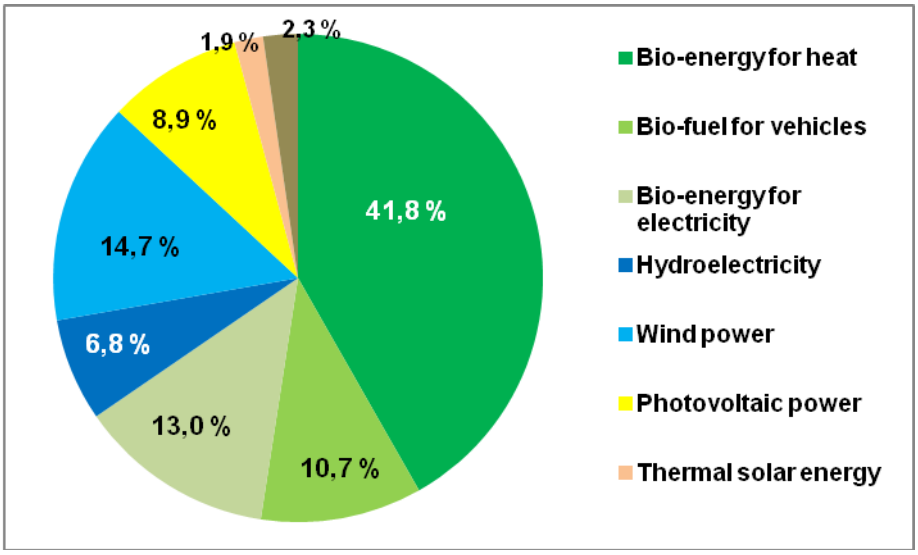
As far as the share of renewable energies in total consumption is concerned, the 2020 objective is 18%. This corresponds to the level assigned to Germany in the “Climate and Energy Package” of the European Union, adopted in 2008. The objective assigned for the following periods reflects a German choice that is independent of outside constraint. At the end of 2012, the result stood at 12.6%, clearly above the level required to remain on the ideal trajectory, or 11.4%. If the trend since 2010 continues, then Germany should exceed its objective by 2020, reaching a share of 19.6%. In 2012, the transport sector was below target. However, the two other sectors with precise targets exceeded their goals.

Table 2 – The Rate of Renewables in Energy Consumption (%)[xviii]

	Situation 2005	Target 2012	Result 2012	Forecast 2020
Heating	6.6	10.0	10.4	15.5
Electricity	10.2	20.9	22.9	38.5
Transport	3.9	7.6	5.5	13.2
Total	6.5	11.4	12.6	19.6

In 2012, renewables accounted for 26 Mtep in total energy consumption of 215 Mtep. The composition of Germany's "renewable energy mix" showed a domination of bio-energies in their three states (solid, liquid and gas). They provided a total output of 17.7Mtep, or 65.5% of all renewable energy consumed. Most bio-fuels come from specific agriculture dedicated to them (cereals, sugar beet, rapeseed and sunflowers, etc.). The same is true for bio-gas which also largely comes from agriculture, and especially maize/corn. Non-governmental organisations have not failed to point out that by increasing the surface area of land cultivated for energy uses, Germany had to import cereals in 2011, for the first time in 25 years.

Figure 9 - Composition of Renewable Energies in 2012[xix]



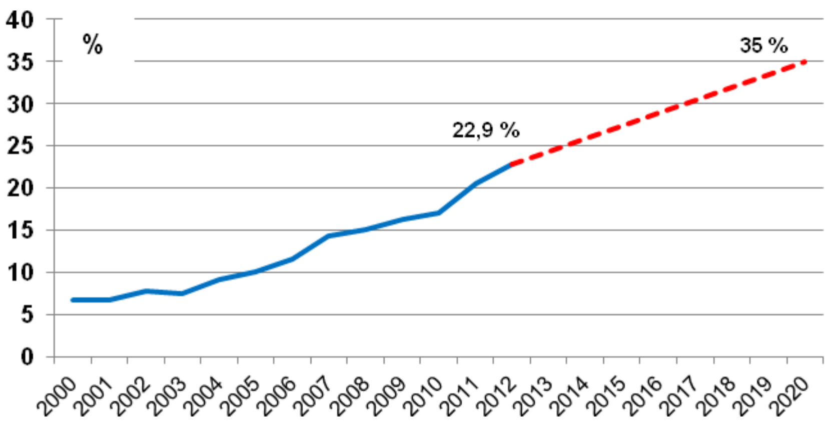
To meet the 2020 objective will require an estimated 33.4 Mtep in bio-energies, nearly twice the level in 2012. In the national action plan sent to the European Commission, the German government indicates that doubts exist about the ability of raise local resources to such an extent, despite the panoply of measures envisaged (higher yields, extension of crop land, planting fast-growing trees, etc.).[xx] The government does not rule out higher imports: probably wood to fill the timber gap or bio-fuels which provide the best "energy content to transport price" ratio. Concerning bio-fuels, imports could also develop for economic reasons, as production is often cheaper in tropical countries using local resources: sugar cane, soya or palm oil. By 2020, Germany is planning to import 32% of its bio-ethanol and 64% of its biodiesel consumption. [xxi]

Bio-energies play an important role in all of the three uses of renewables, namely in electricity, heat and transport. The worry is that limiting imports will lead to their share in electricity production falling from 30% in 2012 (40.9 TWh) to 23% in 2020 (49.5 TWh), according to the national action plan. Hydroelectric resources are already exploited as much as possible. The result is that intermittent resources (photovoltaic and wind power) will see their share rise significantly, from 54.4% (74 TWh) to 67.7% (146 TWh).

Electricity from Renewables

Renewables supplied 22.9% of German electricity production in 2012. This was above the 20.9% target level suggested by a linear path to achieving the 35% target in 2020.

Figure 10 – Share of Electricity Produced by Renewable Energies[xxii]



However, if imports are excluded, then it is far from sure that the 2020 objective will be met, despite very positive trends. Indeed, raising the share from 22.9% to 35% faces several obstacles.

These predictable difficulties and the measures adopted to overcome them will be examined in the following chapters.

The European Dimension

Germany's national choice in favour of renewable energy logically has led its government to argue in favour of EU objectives pointing in the same direction. The federal Minister of the Environment, Mr Peter Altmaier, has striven to convince his counterparts to adopt an ambitious target as an answer to the European Commission's Green Paper, published 27 March 2013, which opens up the debate on objectives for 2030 concerning energy.

A common front on this issue would have strengthened the Chancellor with respect to public opinion, in the electoral run up to the parliamentary elections of the Bundestag on 22 September 2013. Yet it is not entirely possible to rule out that there is a "hidden agenda" in this approach. The energy sector does indeed have a predominant place in CO_2 emissions in Europe. A proactive Community target in terms of renewables would contribute to reducing emissions and hence avoiding a rise in the quota price on the ETS market. Germany, which will likely remain dependent on fossil fuels for more than a decade, will thus be able to escape costs affecting its industrial competitiveness.

To be sure, it would be possible to raise the quota price on the ETS market by other measures. As shown in Section 1.5, the European Commission proposed on 25 July 2012 to delay the sale of quotas at auction (so-called backloading), in order to limit supply and hence get prices to rise, as these had fallen below €5 per tCO_2 for several months. This proposition was rejected by the European Parliament on 16 April, a vote approved by Mr Philip Rösler, Germany's Economics Minister (at the time). The latter also stressed in his press communiqué the risks entailed by rising quota prices for Germany's competitiveness. As the European Parliament decided to re-examine the text, Germany's Employers' Federation (BDI) also stated its view, criticising the decision. In its communiqué of 19 June 2013, it indicated that German industry would be penalised by the higher costs of renewable energy and would also be threatened by the higher costs stemming from a rise in the quota price. On 3 July 2013, the European Parliament finally approved by a short majority the possibility of partial backloading, and Germany's Environment Minister Peter Altmaier praised this turnaround! Mrs Merkel postponed her arbitration beyond the elections of 22 September 2013. Early November, she was able to convince her own camp that supporting backloading was necessary to obtain the commitment of the SPD in a coalition government while making her gesture a mark of her good will in order to ease an agreement with SPD leaders. Following the German green light, the principle of backloading was formally adopted by the Council of the European Union of November 8, 2013.

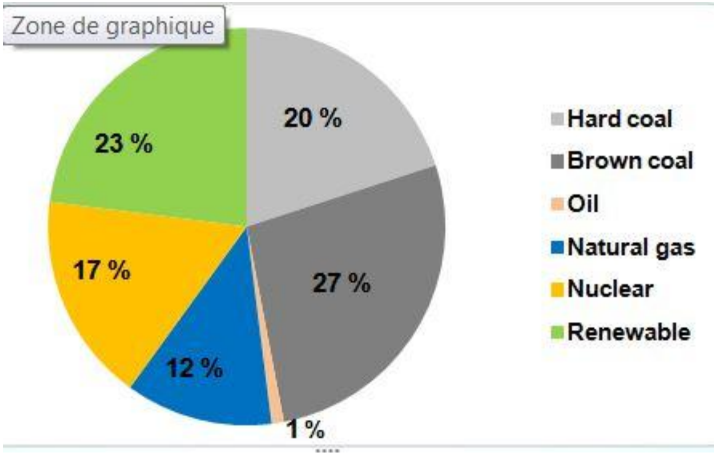
The next German government could find a way in future international negotiation that would permit it both to put forward its exemplary climate objectives and to protect its industry from high costs. This would involve a prorogation of the Kyoto protocol, linked to new "project mechanisms" that would allow to convert into ETS quotas all "carbon credits" obtained from reductions in emissions in developing countries. The latter pleaded in favour of prolonging the protocol at the Doha conference in December 2012, and such a mechanism, which is favourable to investment in these countries would certainly be approved. As said in Section 1.5 above, the mechanism included in the Kyoto Protocol between 2008 and 2012 put downward pressure on quota prices in Europe.

Technical Issues Concerning the Generation of Electricity from Renewable Energies

Looking to the Future

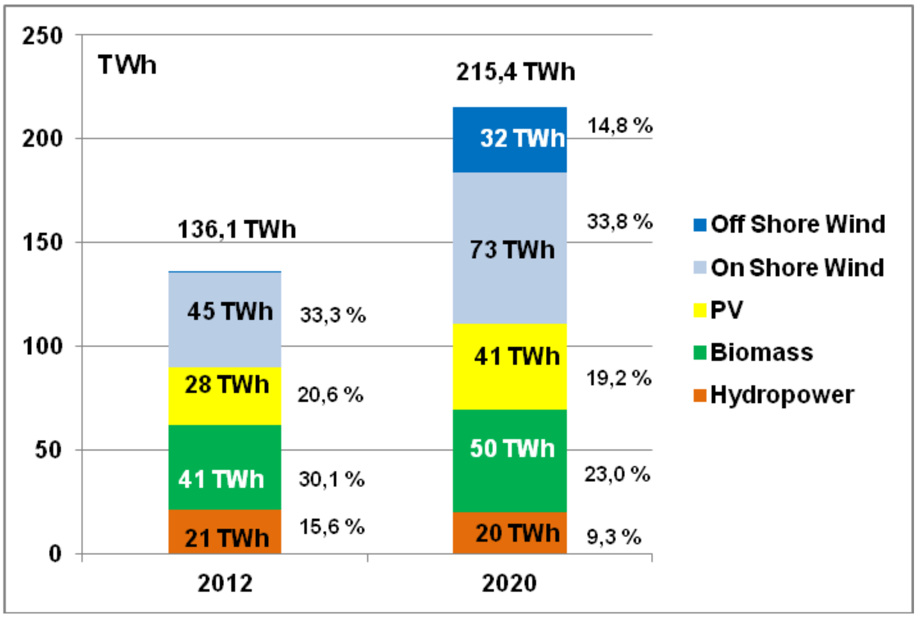
In 2012, 47% of Germany's electricity production came from coal (coal and lignite), 17% from nuclear, 12% from gas and 23% from renewable sources.

Figure 11 – The Share of Primary Energies in Electricity Production, in 2012[xxiii]



How will it be possible to get from 23% in 2012 to 35% in 2020? Most locations favourable to hydroelectric power have already been developed and bio-energy sources are limited. The main new sources are therefore wind farms (onshore and offshore) and photovoltaic solar panel installations. The cumulative production of these two sources is set to double, from 73 TWh in 2012 to 146 TWh in 2020.

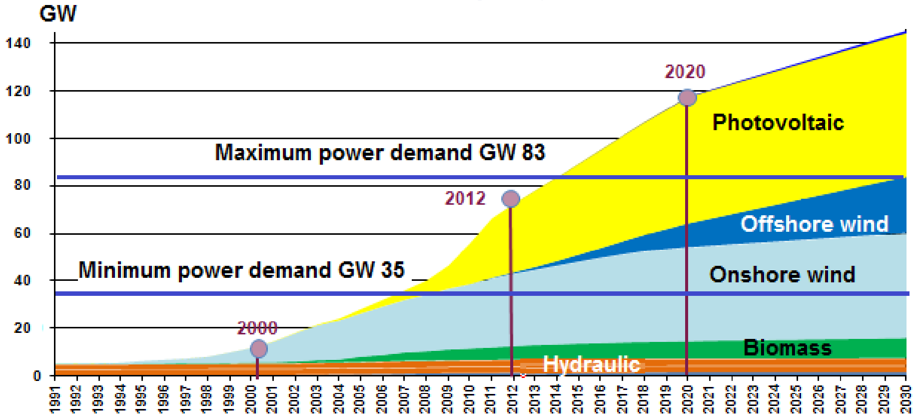
Figure 12 – The Electricity Mix from Renewable Energies in 2012 and 2020[xxiv]



Wind power and photovoltaic solar power are intermittent, depending on levels of wind and sunshine. The load factor which characterises the annual duration of production at full capacity (the "rated" power of any plant) is hardly 10% for photovoltaic power and 23% for wind power. It is therefore necessary to build farms whose capacity is far greater than required, in order to obtain sufficient volumes of current. This raises three problems:

- Wind farms are built in areas with the best wind conditions, but these locations are nor those of former power plants, neither those of consumption. As a result, transmission networks have to be extended. Photovoltaic farms are better distributed, but nearly all of them are connected to local distribution networks which are not designed to take electricity from such a multitude of inputs. Local grids also need to be adapted.
- Wind flows and sunshine can change rapidly, leading to significant fluctuations in supply. Managing such intermittence requires special measures.
- As a result of overcapacity, situations will arise more frequently in which good weather and steady winds will generate more power than required by all German consumers. The latter do not use electricity much for heating, with the peak remaining stable (about 83 GW), and with minimal power requirements of around 35 GW.

Figure 13 – Electricity from Renewable Sources: The Outlook on Installed Capacity[xxv]



The Extension and Refurbishment of Networks[xxvi]

Up until the mid-2000s, Germany's major zones of consumption in the West and the South were equipped with electricity production capacity, so that the national grid had primarily a security function. Several nuclear power plants in these regions were closed in 2011, and so the use of networks rose to supply these parts of the country. Furthermore, the large majority of onshore wind farms in operation in 2012 were in the North and East of Germany. As accessing their production has become a priority, the needs for electricity transmission via high-voltage power lines linking the North-East to the South-West has increased strongly. Germany's Energy Agency (DENA, *Deutsche Energie Agentur*) as calculated that 2,900 km of line need to be reinforced, and 2,800 km needs to be put in place.[xxvii]

As in most European countries, it used to take about 10 years to complete high-voltage power lines in Germany. The federal legislative package in 2011 included a text aimed at bringing these delays down to about four years: the NABEG law (*Netzausbaubeschleunigungs-gesetz*) to accelerate network extensions, which updated the EnLAG law (*Energieleitungsausbaugesetz*) of 26 August 2009. It draws on the measures adopted during unification, which gave the federal authorities the mission of reorganising infrastructure for road haulage and rail transport. The Federal Network Agency (*Bundesnetzagentur* - BNA) was assigned the task of formulating a national plan of new high-voltage facilities for the next 10 to 20 years (*Netzentwicklungs-plan*), and identifying their pathways. Early information and public participation will be looked for and a financial compensatory mechanism created to compensate communes suffering damages. Energy storage facilities will nevertheless be exonerated. The laws provide a single authorisation procedure for lines up to 110 kV and lighten administrative procedures for other works. The text also authorises the government to complete maritime law in order to strengthen the legal bases relating to the connection of offshore wind farms. The government is also mandated to facilitate the completion and management of cross-border works: it may use regulations to modify measures relating to the networks, to encourage investment.

The Parliament is to approve projects defined as priorities by the Federal Networks Agency, every three years. This takes away the *Länders'* power of intervention, which has been judged as paralysing power lines crossing several regions.[4] The first plan was presented to the federal government on 29 May 2012, and included 36 priority liaisons. It was put to a 6-week public consultation. After this initial examination, the BNA amended its plan and presented it for a second consultation. The BNA then submitted its final plan, which was approved by the Bundestag on 25 April 2013, and the Bundesrat on 7 June 2013.

This first test of the new legislation organisation has thus shown itself to be very satisfactory. But it cannot be ruled out that court action will be attempted at some point, leading to delays in the construction of certain works. Furthermore, the completion calendar will indeed stretch out over several years: several transmission lines in the development plan that have only just been adopted were already needed as of March 2011...

It should be noted that the new, long-distance lines to be built will transmit direct current. While the physical principles of such transmission are known, technological breakthroughs still need to come through (such as high-power circuit breakers or low-loss conductors). The scale of Germany's programme favours the development of new techniques, which will undoubtedly also lead to future export outlets.

The legislative measures are far more summary concerning distribution networks. The law on electricity and gas provision (*Energiewirtschaftsgesetz - EnWG*) has limited itself to facilitating the progressive integration of information and communication technology, such as "intelligent meters", in new buildings and for major consumers, along with equipment for distance measurement and control in real time of power injected into the system or drawn from the grid. An industrial approach has been favoured, as the law defines basic functions which appliances have to carry out, while at the same time setting out a sufficiently flexible framework to allow for technical changes and to let operators formulate detailed standards.

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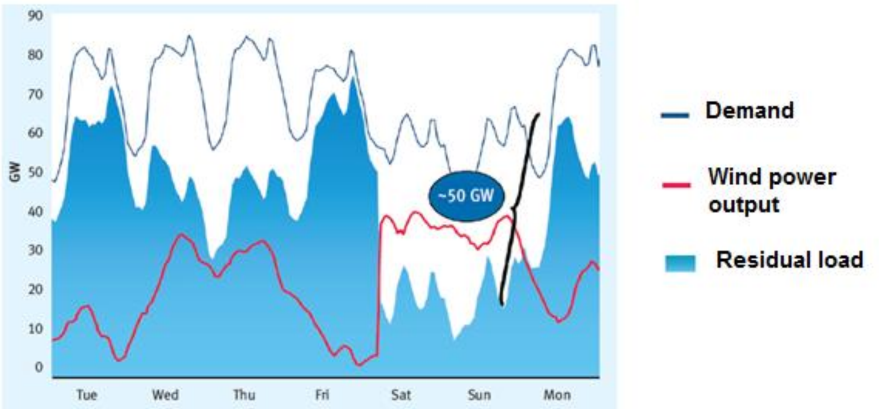
[4] There are 16 *Länder* (the plural of Land) and federated regions in Germany. Each Land has its own government and parliament.

Managing Intermittence

EU Directive 2009/28/CE and German law oblige network managers to give priority to injecting electricity from renewable sources. The difference between such production and consumer demand is called the "residual load" to be supplied by conventional sources (nuclear power, gas, coal and hydroelectricity, etc.). As intermittent power generation has grown, so has the volatility of the residual load. Figure 15 is drawn on the basis of a simulation, illustrating variations in residual load over a week, assuming that 45 GW of wind power is injected into the network. In this case, conventional sources have to be able to provide up to 50 GW in some hours. The phenomenon is of course amplified if similar levels of photovoltaic power are taken into account. This simulation is quite close to forecasts for Germany in 2020, with about 49 GW of installed wind power and 54 GW of solar power[xxviii].

Figure 14 - Fluctuations of the Residual Load[xxix]



There are three solutions within a single country to meet such rapid fluctuations:

Backup Power Stations

The conventional sources best-adapted to strong changes in power are hydraulic dams, turbines with open cycle fuel, and combined cycle natural gas plants. Germany's nuclear power plants can also "follow the load" quite efficiently.[xxx] But their planned shutdown means they will no longer be available to network managers. Lastly, coal-fired plants can contribute as well, though they are less flexible. As hydroelectric power plants are relatively cheap, they will certainly be available. But Germany only has 11 GW of hydraulic capacity, including waterway dams which are not able to modulate power. In contrast, the installed capacity of thermal plants runs to 30 GW for gas or oil, and 55 GW for coal. The continued running of the thermal fleet is not guaranteed, as electricity output from renewables reduces the number of hours it will be drawn upon, to such an extent that earnings will not cover expenses. Moreover, it is often said that the E.ON group intends to close a majority of its gas stations, which are no longer profitable.

To guarantee the security of supply, the government has submitted for authorisation the closure of power stations and has improved the earnings of those still in services, via several measures, including in particular the creation of a so-called "strategic reserve" mechanism. The Federal Network Agency (BNA) for its part has loosened criteria for contributions to primary reserves (provided within 30 seconds), as well as of secondary and tertiary reserves (respectively in less than 5 minutes and 15 minutes). It has also set up a Level 4 reserve. For their part, the network managers have set up a body to help share reserves (*Netzregelverbund*), which is open to managers in neighbouring countries too.

The International Energy Agency has simulated trends in demand with a model whose parameters reflect the changes set out in Germany's power plant fleet, in order to evaluate the security margins of the system (the difference between peak demand and "dispatchable" reserves at power stations, i.e., that can generate electricity at the demand of network managers). The results indicate that there is a comfortable margin until 2015, of about 17% (or 13 GW). But thereafter it will fall, to the point of leading to shutdown risks in 2022. The new conventional power stations which are planned in the projects underway are insufficient to bridge the needs resulting from planned closures.[xxxi] Under normal circumstances, imports provide necessary supplements in power. The most current scenario suggest rising imports from 2020 onwards, reaching 62 TWh in 2050 (or 11% of consumption).[xxxii] But these flows are managed according to commercial rules and will not automatically be available to German network managers in case of need.

Managing Supply and Demand

The law also strengthened the prerogatives of network managers, allowing them to cut off some plants in case of surplus injections, while also permitting them to carry out disconnections or withdrawals in case of risks to the grid. The BNA has fixed compensation conditions in such cases. Withdrawals arise when consumers voluntarily cut demand. They are undertaken by large industrial or commercial sites, which take at least 50 MW in power. The legislation setting out the conditions for participating in this system was finally passed in January 2013 (*Verordnung über abschaltbare Lasten*). The compensation of withdrawals for sites selected appears to be quite generous, with a total cost fluctuating between €125 million and €350 million per year. Such spending is entirely passed on by network managers to final consumers.

Distribution grid managers also have the possibility of offering clients voluntary withdrawal, which gives them reductions in the "distribution" component of their bills. The modulation of consumption by customers will be facilitated by the installation of intelligent computers. Consequently, cuts will no longer really be withdrawals but rather choices made about when to use appliances, according to the spot price of current.

Electricity storage

Large-scale storage will be the best means to use surplus electricity in times when output from renewable resources exceeds demand.

To date, the only means applicable for storing massive amounts of energy are through hydraulic pumping and storage: this is also called gravitational storage. Water is pumped from a lake downstream to a lake upstream in times of overcapacity, and subsequently released back down through turbines to generate electricity at times of peak demand. These systems are very flexible in terms of power and availability, but they require specific sites… which are scare in Germany. As a result, Germany has passed contracts with border countries to exploit their hydraulic systems jointly: Austria and Switzerland at present, as well as Norway soon thanks to an underground cable.

However, Germany wants to move beyond these agreements, whose capacities are far below its needs. In June 2012, the government released funds of €200 million to finance in an initial wave of research, and after receiving 400 project submissions, 60 projects were selected. All technologies are being explored, including compressed air, fly-wheels, super-conductors, batteries of all types and hydrogen. The latter is of particular interest as it is produced by the electrolysis of water using electricity from renewable sources. Its applications are many, including:

- use as fuel in normal combustion engines (several German cities already provide it for this);
- re-conversion into electricity by a fuel cell, for example to drive electric cars;
- injection directly into the natural gas network, though in low quantities so that burners do not need to be modified;
- combination with CO_2 to produce methane.

The latter process, called methanation, raises great hopes. If developed on a large scale, CO_2 produced in power stations could be reused to produce new fuel for the very same power stations. This would make it possible to decouple the production and consumption of electricity. Electricity can be produced when there is wind and sun and then be transformed into methane, which could be stored as a gas and then be reconverted into electricity in response to demand, in combined-cycle gas plants. Germany already has large underground storage capacity for natural gas, and this infrastructure could be used to store surplus electricity converted into methane. It is a kind of philosopher's stone that would allow Germany to achieve nearly 100% of renewable electricity production by 2050.

The energy yields on the processes described above are still mediocre (with the exception of hydraulic storage), while costs remain prohibitive. The large efforts currently being made by German researchers could lead to significant progress on both these fronts. However, given the scale of needs (presently it is estimated that storage needs will be 40 TWh in 2020), even were a major breakthrough to occur within months, the construction of installations would be too slow to provide a full response before the middle of the next decade. In any case, all these technological efforts will require the development of equipment that can be produced industrially.

It should also be recalled that work is being carried out to store heat on a large scale in Germany too, due to the choice made favouring co-generation (see Section 1.5).

The Industrial Orientation

The question of storage relates to a key issue in steps taken in Germany's energy turnaround, namely Germany's research programme. The framework programme adopted in 2011 dedicated €3.5 billion over three years to four major research axes: i) technologies linked to renewable energies, ii) energy efficiency, iii) energy storage, and …. iv) nuclear power. Germany in fact is seeking to turn its early abandonment of nuclear energy into an advantage, to develop nuclear-plant decommissioning technology and methods which it will be able to export later.

The guiding principle of this research programme is to prepare industrial processes, from the outset. The hope of taking a lead over other industrialised countries stands out in all sectors, be it biogas storage, the production of bio-fuels, the development of new organic photovoltaic cells or the development of hydrogen applications and fuel cells. This is not to forget more traditional sectors like, for example, yields by co-generation plant.

The links between business and politics are all too visible in the emblematic car industry. The "electro-mobility platform" brings together researchers, car-makers and public authorities to centralise the results of programmes, launch demonstration operations, channel public money to research projects to explore and sketch out future legislation aimed at leading the market, drawing, for example, on tax incentives. €1.4 billion has been allocated to this programme, and the government's objective is to have 1 million electric cars in operation by 2020, and 6 million by 2030.

Government support is also visible in other ways, such as foreign policy. Accordingly, Germany has recently signed two agreements with countries producing raw materials that are much needed in high technologies. The first is an agreement with Chile to facilitate investment by German firms in lithium extraction (signed 26 January 2013), and the second is a broader partnership with Mongolia (a meeting occurred on 8 May 2013), as this country has important reserves of so-called "rare earths" which are vital in certain high technologies.

In the field of domestic appliances, preliminary applications have been shown to the general public, which still look like experimental prototypes, given their prices, size and low performance: for example, cupboards containing batteries capable of storing electricity produced by photovoltaic panels, combined gas and electricity hot water boilers that can store surplus electricity as hot water, or boilers operating via cogeneration, providing families with top-up electricity during winters. Though sales are still experimental, this has done little to reduce the enthusiasm of designers, who are striving to sensitise future buyers early.

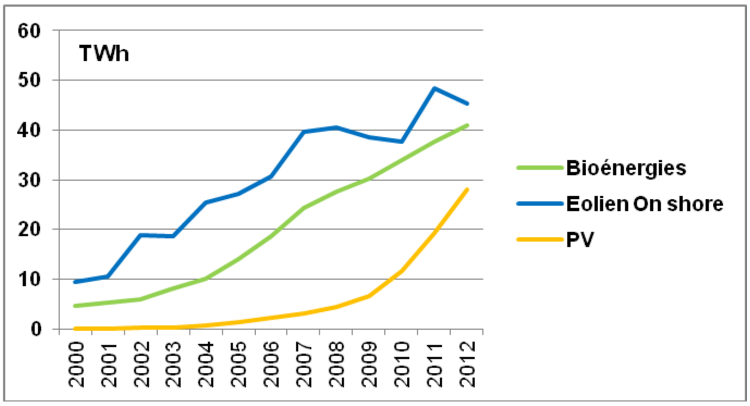
Similar approaches have already take place in the past and could have expanded, even without the "energy turnaround". But the spectacular decision to favour renewable energies in 2010 and 2011 has given visibility to the German energy industry which it is using to the best, with government support both in the national market and for exports.

Economic Issues Concerning the Generation of Electricity from Renewable Energies

The Promotion of Electricity from Renewable Energies

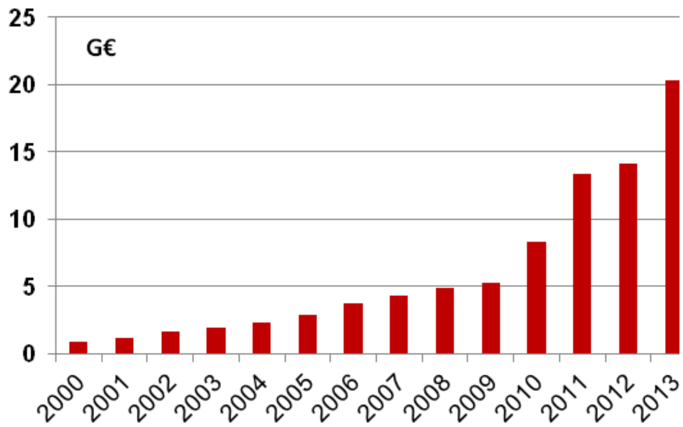
To promote electricity generated from renewable energy sources, the EEG law passed the 29 March 2000 gave it a mandatory priority in accessing the network, while paying a "feed-in tariff". This tariff is set by the government for each technology, at a level judged to provide incentives, and for a long period of time (20 years). The measure has been very effective. Initial completed projects have provided lessons that help cut costs, which have been accelerated thanks to technological progress induced by the development of markets. Margins between the cost per kWh and the guaranteed tariff have increased, attracting new actors so that the generation of electricity from renewables has expanded rapidly. The system in fact provides visibility which has become rare within the energy sector: low risks are attractive to investors, who are also reassured by the normalisation of procedures put in place.

Figure 15 – The Evolution of Electricity Production from Renewable Sources[xxxiii] ***(Excl. hydroelectricity which has few guaranteed prices)***



When kWhs from renewable sources are supplied, the local transmission grid operator pays the appropriate tariff for the guaranteed purchase. Subsequently, it acts as a normal supplier, selling the electricity on the wholesale market. The difference between the purchase tariff and the sale price is accumulated in the "EEG account". Looking at Figure 15, it seems that this account will increase at the same pace as electricity generated from renewables: in fact, a clear acceleration may be observed since the photovoltaic electricity production began.

Figure 16 – The Increase in the EEG Account, in € billions[xxxiv]



For photovoltaic electricity, the difference between the feed-in tariff and the market price has indeed been markedly higher than in other sectors, so that the development of this source has led to a rapid rise in the EEG account. For instance, in 2005, the difference was about 7 c€/kWh for bio-energies, 5 c€/kWh for wind power, and a staggering 49 c€/kWh for photovoltaic electricity.[xxxv] Thus, even though the total electricity generated by solar panels seems small, its impact on the EEC account has been considerable.

German lawmakers have reacted by adjusting the regulatory framework progressively to put safeguards in place, the most notable coming into force on 1st January 2012:

- For all technologies, incentives for direct sale have been created. Operators can thus choose to sell directly all or part of their production from renewable energy sources on the market during the period of their choice, upon notice to the network operator. The benefit of the tariff guarantee is interrupted if the market price is higher. If the opposite is true, the network operator pays compensation to the operator. A market premium and a flexibility premium reinforce this incentive.
- The feed-in tariffs have been revised downwards for plants entering operation after 1st January 2012. In addition, a falling coefficient has been introduced, leading to a gradual reduction in the rate applied to installations entering operation in each subsequent year. Favorable conditions, however, are granted

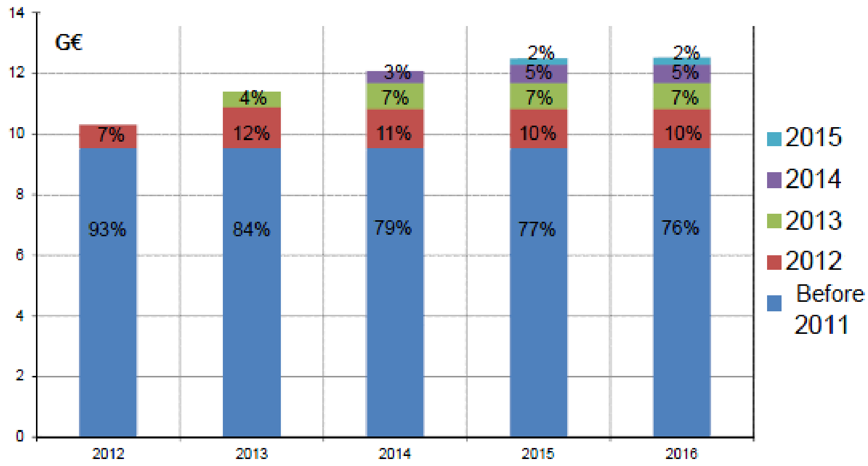
to offshore wind farms connected before 2018, as well as onshore wind power capacity undergoing repowering.

- For plants with a capacity greater than 100 kW (and 30 kW for photovoltaic plants) there is an obligation to provide remote control allowing the grid operator to control the power supplied. Facilities producing electricity from biogas must have a tank to store the gas produced for 150 days (this requirement does not apply to facilities operated only from manure). When for safety reasons, the grid operator reduces the power demand of a facility, the operator is compensated for 95 % of the revenue lost.
- Encouraging storage and consumption. Electricity stored temporarily has a guaranteed purchase price if the operator agrees to leave all available power to the grid operator and is prohibited from selling part of his/her production on the market.
- For photovoltaic generation, three specific provisions have been implemented. First, the guaranteed purchase price has been lowered. Second, a capacity ceiling has been fixed (GW52), beyond which new plants can no longer claim the guaranteed purchase price. Finally, this guaranteed rate will experience further cuts: an accelerated decline within a period of 12 months, depending on the capacity coming into operation: from -3% above 3.5 GW, to -15% for more than 7.5 GW.

The latter provision is intended to put an end to the "end-of-year rush" which existed earlier, as each announcement of a reduction in the guaranteed purchase price on 1st January in the following year led to massive installations of solar panels to benefit from the ongoing rate until 31st December...

According to the Öko-Institut in Berlin, these measures will stop the progression of the relative share of photovoltaic electricity production in the EEG account. The Institute asserts that the generation of electricity from this technology will nonetheless continue to rise, as the price of installations falls more quickly than the declining path of the feed-in tariff. However, for the Institute, the latter is henceforth so close to the market price that the share of photovoltaic electricity in the EEG Account will only increase slightly.

Figure 17 – The Outlook for the Evolution of Photovoltaic Electricity in the EEG Account[xxxvi]



The EEG Account is nevertheless likely to continue to rise, largely due to the impact of offshore wind farms which have a guaranteed feed-in tariff significantly higher than the market price (13.8 c€/kWh in 2013). This should lead to increases in output quite quickly, rising from 0.7 TWh in 2012, to 33 TWh by 2020 and 61 TWh by 2025.[xxxvii] Onshore wind power is also expected to double in 13 years, rising from 45.3 TWh in 2012 to 91.2 TWh by 2025. This will follow from overhauling of existing farms to increase their output (repowering). Though the difference between the feed-in tariff and the market price is quite small (about 2.9 c€/kWh in 2013), the volumes involved are sufficiently high to influence the EEG Account significantly.

To end with the EEG Account, it is a debt that German consumers have to producers of electricity from renewable sources. The amount depends on numerous factors (the start date of the activity, the expected volumes of production, technology, etc.). A precise evaluation is not possible, but by extending trends observed since 2000, a simple calculation would lead to a sum of €250 billion (on top of the €67 billion already paid between 2000 and 2012).[xxxviii] This is a debt which is "required by the State", but it is not included in Germany's sovereign public accounts. If it were, would Germany still benefit from its triple a credit rating?

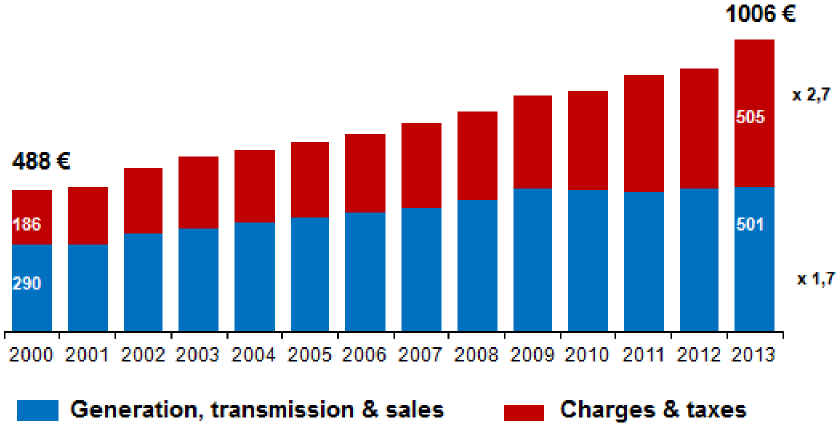
Electricity from Renewable Energy Sources and its Price

The sums of the EEG account are passed on to the consumer via an "EEG surcharge" (*EEG Umlage*). It has risen every year, rising from 2.06 c€/kWh in 2010 to 5.277 c€/KWh in 2013. This surcharge has led to a rise in average household bills, which practically doubled between 2000 and 2013. The "technical" component of a household's bill (covering costs of producing electricity, transmission and distribution) today accounts for less than 50% of the total. The remainder is made up by charges and taxes. In 2000, the EEG surcharge ran only to 3.7%, of all charges and taxes: today it accounts for 37%. The other components have remained practically unchanged:

- 1.79 c€/kWh for the concession right since 2000.
- 2.05 c€/kWh since 2003 for the environmental tax on electricity (*Stromsteuer*).

It should be noted that VAT is applied to all subordinate charges and taxes.

Figure 18 – The Evolution of the Annual Average Household Bill [xxxix]
A Representative Household Client, Consuming kWh 3500 per year



The cost per kWh for a German household is the second most expensive in Europe, behind Denmark. A rise in the price of electricity leads to a fall in income for a significant share of the population, with the Hartz laws having reduced income support and encouraging the use of part time employment by companies, since 2005. This twofold evolution has led to a rise in "fuel poverty", referring to the fact that certain customers have difficulties in paying for their energy bills. This is a phenomenon which is hard to gauge, as electricity distribution to households in Germany is highly fragmented. As a result, there is a large disparity in prices per kWh paid by consumers, which makes their evaluation difficult. Fuel poverty is therefore not measured in federal statistics.

The most recent national surveys nevertheless have estimated fuel poverty to lie between 10% and 15% of households, in 2012. Depending on the sources, between 600,000 and 800,000 households are cut off from supply every year, due to the non-payment of their bills.[xl] These figures are very high, if one takes into account the fact that no more than 5% of German households are heated with electricity. Electricity bills thus generally concern "specific consumption", for which only electricity can be used: lighting, appliances, electronics, etc. In 2010, electricity bills accounted for between 4% and 7.5% of household incomes below €1,000 per month.[xli] The margins for cutting consumption are all the more limited as households on average are already equipped with efficient appliances, while sensitivity to environmental behaviour has induced virtuous behaviour. Despite having higher appliance ownership rates than their French counterparts, German households use less electricity.[iii]

The "technical" share is made up of supply and transmission. The supply component varies as a function of fuel prices and investments in maintaining and replacing facilities. In 2013, it accounted for about 30% of the average household bill, and competition between producers only exists concerning this 30%. The 20% relating to transmission and distribution is set by the Federal Agency of Networks or BNA (*Bundes Netz Agentur*) and regional regulators. Transmission costs will likely rise due to the significant investments which need to be made to connect sources of renewable electricity, as well as new conventional power stations. The grid also needs to be modernised: see the figures above (Section 2.2).

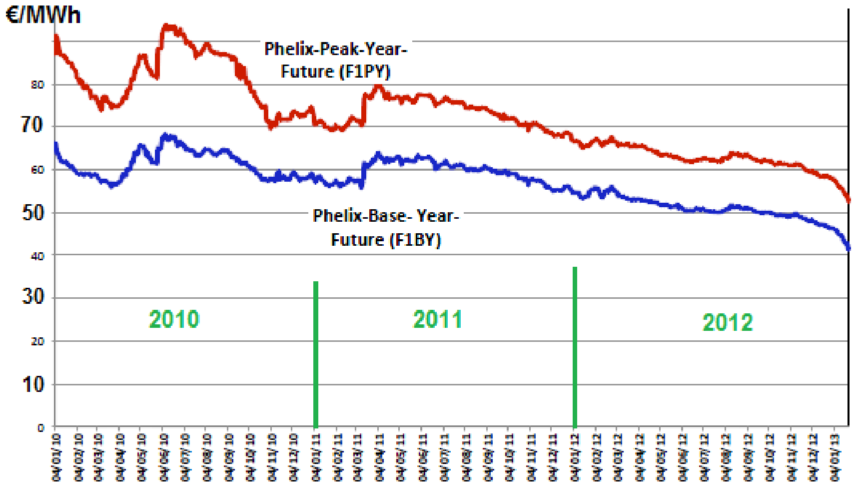
The refurbishment and extension of the high-voltage network concerns 2,900 km and 2,800 km respectively. The German Energy Agency (DENA) has estimated costs for this to be between €1 billion and €1.6 billion per year on land, depending on the technology chosen. The total budget estimate for options already decided runs to €20 billion. A further €3.7 billion to €13 billion needs to be added for offshore connections for wind farms, according to the low (GW 7) or high (GW 13) completion scenario.[xlii] The laying of a line linking Germany and Norway will cost close to €2 billion.[xliii]

Renewing and extending the distribution grid involves 135,000 km and 200,000 km of lines. For this grid, the overall investment this entails is between €27.5 billion and €42.5 billion, according to whether the scenario adopted is by the Federal Network Agency (the NEP 2012 B scenario), or by the cumulative forecasts of the 16 *Länder*.[xliv]

Lastly, the "technical" part of household bills covers additional costs linked to falling yields by classical thermal power plants, which guarantee supply as renewables fluctuate. Compensation paid to sites that have subscribed to voluntary withdrawal contracts, and more generally "system" costs have been evaluated at €10 to €20 per MWh,[5] in a study recently published under the auspices of the OECD.[xlv]

The above considerations do not show up in the wholesale market. Instead, prices here have been falling since 2011. This fall corresponds to the massive arrival of electricity from photovoltaic solar panels, installed in 2010 and 2011. We have seen above that transmission network operators buy such power at guaranteed feed-in tariffs, and sell it on the wholesale market. For sales to be ensured, operators systematically offer a price below that of non-renewable sources. This sales strategy has led to market prices being pulled downwards, in proportion to the electricity resold, and so for the production of all renewables.

Figure 19 – The Cost of Electricity on Germany's Wholesale market[xlvi]



As market prices fall, the EEG Account increases, as it is linked to the difference between guaranteed feed-in tariffs and market prices!

The rise in the kWh price of electricity affects not only households, but also industry. The government realised very early on the risk of falling competitiveness German industry faced due to higher prices. As a result, it introduced a falling EEG surcharge for manufacturing industries. It is only applied fully for the first GWh: they only pay 10% for their consumption between 1 GW and 10 GW, and 1% between 10 GWh and 100 GWh, and the price levels off at 0.05c€/kWh above 100 GWh. Electricity-intensive industries (more than 100 GWh and with an electricity bill greater than 20% of their value added) only pay a surcharge of 0.05 c€/kWh for their total

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[5] Apart from system costs alone, the study estimates the full additional cost of production to be between €19/MWh for onshore wind power, €28/MWh for offshore wind power and €57/MWh for photovoltaic electricity.

consumption. To get these reductions, companies consuming more than 10 GWh per year have to prove that they have implemented potential energy savings. Lastly, a rebate is granted to companies that produce electricity themselves. Overall, 1,638 firms benefited from a reduction in the EEG surcharge in 2013: they accounted for 53% of the electricity consumed by German industry. The reduction is estimated at €4.3 billion; and this fraction of the EEG Account not paid for by large industrial users increases the surcharge applied to all others. The surcharge would only be 4.23 c€/kWh (instead of 5.28 c€/kWh) if it were spread across all clients. In other words, clients paying the surcharge at its full rate subsidise heavy industry to the tune of 1.05 c€/kWh.[xlvii]

Some German industrial sectors also benefit from other advantages:

- a reduced rate of environment tax on electricity: 1.54 c €/kWh (compared to 2.05 c€/kWh for households) or 0.15 c€/kWh for industries with retirement schemes (the earnings of the environmental levy is intended to finance Germany's general pension scheme).
- a reduced rate to 0.11 c€/kWh for the concession fee (instead of 1.79 c€/kWh for residential customers) or complete exemption for some businesses.
- a reduced rate for the cost of co-generation (*KWK Umlage*: a mechanism which works like the EEG surcharge).
- a reduction of up to 80 % or even completely free in some cases, of the rate for using networks. Industrial consumption benefiting from these reductions is estimated at 74 TWh in 2013, i.e., 30 % of the 243.1 TWh which are set to be delivered to the whole of German industry in 2013.
- an allowance to compensate for the increase in electricity prices. As a derogation to EU rules prohibiting state aid, subsidies from public funds are authorised for certain undertakings by EU Directive 2009/29/EC. The amounts paid in this context from the federal budget were estimated at €500 million in 2012.

Overall, the reduction in the EEG surcharge and all measures listed above provided German industry with savings estimated at €10 billion in 2012.[xlviii] Average prices (before VAT) were 9.82 c€/kWh for households, compared to 7.26 c€/kWh for small industries and 2.78 c€/kWh for large companies. Very large consumers have another advantage: they can buy their power directly in the wholesale market. They thus benefit from prices pulled down by the arrival of power from renewable sources, which is paid at guaranteed feed-in tariffs, that is to say by the EEG surcharge, of which these large consumers pay little... At the beginning of 2013, the average price on the wholesale markets fell below 5 c€/kWh (price for delivery in base load), thus lower than the EEG surcharge level, which was set at 5.277 c€/kWh.

Due to market coupling, the downward trend in wholesale markets also appears in the Germany's neighbouring countries.[6] Large consumers in these countries therefore also benefit from lower prices when conditions are favourable for wind power or photovoltaic energy in Germany, though this power is subsidized by German consumers subject to the EEG surcharge.

The Public Debate about the Electricity Price

The previous increase in the EEG surcharge, announced 15th October 2012, led to a broad public debate on the price of electricity in Germany. The surcharge rose from 3.53 c€/kWh in 2012 to 5.277 c€/kWh in 2013: an increase of nearly 50%. The former Minister of Economics (a member of the Liberal Party, or FDP, which was the minority party in the coalition government at the time) condemned the same day the support system for renewable energy as being "out of all control", and threatening the industrial competitiveness of Germany .

This announcement only confirmed perceptible fears among the public. A survey conducted in September 2012 showed that for 53% respondents, prices had become the subject which should henceforth be a priority in Germany's energy policy. This finding supports the results of a previous survey, conducted in June 2012, in which 62% of respondents felt that the energy transition was moving forward badly, while 75% feared it would lead to higher prices.

However, 83% of respondents to the second survey felt it necessary to expand renewable energies. The government is thus faced with a complex equation of maintaining a favourable environment for the development of renewable energy sources, while reducing the cost to the country. In the run up to the elections of September 2013, the government refrained from launching bold initiatives, and Chancellor Angela Merkel has not mentioned any new concrete paths to be taken.

Aware of the need for reform, but anxious not to alienate the renewable energy industry, the environment minister, Peter Altmaier, set up a consultative body (*EEG Dialog*), in the autumn of 2012. Its conclusions could be included in a law revising the current system

[6] Thanks to market coupling, operators in wholesale electricity markets have access to all supplies from participating countries, with no need to take borders into account. The system has been experimented since 2010 in Germany, Belgium, France, Luxembourg and the Netherlands. It should be extended to the whole of Europe by the end of 2014.

extensively. Six working groups met between 28 November 2012 and 14 March 2013. Alongside the work of this body, the Ministries of Economics and the Environment presented the outline of an immediately applicable modification on 13th February 2013, resulting in the capping of the EEG Account. The Chancellor however subsequently backed down in the face of opposition by members of the Bundesrat, whom she had gathered together for informal discussions on 21st March 2013 about this project.[7]

The text of the 13th February 2013 confirms the current objectives, but stated the importance of limiting costs (*Energiewende sichern - Kosten begrenzen*). The principles that inspired the text remain partially or widely applicable in the reform which will be implemented now that the elections are over. Points include:

- An increase in the parameters affecting the decline in tariffs so that they quickly converge on the market price.
- The generalisation as quickly as possible of the sale of electricity into markets by producers themselves.
- Reconsideration of exonerations of the present EEG surcharge for industry, envisaging a special tax on producer profits (*EEG-Soli*).
- Linking the development of generation to the extension of the network, and the creation of capacity reserves so that the security of supply may be preserved. Such linkage assumes a form of planning at the federal level.

The Minister of the Environment, Peter Altmaier, justified these propositions in an interview with the daily *Frankfurter Allgemeine Zeitung* (19th February 2013), asserting that the energy transition could cost €1 trillion. Elected politicians have confided that they had thought of going further than the 13th February 2013 text, by reducing the guaranteed feed-in tariff applied to installations already in place. But this idea was dropped. It would have ruined investor confidence and could even have led to a banking crisis, given the scale of debts contracted to create new generation plants, debts whose repayment would have become fragile. In contrast, lawmakers have not given up of examining taxation relating to the EEG surcharge: it could be paid not only by electricity consumers by also by all taxpayers.

By their proposals, the Ministers of Economics and the Environment have acknowledged rising worries in business circles. Defending industrial competitiveness is a unanimously-shared objective among Germany's political class. The impact of the energy

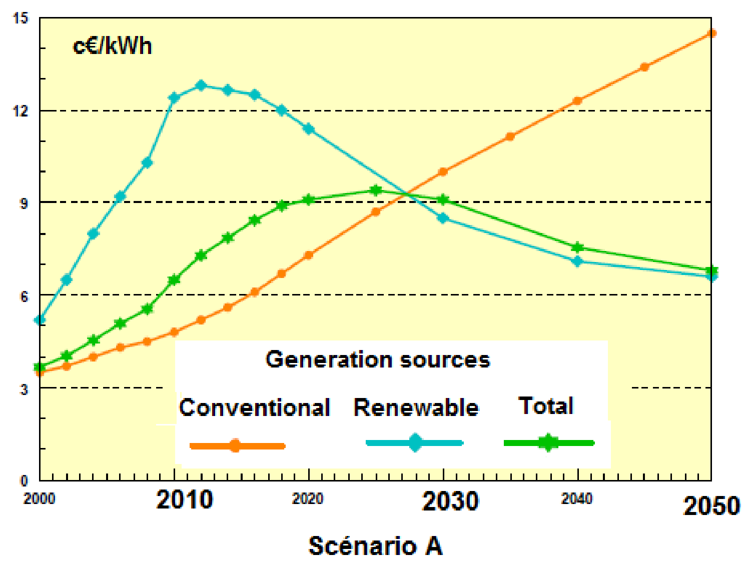
[7] The Bundesrat is the upper chamber of Germany's parliament, made up of representatives from the 16 *Länder*.

turnaround on manufacturing industry is a major issue. At the start of 2013, the IDW economics institute in Cologne (*Institut der deutschen Wirtschaft Köln*) published the results of a survey it conducted of 1,500 company executives, between March and July 2012.[xlix] In 81% of replies, a rise in energy costs was a preoccupation; less than 30% of the persons surveyed felt that the energy turnaround would provide them with markets, while an identical proportion feared that their market positions were threatened. The advantages of the energy turnaround in terms of innovation seemed real in 11% of replies, whereas 60% of persons surveyed considered them to be imperceptible. Moreover, the study indicated a fall in investment in energy intensive sectors, though it did not reveal any risks of off-shoring.

The graph below shows up the risks faced by German industry:

- The orange curve indicates the cost of production of electricity from fossil fuels (the actual cost up until 2010, then the simulated cost).
- The blue curve is the production cost of electricity from renewable sources (real, plus simulated).
- The green curve is the total cost; the addition of the two other curves, weighted by volume for each source.

Figure 20 – Scenarios of Cost Trends[l]



Scenario A is usually taken as a reference and is based on very favourable assumptions concerning renewable energies, whose costs are assumed to fall rapidly. At the same time, the price of fossil fuels rises quickly on international markets, while the price of CO_2 quotas in the ETS system increases regularly from €14 to €27 between 2010 and 2020. Despite these favourable assumptions, German consumers will pay high prices until 2026, the date at which the three lines cross. If the reality turns out differently, for example if the world price of fossil fuels rises less quickly than forecast, if the price quota of CO_2 stagnates (it did fall below €5 at the start of 2013) or if the costs of renewables fall too slowly, then the curves will cross-over further to the right and so the surcharge could continue until… 2050!

Germany's employer organisation has drawn radical conclusions, as it proposes abolishing the EEG Account mechanism and the corresponding surcharge, right away. Its collective body, the BDI, indeed brings together both large and small firms. The latter do not benefit from exonerations granted to large companies, so that the struggle against all charges has become a rallying call. The BDI thus avoids challenging the development of renewable energies, while underlining the competitiveness handicap which a far higher price per KWh represents for German industry, when compared to others (Europeans, Americans or Chinese). Lastly, the BDI president, Mr Ulrich Grillo, has noted that revenues flowing to government via VAT have automatically increased in proportion to the rise in electricity prices, including charges. He has therefore claimed that surpluses be paid back to customers on the one hand by reducing the rate of environmental tax. On the other hand, he has called for more subsidies for energy efficiency efforts.

The DEX index, which each month measures how 2,500 company bosses feel about the energy turnaround, confirms the growing deception in these circles: in June 2013, the average appreciation fell to 9.5/20, in other words less than half, after a year-long's decline. This survey has shown up a new source of worry, namely the problem of short power cuts (less than 3 minutes), which are tending to proliferate (16% of directors surveyed say that they had suffered one such cut in the preceding 12 months). In half of all cases these cuts disrupted business seriously.[li]

Professionals working in renewable energy consider that maintaining the present system of feed-in tariffs is vital. Given that they represented an annual turnover of €14.4 billion in 2012, they carry some weight in the public debate.[lii] Despite the doubts among employers as shown in surveys, the renewable energy sector's first line of defence is to stress its importance in job creation and innovation.

Employment and Economic Benefits

Employment remains a controversial issue. The Ministry of the Environment has published a detailed study, recognising that it is very hard to evaluate net job creation: i.e. jobs that would not have been created without supportive public policy.[liii] Consequently, only the gross figure is quoted. It is the addition of all direct jobs (in the sectors focused on renewable energies) and indirect jobs (among sub-contractors). But this figure does not take into account: i) jobs destroyed in other sectors; ii) job resulting in the transformation of existing sectors; iii) jobs threatened by the high price of electricity; or iv) those jobs which would have been created had investment gone into other activities.

Given these provisos, the document states that 381,600 gross jobs were created in Germany's renewable energy sector, of which 74% were in electricity. These jobs have considerably improved labour market conditions in three *Länder* of former East Germany, which have been badly affected by unemployment (Brandenburg, Mecklemburg-Pomerania and Saxe-Anhalt), but that are today well placed concerning wind power and photovoltaic energy. In the future, the economic prosperity of the sector is linked to exports, which are in turn influenced by the price of fossil fuels on the world market. In the pessimistic scenario (the world economy and the prices of competing energies rise only slowly), the sector will generate 480,000 jobs in 2020, and 520,000 jobs in 2030. In the optimistic scenario, job growth will rise to 600,000 in 2020 and 640,000 by 2030. The limited growth here between 2020 and 2030 is due to productivity gains, reducing the number of jobs needed to produce the same level of turnover. The study stresses that jobs in the renewable energy sector are largely for skilled labour (nearly 80% in 2009, of which 10% are university-qualified). Lastly, 62% of recent jobs in 2011 related to investment. Other jobs concerned operation and maintenance (20%) or supplies for bio-energies (15%).

Jobs linked to investment are dependent on the pace of installing plant in Germany and the export capacities of the country. The authors of the study believe that investment will experience such a rapid rate worldwide in the decades ahead that German industry is guaranteed of having a sufficient market to see job growth. The current difficulties of the photovoltaic industry have not shaken this conviction. It should be recalled that since 2012, nearly forty companies in this sector have declared themselves insolvent or have sold a part of their business: some of these firms had been among the world's leaders until 2010 (Q-Cells, Solar Millenium, Solon, etc.). Is this tragic situation an indicator of similar trends elsewhere? In this dark scenario, emerging countries will rapidly catch up with the technological advance of European countries, and will push European producers out of their own markets, possibly by dubious means, which Chinese manufacturers of solar panels are suspected of having employed: they are believed to have received loans from local banks they do not have to pay back.

The federal government seems to have abandoned the sector, refusing to support sanctions proposed by the European Commission against imports of Chinese solar panels. With no official explanation, it is possible to view such panels today as being mere "commodities" to import at the cheapest price. Thus it is possible to continue developing electricity generation in the sector, and preserve jobs of installers, which reduce energy costs to the consumer. It may also be assumed that Germany's solar panel manufacturers have been sacrificed in order not to affect trade relations with China, which is an important export market for German industry. The government constantly counts the number of jobs in the capital equipment sector as being among the benefits of exporting renewable energies, as when these sectors sell their machinery abroad to help make solar panels, for example, or when appliances used to clean solar panels are sold.

The photovoltaic industry stands out as having been the most spend-thrift between 2008 and 2012. According to a university study, the total costs it has generated for the German consumer runs to €108 billion in five years (compared to €20.5 billion for wind power), and the cost per tonne of CO_2 avoided is €716.[liv]

Financing the Energy Turnaround

From a financial point of view, the German energy turnaround covers several types of activity. These range from highly-profitable operations which use tested technologies in projects benefiting from long term guaranteed tariff, for example, to operations with uncertain returns due to technical hazards, via works with very long periods of return, such as the renovation of thermal power stations. As the energy transition began more than 10 years ago, the financial tools have been progressively refined to meet all situations.

The real pivot of the financial system is the KfW. This public institution is guaranteed by the federal government, which allows it to raise money in financial markets under excellent conditions. About €80 billion are thus borrowed every year, according to a recent study by the IDDRI.[lv] The KfW also receives a direct grant from the State, which comes from the Energy Climate Fund, which is itself funded by the sale of CO_2 quotas in the ETS system. In 2012, the Energy Climate Fund provided about €1.5 billion to support subsidies at preferential rates.[8] These resources allow the KfW to channel "designated" monies to private banks for projects concerning the energy sector and to pay subsidies directly. Local banks draw on a network of experts on the ground to control the technical quality of

[8] €1.5 billion is quite similar to the annual subsidy paid by the federal government to German coal mines. This subsidy will end in 2018. The federal budget has also compensated the lack of revenues generated by the sale of CO_2, as the price on the ETS market has fallen below the level which was taken into account in formulating the multiannual programme of the KfW.

projects and the financial viability of participants. They grant loans at low rates thanks to funds acquired via the KfW.

In a report published in 2012, the KfW announced that it will provide €100 billion in five years to finance Germany's energy transition.[lvi] €5 billion of this finance will be used in the short term on projects for offshore wind farms. The report quotes the example of the wind farm of Meerwind to which the KfW lent €330 million, out of a total loan of €1 billion, and involving 16 banks. At the other end of the spectrum, the KfW also provided €4.2 million out of a total cost of €4.8 million for a biogas project in Wollbrandhausen. The average interest rate for these loans was 1.7%.

Both the KfW and commercial banks act as investors, taking direct shareholdings in some projects. Their commitment facilitates the participation of traditional financial actors, such as investment funds. Several German commercial banks have furthermore developed investment vehicles geared to renewable energies, which constitute a particular type of investment for savers. A local funding phenomenon also seems to be emerging, either when a developer associates local residents of a plant, or when citizens spontaneously create a structure dedicated to their own project. The latter may take various legal forms, such as private or public limited companies. Cooperatives are also experiencing a certain success, as there are more than 500, with 80,000 members in February 2013.[lvii] It should be noted that participation in all types of cooperatives is very frequent in Germany. In contrast, crowd funding – appealing directly for public contributions – does not seem to have developed that much, so far.

The financial measures in place in Germany seem to have compensated the relative withdrawal of the four "major" electricity companies which dominate traditional generation (EnBW, E.ON, RWE and Vattenfall). At the beginning of the 2000, these companies hesitated in investing in the generation of electricity from renewable resources. More recently, their financing capacities have been cut by government decisions, first by taxes on revenues from nuclear power plants, and subsequently by their planned closure.[9] Changes in the market for fossil fuels have also had redistributive effects across the companies: E.ON was initially favoured by the competitiveness of gas compared to coal, but saw its margins fall when coal regained competitiveness, as RWE and Vattenfall were better placed concerning solid fuels; E.ON and EnBW have been more affected by the closure of the first nuclear power stations. The emphasis which is henceforth being placed on offshore wind farms could give the majors a second chance. Investment in these projects is far more concentrated than in distributed wind and solar power installations.

[9] The companies have taken the public authorities to court for damages.

Moreover, managing large projects also fits better with their know-how.

In contrast to the major private groups, municipal energy companies (*Stadtwerke*), which are many and have a long history in Germany, very quickly saw the importance of being involved in renewable energies. The EU directives relating to the market liberalisation of gas and electricity have exempted most of these companies from divesting from their networks ("unbundling", which is obligatory elsewhere). As a result, they have been relatively protected from competition and so have been able to invest in projects favouring local resources, with a notable stress on heat production. Their share in producing electricity from renewable resources still seems to be modest: less than 5% of all installed equipment.[lviii]

The European Dimension

Since 2010, the capacity of wind farms situated in Northern Germany can exceed the capacity of the national grid to take the electricity produced and dispatch it to the rest of the country, on days when wind is favourable and demand weak. This phenomenon has been considerably aggravated by the massive development of solar panels in the Southern *Länder*. Two consequences follow:

- There are transit or loop flows which use networks in neighbouring countries, mainly Poland, the Czech Republic and the Netherlands. In some cases, these flows saturate the networks of countries they cross, making them non-operational for national needs.
- The spreading, via the coupling of markets, of low electricity prices to the wholesale markets of neighbours, in times when wind and solar power output is strong and demand is weak.

Faced with this first situation, Poland and the Czech Republic have threatened to install phase shifters, acting as border circuit-breakers, when massive amounts of electricity arrive and disorganise their networks. The European Commission is attached to the idea of creating an internal market in electricity, and has pleaded more in favour of building an electricity super grid, which would allow electricity from the major areas of output (such as wind farms forecast for the North Sea) to be distributed to vast sets of consumers. For Germany, the enhancement of interconnections would help encourage the proliferation of renewables and hence reduce moments of disconnection faced by renewable energies when their output is not longer used up because of poorly adapted networks. In contrast, interconnections favour imports given the absence renewables production, when foreign power stations offer better prices than German ones.

Who is to bear the costs of these future grids? It could be argued that Germany, which alone took the decision to draw on renewable sources of electricity massively, should also bear the financial costs. Germany for its part considers that the promotion of renewable energies is part of the framework of the EU's common policy and hence it is only logical that Community funds earmarked for the "Connecting Europe Facility" as of 2014 (€9.1 billion) be partly used to finance these networks. This is not an anecdotal matter: in its 10-year development plan, running to €104 billion, the ENTSO-E association estimates that 80% of spending will go to extending and reinforcing European transmission networks necessary for the development of electricity from renewable sources.

In the second case, German exports of electricity are only part of a general trend. The scale of this phenomenon may be judged by the fact that on certain days there is in fact a negative price on the wholesale markets. As they know that they will be called on to re-activate generation within a few hours, thermal power stations believe it is less costly to pay buyers to consume more, rather than cut-off generation, as frequent and short stops of their machinery lead to the premature ageing of material. This extreme case is an illustration of worrying trends: market price signals encourage power producers of several countries to close down some of their capacity.

To prevent the closure of power stations which are indispensible to the security of supply, several countries have implemented "capacity mechanisms" (or are thinking of doing so), aimed at remunerating plants for their availability in case of need. These mechanisms are designed on a national basis: their juxtaposition could lead to a fragmentation of the European power network. This in turn would make transactions more complex, even though the coupling of European markets has been designed to make it easier. The German employer federation has expressed its fears that market mechanisms will further increase bills, which most companies face and which already bear on the costs of renewables. Germany is not alone on this. Voices are being raised in several European capitals, calling for a re-thinking of the market design of Europe's power sector, which is being undermined by renewables. Among other things, "balancing markets" could be harmonised in EU countries: these relate to so-called *intraday* adjustments to balance differences in forecast and actual consumption.

This issue will probably be linked to the harmonisation, for the whole of the European Union, of aid schemes for the development of renewable energies, which the European Commission has called for, defending the principle of market integration. In the shorter term, the Commission has undertaken to revise its guidelines concerning state aid: the relief accorded to German industry concerning the EEG rebate may then be reconsidered. It will be very interesting to follow the position of the German government on this issue.

Another area of European policy is worth mentioning here. This concerns the ease with which Germany drains capital to finance its energy transition. This is illustrated by a few figures: while the KfW collects an average of €80 billion per year from financial markets, the European Investment Bank (EIB), which acts throughout the 27-member EU, only raised €71 billion in 2012. Whereas the KfW has announced that it will aid German renewable energies to a level of €20 billion on average per year, the EIB injected €3.3 billion in the sector in 2012 across the EU... and for several projects in developing countries. Furthermore, Germany's renewable energy sector also takes a share of EIB funds: about €568 million in 2012, compared to €100 million for Rumania for example.[lix] Yet the EIB would appear to be the best-suited institution to facilitate funding of the energy transition in countries weakened by the crisis. Should Greece want to set up a national banking organisation comparable to the KfW, for example, what credit would international markets give to financial guarantees provided by the Greek government?

In the coming years, the prudential measures adopted in the wake of the financial crisis triggered in 2008 – known as Basel III for banks and as Solvency II for insurance companies – will likely restrict access to credit for projects with very long periods of return. Germany's economic good health, its legislative stability and the solidity of its institutions will probably allow it to retain access to finance in line with needs. But this access is not guaranteed for the whole of the EU. The choices of energy systems requiring heavy investments may therefore be difficult to sustain for Germany's neighbours. Renewable energies and measures of energy efficiency are extremely capital intensive: access to cheap finance is a crucial advantage in their development.

The difference of national situations with respect to finance should incite governments of the countries most affected by the economic crisis to consider carefully German demands concerning the European Commission's Green Paper relating to the 2030 objectives, and published 27 March 2013. Not surprisingly, Germany has come out in favour of a high share of renewables for this time horizon. Despite its exceptional capacity to access financial markets, Germany suffers from sustained excess costs in the generation of electricity, as illustrated in Figure 20 above. As they do not enjoy similar access to capital markets, other European countries could face far higher additional costs. The competitive advantage of their industries will fall with respect to Germany in intra-European trade. In world markets, German products often benefit from "non-price" competition, reflecting consumers' preferences for quality and technologically-innovative products: the car industry is the best illustration of this. With higher electricity costs, other European countries, whose exports depend strongly on sales prices, face competitive losses compared to products from other regions of the world.

With this in mind, let us end this section on Europe with a personal comment. Germany's commitment to renewable energies is sometimes compared, by politicians in Berlin themselves, to a religion. As with all religions, some believers feel a duty to convert heretics. Thus, it is possible to meet representatives of British, French of Polish governments who are annoyed at being treated as lost sheep when they do not share the same enthusiasm as their German counterparts for renewable energies. Germany's decision to scrap nuclear energy was taken on the basis of a report submitted by an "ethics commission", and the moral dimension of the decision is still very clear after two years. It has even led various German actors to reject remarks about the relative costs of the energy turnaround. The very official "Leitstudie 2011" includes, for example, a page of arguments explaining that economic calculations are pointless, as the benefits of renewable energies cannot be quantified: international detente due to lower competition for fossil fuels; the inability of converting these resources to military ends; local installation which is supportive of local democracy, etc. Thus, for the authors of the study, the rise in prices should not be considered as a burden. Instead, it bears witness to the just effort of an "enlightened and courageous policy in favour of the protection of the environment".[lx]

Conclusion: Germany's Energy Transition as a Model or Counter-Model

The energy turnaround has been presented by the German government as an ethical choice: concern about the risks to neighbouring countries of a nuclear accident and the willingness to preserve future generations from the threat of energy shortages. These have been two preoccupations that Germany judges to be incompatible with the prolonged operation of its nuclear power stations and the continued recourse to imported fossil fuels. Taking such a principled approach does not exclude commercial concerns (the potentials of the world market for alterative energies), nor electoral considerations (polls indicating the sensitivity of public opinion on the issue). In fact, the early closure of Germany's nuclear power plants and the forced march to renewable energy have the support of a very large majority of the population, which is convinced that the country can meet the challenge and benefit from strengthening its technological advance and economic strength.

The mobilisation around this project has already allowed exemplary results to be obtained. To begin with, the coherence of the legal framework needs to be acknowledged, as should the capacity of elected politicians to amend it flexibly, and smoothly, according to measured results, so that the visibility projects require is permanently satisfied. The clarity of the regulatory framework is enhanced by the transparency on projects carried out, which helps maintain the interest of citizens and provides useful information for investors. Secondly, support for renewable energies is unambiguously linked to the future of industry. Despite some failures, most obviously that of photovoltaic solar panels, the research and development effort is striking in its size. To date, it is possible to think that Germany's industrial sector will draw on the advances of these programmes in order to conquer or retain important markets worldwide, especially in sectors in which it already has strengths: for instance, capital goods and cars.

These advances have been facilitated by specific characteristics of German industry, such as federalism, which favours a proliferation of experiences and local commitment. The same holds for Germany's relative social consensus. This exists in two forms: on the one hand, governmental coalitions which are unimaginable in other countries and which guarantee continuity, and on the other hand, a deep agreement within the population about the primacy of industry, which leads to a willingness to pay on behalf of household consumers.

Despite remarkable progress so far, problems are looming. The willingness of politicians to respect objectives on renewable energies has led to minimize another objective, namely that of greenhouse gas emissions. The protection of margins in large industries has been pursued at a cost to small firms and households' disposable income, both of which have been affected by rising electricity prices. The continuation of present trends does not seem sustainable. It would tarnish the ethical nature of the initial choice, through its negative climatic consequences and greater social pressure on the poorest part of the population.

The security of supply is henceforth weakened, and it is hard to imagine what would happen to Germany's international image if a severe blackout were to occur. In other words, the gap between electricity generation from renewable resources and the implementation of measures to accompany this – mainly the reinforcement of networks – creates a dangerous situation. On this last point, there is a clear lesson for neighbouring countries: regulatory coherence is not enough; technical coherence is as important.

Lastly, if there is one area in which Germany has become a counter-example, it would be the European dimension. Very schematically, it is possible to qualify German policy as following a non-cooperative strategy. Having decided to shut down suddenly its eight nuclear reactors, without the slightest consultation, the Chancellery seems to expect neighbouring countries to favour the success of its project, by making their electricity transmission networks available, and by absorbing Germany's surplus output from wind or solar power. Germany is able to profit from the international financial situation that allows it to get the necessary funding for its projects. It is therefore in a position in which its project has all the chances of succeeding, because other countries cannot take the same path as it.

An awareness of the limits of this strategy does seem to be emerging in Germany. If the country which has taken on a leadership role in Europe comes back to a more cooperative and inclusive strategy, it could indeed become a real example.

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