EUROPEAN POLICY CENTRE

9 October 2017

DISCUSSION PAPER

Germany's energy transition: making it deliver

Annika Hedberg

Summary

Germany has taken great pride in spearheading a shift to a greener economy. Its *Energiewende* (energy transition) has received international attention because of the ambitious effort to increase the share of renewables in the energy mix and some have gone as far as portraying it as a model for building a renewable future. The story, however, comes with its shades of grey. While both the vision and the objectives are commendable, the implementation has been mixed. While many of the challenges that have arisen have been acknowledged by the government, Germany's experience is an invaluable source of lessons for the country itself and the EU as a whole. The German example reminds how important it is for countries to have a comprehensive vision for a sustainable energy system from the start and an all-inclusive strategy for its achievement, which are in line with the EU objectives and implemented in coordination with other member states.

In a nutshell, Germany's green and renewable future is still far from reality. While the share of renewables in electricity production has increased greatly, the overall picture is less positive. Whereas the focus has been on the electricity sector, little has been done to bring about energy transition in the heating and transport sectors. As a result, fossil fuels continue to dominate as the principal sources of energy, and Germany is expected to miss its target of reducing greenhouse gas emissions by 40% by 2020.

More specifically, the renewable energy transition has demonstrated the importance of optimal deployment of solar cells, collaboration with neighbouring member states, grid adequacy, granting bioenergy the right weight in the energy mix, cost-efficient investments and the role of the public. Today, the greatest challenge for Germany is its contradictory reliance on fossil fuels. It is a major coal importer but also a producer, with significant lignite reserves. Its dependence on coal and failure to set a date for a coal phase-out have negative implications for both the country itself and the rest of the EU. While gas is often promoted as a transition fuel, increasing gas consumption raises political and energy security concerns, especially if this is done by increasing dependence on Russian gas. One can also challenge the economic viability of the investments if they fail to recognise climate and energy trends and objectives. Furthermore, taking Germany's major role as a car manufacturer, improvements in the transport sector would have multiple impacts not only domestically but also on other countries. Much work remains to be done if Germany wishes to be at the forefront of the transport transition, which includes electrification of the sector.

National energy transitions do not happen in isolation. Germany can make a significant contribution to the energy debate across the EU. Yet, it must also draw from other member states' experiences and take into consideration the impact Germany has on its immediate neighbours. The EU provides a bigger context, the framework and drivers that influence the success of the energy transition. While the commitments and measures taken at the EU level are shaped by Germany, they also have implications for it. Germany together with the other 27 member states have agreed on a vision to achieve more secure, cheaper and sustainable energy, and couple this with forward-looking climate action

The King Baudouin Foundation is the strategic partner of the European Policy Centre

under the EU's Energy Union. Germany has an important responsibility in making sure the EU achieve its objectives in terms of increased energy security, increased energy efficiency, and the decarbonising of its economy. It is in the interest of both Germany and the rest of the EU that its domestic measures are aligned with these objectives.

Germany has a first mover advantage: with its vision, it could be a key player in leading climate action not only in Europe but globally. However, it can only provide a credible and attractive model for others if it gets its own house in order.

Introduction

Because of its geographic location, Germany is a central player in the Single Market. With the United Kingdom (UK) in disarray with internal challenges and already one foot outside the EU door, France battling with overdue domestic reforms, Italy in economic stasis, Poland more focused on bashing the EU than constructively engaging with it, the others too small to alter the course of the EU on their own – Germany's role as an economic, political and even foreign policy actor has steadily increased over the past years. Thus, whatever Germany does or wants to do can have significant implications for the EU as a whole. At the same time, Berlin requires the support of the other member states and the EU policy framework to sustain its economic successes and achieve its policy objectives. This is particularly true in the fields of climate action and energy.

Germany has taken great pride in leading a shift to a greener economy. Its *Energiewende*, energy transition, has received international attention. Some have portrayed it as a model for building a renewable future. Published during the COP22, the United Nations Climate Change Conference in November 2016, Germany's Climate Action Plan 2050 has received much visibility. It has been promoted as the latest policy initiative for getting the country on track with achieving its domestic energy and climate goals.

This paper takes a thorough look at Germany's energy transition, its successes, failures and implications for the rest of the EU.[1] It demonstrates the advantages and disadvantages of being a first mover. Establishing a new approach to address climate and energy challenges provides an opportunity to take the lead and set standards for others as well. However, to gain attraction, any new model for an energy transition must demonstrate the benefits for the economy, society and environment. As mistakes will be made, key is to find a way to improve policies and processes while providing stability and predictability for investors and other stakeholders. Considering some of the fundamental contradictions in the German energy transition, this paper suggests that a number of improvements are required before it can serve as an example for others. Also given the high level of interdependence between climate and energy policies both at national and EU levels, this paper makes recommendations for achieving a sustainable energy transition that can benefit both Germany and the EU. While it recognises that EU policies can succeed only if Germany is on board with implementing them, it also shows that the *Energiewende* can only work if fully aligned with the EU framework for action.

1. A commendable vision

Germany's energy transition has been driven by its decision to abandon and replace nuclear power by 2022. While the use of nuclear has been disputed for decades, the 2011 Fukushima accident in Japan was the last nail to the coffin.[2] While the German government had put forward targets for reducing greenhouse gas (GHG) emissions already in 2007, after the accident it became clear that this should be done without relying on nuclear.

Germany's targets include:

- cutting greenhouse gas emissions (GHG) by 40% by 2020 and up to 95% in 2050, compared to 1990 levels;
- increasing the share of renewables in (gross final) energy consumption to 60% by 2050;
- increasing the share of renewables in (gross) power consumption to minimum of 80% by 2050.

The German government's 2050 Climate Action Plan, adopted on 4 November 2016, reiterates these objectives, and gives further intermediate sectoral targets for 2030.[3] It recognises that not only energy but also other sectors have a role to play in reducing their emissions from 1990 levels (see table 1).

Table 1 – Emissions reduction targets per sector for 2030 (from 1990 levels)

Energy sector	61-62%
Building sector	66-67%
Transport	40-42%
Industry	49-51%
Agriculture	31-34%

Germany can be credited for its vision and ambitious targets in taking the country on a new path. Its greenhouse gas reduction and renewable targets for 2020 are higher than those agreed at EU level. Its sectoral targets for 2030 are commendable. Other domestic initiatives, such as the building performance laws, have been a source of inspiration for the EU legislation.

As the analysis below will show, however, implementation remains patchy and the vision has not translated into results yet. The task is obviously daunting. A critical assessment of lessons learnt is required. As Germany continues to reflect on the best way to proceed, it is in its interest and the interest of the rest of the EU that the country aims to complement the vision with a comprehensive action plan and measures that deliver on these objectives. Germany could be a key player in leading climate action not only in Europe but globally. However, it can provide a credible and attractive model for others only if it can prove that the transition can be cost-effective and bring significant economic, societal and environmental benefits.

2. Understanding the *Energiewende* within the EU framework

It is worth putting Germany's energy transition into a European context. Germany is the EU's largest energy consumer, accounting for 19.5% of the EU28 energy demand in 2014.[4] Its greenhouse gas emissions account for more than 20% of the EU's total.[5] Geographically located at the centre of Europe, Germany's energy system is interconnected with Austria, Belgium, the Czech Republic, Denmark, France, Luxembourg, the Netherlands, Poland, Sweden and Switzerland. Germany is an important player in the EU's internal energy market, which aims to ensure that energy – be it gas or electricity – can flow freely across borders, without technical or regulatory barriers. Whatever it does has thus direct impact on its neighbours and *vice versa*.

At the same time, the EU provides a bigger context, the framework and drivers that influence the success of the energy transition. While the commitments and measures taken at the EU level are shaped by Germany, they also have implications for it. Germany together with the other 27 member states have agreed on a vision to achieve more secure, cheaper and sustainable energy, and couple this with forward-looking climate action in Europe. The work has been going on for years, and the heads of state and government reiterated this commitment at the March 2015 European Council. They agreed to build an Energy Union based on five priorities: 1) energy security, while emphasising the importance of solidarity and trust, 2) completing the internal energy market, 3) increasing energy efficiency, 4) decarbonising the economy, and 5) promoting research, innovation and competitiveness. An important part of the EU's climate and energy policy framework are the targets for 2020 and 2030 (see table 2).

Table 2 – EU's climate and energy targets

	20/20/20 targets for 2020	**2030 climate & energy framework**
GHG emission reduction (compared to 1990 levels)	20%	40%
Share of renewables in energy consumption	20%	27%
Increasing energy efficiency	20%	27%

It is worth to note that the discussion on increasing the ambition on the 2030 targets continues now that the international climate agreement came into force in November 2016. The international framework for climate action pushes the EU and its member states to do their share in limiting the rise in global temperature to 2°C, preferably below 1.5°C, above pre-industrial levels.

The EU has already developed several instruments to promote more secure, affordable and sustainable energy. As a latest addition, on 30 November 2016, the European Commission put forward a "Clean Energy For All Europeans" package to translate the EU's climate and energy objectives into legislation and action.[6] This package contains legislative proposals on energy efficiency (including a proposal to increase its 2030 target to 30%), renewables, new electricity market design, security of electricity supply and governance rules as well as several initiatives to accelerate innovation and spur investment. While criticised by stakeholders across the EU for not being an adequate response to the challenges faced within Europe and globally, it will surely test member states' willingness to cooperate towards an Energy Union.

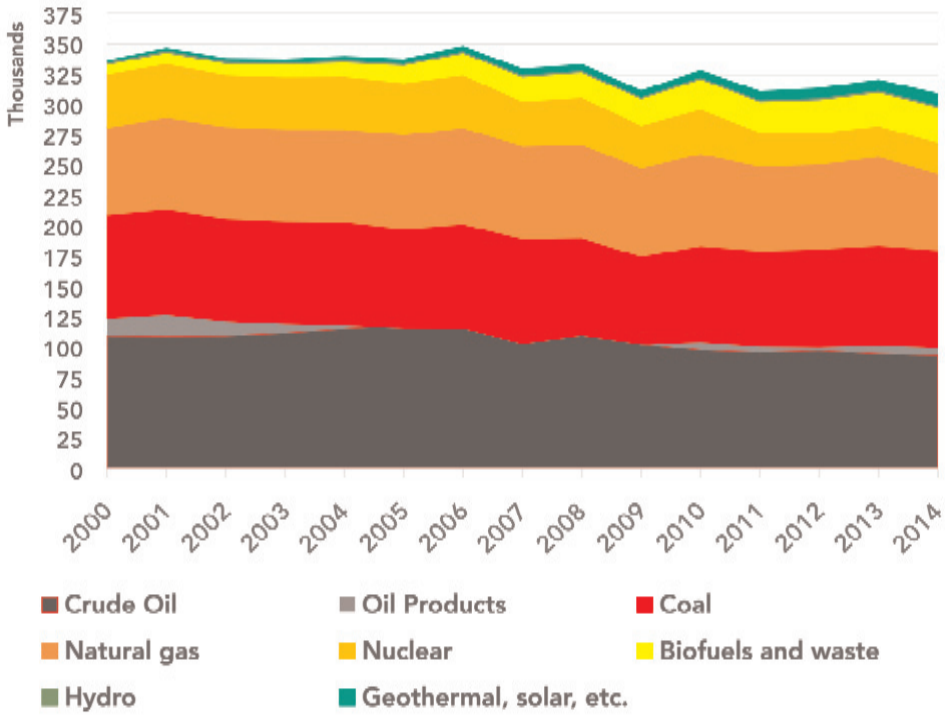
Germany has an important role in ensuring that EU objectives are met in collaboration with the other member states. As this paper will show, work remains to be done at both domestic and EU levels. While the *Energiewende* has led to some positive developments in Germany, it has not been fully aligned with EU climate and energy objectives. It exemplifies the constant and difficult battle between strong national interests and EU objectives. It showcases how important collaboration across borders is, the benefits it can bring, and why national projects should be more focused on achieving the agreed EU objectives.

3. State of play of Germany's energy transition

To understand where Germany stands in its energy transition, one needs to look at the numbers for the energy system as a whole. This can be done by considering final energy consumption, how much different end consumers use energy, and energy production, which sources of energy make up the national energy mix.

In 2017, according to the latest figures on Germany's final consumption, industry accounts for close to 27%, households for around 30% and transport for around 26%.[7] Industry and households especially are important users of electricity and heating. Despite the difficulty to calculate the breakdown between electricity and heating due to overlaps, to give an indication, electricity accounts for around 21%[8] and heating 53%[9] of Germany's final energy consumption. As shown in graph 1, fossil fuels continue to dominate as the main source of energy for the country.

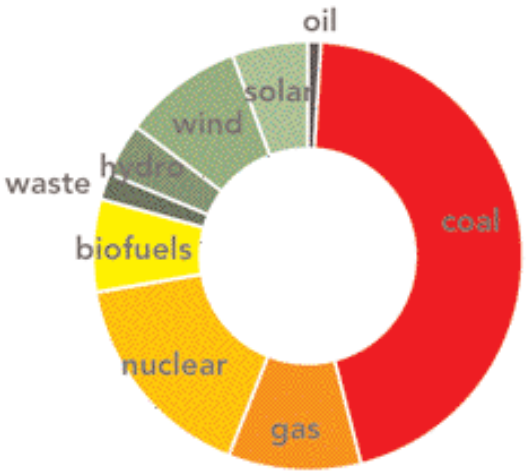
Graph 1. Germany's primary energy supply in 2000-2014 (in thousand tonnes of oil equivalent, ktoe, on a net calorific value basis)



Source: International Energy Agency[10]

In 2014, electricity was generated mainly with fossil fuels (56%): strongly dominated by coal (45%), but relying heavily also on gas (10%) and less on oil (1%).[11] This is comparable to Italy, where 55% of electricity is generated by fossil fuels.[12] In comparison, in France fossil fuels account for less than 5% of electricity production, because it is mainly generated from nuclear energy.[13] In Germany, renewable electricity (accounting for 27.7% of power generation in 2014) came mainly from wind (9%) and biofuels (7%). Although solar tends to receive the greatest attention, its contribution is limited (5.7%), in line with hydro (4%) and waste (2%). In 2011, nuclear accounted for 22% of the country's electricity supply. Since the Fukushima accident, the country has shut down 9 of its 17 reactors. Currently nuclear accounts for 15% of electricity production. It should be noted that even though this paper uses latest figures from the International Energy Agency to ease comparisons across countries, these shares have continued to evolve since 2014. For example, according to official German sources, renewables accounted already for 29% for gross electricity production in 2016.[14]

Graph 2. Energy sources for the production of electricity in Germany (Figures from 2014)

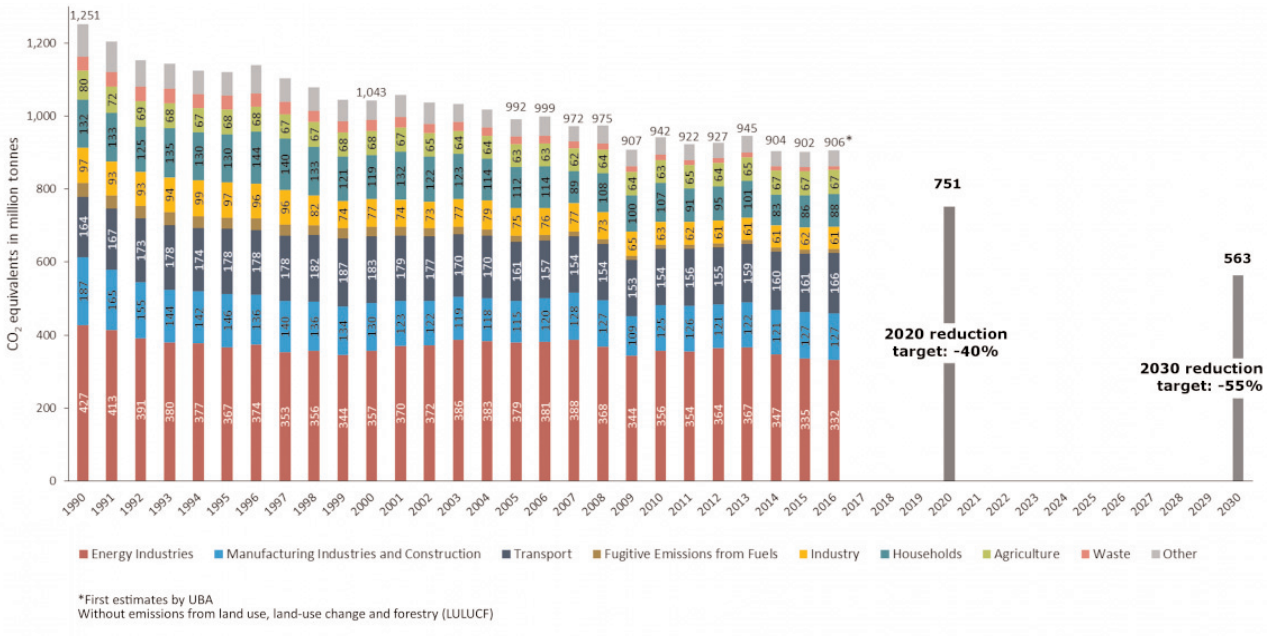


Source: International Energy Agency[15]

Given that heating accounts for around 50% of Germany's final energy consumption, the sector's continued reliance on gas (42.5%) and coal (33%) is striking.[16] In comparison, in Sweden, only 8% of heat is produced by coal and 3% by gas – the main sources are biofuels (54%) and waste (23%). In the transport sector, Germany is no exception to the rest of the EU. Renewables are a marginal source and fossil fuels make up 94% of the energy consumed.[17]

The heavy reliance of Germany on fossil fuels explains why greenhouse gas emissions have not dropped as much as hoped, as shown in the graph 3. In a nutshell, while Germany has portrayed itself as a being at the forefront of an energy transition, the actual numbers tell a different story: Germany's green energy transition and renewable revolution are still far from a reality.

Graph 3. Germany's greenhouse gas emissions (1990-2030)



Source: a graph by Clean Energy Wire[18] with figures from German Environment Agency[19]

Results have been modest because, in fact, Germany's *Energiewende* has been about electricity – not energy – transition. There is a case for starting an energy reform with the power sector. However as the political focus at the onset has been on closing nuclear power plants rather than building a comprehensive energy transition strategy, this has led to unwanted consequences.

While Germany has focused on the electricity sector, little has been done to bring about energy transition in the heating and transport sectors. Its efforts to improve energy efficiency have been insufficient. It has not lowered its dependence on energy imports. It has incentivised the deployment of renewables in sub-optimal places where return on investment has been weak. As shown in graph 3, above, Germany's GHG emissions have not declined since 2009. The country has increased its reliance on fossil fuels, including on coal and gas, and it is expected to miss its 2020 GHG emissions reduction target of 40% and cut emissions by only 30%.[20] As a result, Germany's electricity transition has led to a mix of costly measures for people's purse and health.

Another challenge with Germany's energy transition is that it was launched with little consideration for its cross-border ramifications and without consulting neighbouring countries. Initially, it was considered exclusively as a domestic matter. However, the implications of Germany's actions have been felt abroad, for example, on these three accounts:

- From a grid management perspective, Germany's neighbours have acted as buffers for its fluctuating renewable electricity production (see section 4 for more details).

- From an environmental and health standpoint, the air pollution generated by burning coal has not been constrained by the country's borders (see section 5 for more details).

- From a geopolitical viewpoint, Germany's plans to further increase imports of Russian gas have raised not just energy security questions for the EU, but also wider political, legal and economic concerns (see section 5 for more details).

Arguably, Germany's energy transition has created an incoherent policy framework that is not fully aligned with the EU's climate and energy goals.

Many of the challenges have now been officially acknowledged and Germany's 2050 Climate Action Plan is a step towards correcting some of the mistakes of the *Energiewende*. It takes a more comprehensive approach and attempts to better integrate climate and energy goals.[21] As noted above, the plan recalls the government's commitment to reduce by 2050 greenhouse gas emissions by 80-95% compared to 1990 levels. While the document has been watered down from earlier versions and is weak on details, it provides a vision and points in the right direction with a greater emphasis on reducing greenhouse gas emissions across sectors. Yet, implementation will be pivotal and the work has only just begun. Public knowledge and debate leave more to be desired. Moreover, strong opposition from industry can be expected when the vision will be translated into concrete measures to reduce coal-fired power generation or transform the transport sector. Understanding the challenges and the mistakes can help draw up the required corrective measures. They can also provide valuable lessons for countries in and outside the EU.

4. From lessons learnt to a new approach on renewables

Many in Germany consider the energy transition success story in terms of renewables. It is true that Germany has invested greatly in renewables: EUR 150 billion between 2005 and 2015.[22] The share of renewable electricity has also risen significantly during last years. The story comes nevertheless with its shades of grey. While measures are currently being taken to correct some of the acknowledged mistakes, meanwhile, more could and should, arguably, be done.

4.1. Support schemes and sub-optimal deployment

Questions about the **cost of the investments and subsidies** for solar cells or photovoltaic panels (PV) are legitimate, especially in areas where the return on investment has been minimal. For example, although solar energy produces less electricity than onshore wind, in Germany it has received much more support. While on sunny days solar panels can generate over 50% of the country's electricity demand, over a year solar energy only accounts for around 5% of electricity production. Another challenge is that the peak time for solar power generation is when electricity consumption is at a minimum: during midday on sunny summer days. During winter when electricity consumption is highest, solar generation meets only about 1% of the overall demand. No matter how climate-friendly solar panels are, Germany's geographic location and weather conditions do not allow solar to become more than a marginal source of electricity – at least until technology greatly improves and solutions for storing the generated electricity improve. This inherent contradiction is reflected in the fact that Spain produces about 65% more solar energy than Germany despite the latter having installed some 600% more solar photovoltaic capacity.[23] However, to be fair: while the initial investments in solar in Germany were not economically cost-efficient, because of technological advancements, solar is nowadays becoming more cost competitive in Germany and Europe in general.

Investment and growth in renewables (solar PV but also biomass and wind) have spurred thanks to **feed-in-tariffs** that guaranteed a remuneration above the retail or wholesale electricity rates. The high installation rates for solar solutions, even when it made limited economic sense, is the result of preferential subsidies. It should not be forgotten that also other energy sources like the coal sector benefit from subsidies, and as with renewables, this practice distorts the market. The government has recognised that it went too far in supporting the installation of solar cells and it has started reforming its support schemes. In force since 1 January 2017, the reformed Renewable Energy Act (EEG) has replaced the feed-in-tariffs with auctions for renewable installations above 750 kilowatt (kW) capacity (150 kW for biomass). Shifting to auctions should encourage competition and lower prices. Making payments only to those renewable installations that have won a tender, should help to manage costs and control the added capacity. The new approach is already bearing fruit.[24] Since many other countries have replicated Germany's feed-in-tariffs model for their renewable promotion schemes, one would expect also others to critically assess the benefits and challenges with the system.

With the benefit of hindsight, subsidies to German solar cell manufacturers have arguably slowed down optimal deployment of solar PV not only in Germany and the EU, but also globally. They helped to keep the price of solar PV artificially high, as they did not aim to achieve the best return on investment. While it was perhaps in Germany's national interest to protect its industry, the subsidies have had a negative impact on climate globally. It is the Chinese, not the German, mass scale production of solar PV that has driven cost down and helped reduce GHG emissions worldwide thanks to the production of solar electricity in optimal geographic areas. Rather than taking advantage of the increased competition, the EU has contributed to slowing down solar deployment in Europe by imposing in 2013 anti-dumping measures and a minimum import price on China. While the EU argued that this was needed to guarantee undistorted competition with European manufacturers, this decision remains questionable from an economic and environmental perspective. In fact, while implemented at the expense of German and European consumers and going against the wish of most solar industry professionals, it gave a life extension to one major German solar company. Undistorted competition should be upheld, and environmental and technological standards must be respected, however arguably artificially high prices in the EU remain a barrier to getting the best technologies

at the best possible price for European consumers. In March 2017, the EU extended its anti-dumping duties on Chinese solar PV for 18 months. It pledged to carry out a review of this measure to evaluate its appropriateness. Hopefully, it will lead to a positive outcome for European consumers.

4.2. Impact on neighbours

Due to the intermittent nature of solar and wind generation and the lack of storage solutions, the **fluctuations** affect both Germany and its neighbouring countries. Even though domestic renewable energy generation is increasing, Germany continues to need electricity imports at peak demand times. These imports are expensive and fuel increased electricity prices within the country. Conversely, when electricity is generated during low demand periods, Germany must avoid overloading the domestic grid and is forced to export its surplus to neighbouring countries at lower than market prices. Neighbouring countries, including Austria, the Czech Republic, France, Poland, and Switzerland have not been overly enthusiastic about the fluctuations in German power generation. They impact local grid stability, and thus put a burden and the cost on the neighbouring country's transmission system operators (TSOs) and consumers. France has depended on German electricity to cover its peak winter consumption and was not initially pleased about the latter's decision to close its nuclear power stations. Poland and the Czech Republic again dislike the excess electricity coming from Germany and have decided to put in place phase-shifters at their borders to block unwanted electricity flows, which undermines the EU's internal electricity market goals.

The free flow of electricity across borders is the key objective of the internal energy market, which should be enabled and encouraged by developing interconnectors for example. Today, Germany is a net electricity exporter and the European power grid should be able to cater for this. In theory, cheaper electricity exports from Germany should be positive for the EU since they can lower prices for consumers in neighbouring countries. The challenge is the functioning of the electricity market and member states' tendency to protect their national energy industry. The overall lesson is that more collaboration is needed between member states to manage fluctuations and to ensure that the flows are driven by price signals. It is in Germany's and the EU's interest to complete the internal electricity market so that fluctuations are no longer a problem and electricity flows freely across borders according to demand.[25] As long as this is not the case, it is Germany's interest to put the missing national infrastructure in place.

4.3. Grid inadequacy

While the infrastructure is in place for Germany to export its surplus electricity to neighbouring countries, it lacks an adequate **national infrastructure** that would integrate renewables in the electricity grid and ensure flow across the country. Germany has showcased the possibilities with decentralised energy system for renewables, whereby small and medium-size power plants generate electricity for local consumers. However, this is insufficient for a large country that needs a comprehensive network that can ensure electricity flows to cities and large industrial consumers when they need it. So far, the country has not developed power lines linking the north, where renewable electricity is produced, to the south, where big industrial consumers are located. This constitutes an enormous missed opportunity: in 2015, northern Germany produced 4,100 gigawatt hours (GWh) in excess energy, which is equivalent to the electricity consumption of 1.2 million households for a full year. At times, the wind turbines in the north produce so much electricity that renewable energy providers are paid to switch them off to stop overloading the power grid.[26] Thus, while there is still great potential to develop wind capacity in northern Germany, as long as there is no infrastructure (grid and/or storage) to accommodate the surplus, it cannot meet the country's electricity demand. If the EU's internal electricity market worked as hoped, this would be less of an issue, but as long as that is not the case, Germany should do its share and invest in the needed domestic infrastructure.

The long and ongoing battle to put in place overhead or underground power lines is reflective of the challenges that come with trying to please the public. German political parties supported the *Energiewende* and phasing out of nuclear, because this is what the public demanded after the Fukushima's accident. However, politicians are now faced with an impossible equation, where citizens want renewables but not the power lines for aesthetic or touristic reasons. Under public pressure, policymakers have decided to place them underground,

which runs a risk of becoming another costly exercise to be paid by taxpayers. The division of powers between the federal and regional levels makes arguably the decision-making processes even more difficult.

4.4. The controversial role of bioenergy

A further widely ignored fact about the Energiewende is that while renewable generation is often simplified into a discussion on photovoltaics and wind, the reality is that a significant amount of renewable generation comes from **biomass**. Bio-based materials are a very important source of energy, especially in the heating and transport sectors. In Germany, bioenergy accounts for 85-90% of renewable final energy consumption in heating and transport.[27] For example, biomass is used to fuel small combined heat and power (CHP) plants. Although some argue it can help increase the share of renewables in the heating sector, biomass is not and should not be seen as the silver bullet for meeting renewables targets. This means at its worst direct burning of wood, currently the dominant renewable fuel in the German heating sector. The risks are great: the direct burning of wood increases GHG emissions and small particle pollution. It is an inefficient use of a material that could create much greater value for society and the economy if it were used for other purposes such as packaging or cosmetics.

4.5. The cost

Citizens and small and medium sized companies bear the **cost of the *Energiewende***. As a result, German households pay the second highest electricity price in the EU (including all taxes and levies).[28] Relative to the cost of other goods and services, electricity for German households is the most expensive in the EU.[29] Large industry players, however, benefit from exemptions in order to preserve their competitiveness in the Single Market. Figures from 2014 show that subsidies for renewables cost German consumers annually EUR 23 billion.[30] The bill will further rise with the arguably high price of the construction of a new underground power grid. According to a study by the Düsseldorf Institute for Competition Economics, the cumulative cost of the *Energiewende* could exceed EUR 25,000 for a four-person household by 2025.[31] If German consumers understand the costs and are willing to pay for it, that is fine. This model, however, may have less appeal for more cost-sensitive consumers in other countries.

4.6. Role of public and consumers

German **citizens** have played a key role in initiating and carrying out the *Energiewende*. Their ownership of and support for the energy transition has not always led to consistent decisions, but it has brought positive elements. It may also explain their willingness to cover the costs. For sure, it has helped raise investment and political support. Allowing smaller providers to access the grid and requiring energy providers to buy renewables has given a strong incentive for cities, communities and individual households to participate in the transition. Further building up people's knowledge and abilities to contribute in the transition will make them even stronger enablers of the transition.

A number of lessons have been learned, as noted above, and despite the remaining challenges, the prospects for renewables are great. Renewable electricity generation, such as onshore wind and hydropower, can already compete with fossil-fuel fired power generation on costs. Solar is increasingly competitive too. After a high upfront investment costs (which are rapidly falling) the operational and maintenance costs are low compared to coal for example. In short, renewables are increasingly cost-competitive and attractive.[32] Renewables must form an important part of the energy mix of the future if the aim is to reduce energy-related GHG emissions and increase energy security. It makes sense therefore to learn from past mistakes and ensure that development and deployment will be carried out in the most effective way possible.

Germany needs a comprehensive approach with renewables

Germany is committed to increasing the share of renewable electricity to 40-45% by 2025 and to 55-60% by 2035. It hopes that by 2050, at least 80% of electricity consumption and 60% of energy consumption would come from renewable energy. To achieve these goals Germany needs a cost-effective and future-proofed approach:

- More efforts are needed to make plans for **coal phase-out**, to be replaced by renewables. The current reliance on conventional capacity slows down utilisation of, for example, wind energy.
- It is in Germany's interest to support **investment** in solar and wind only in places where they make sense, and build the needed grid infrastructure within Germany. It should be careful how it uses subsidies and incentives, and for which aim.
- Germany needs to ensure that the renewables targets for electricity, transport or heating will not be met by simply increasing use of **biomass** in a non-sustainable way.
- Germany needs to ensure that the **people and industry** have the knowledge, skills and the tools to remain committed to the transition. Open discussion is needed about the benefits and needed measures for achieving a comprehensive renewables strategy.

EU-wide collaboration on renewables is needed

To meet the EU's and Germany's renewable targets, EU-wide coordination and collaboration is a must. The Commission's review of the Renewable Energy Directive[33] and its proposals for a New Electricity Market Design[34] recognise that renewables are no longer a niche technology. It thus proposes a more market-oriented approach to foster their development, with an aim to facilitate the development of an electricity market suitable for renewables that can get electricity flowing wherever it is most needed. They also set general principles on support schemes. As the work continues, it is important to keep the following in mind.

- **National renewable policies and support schemes** should be harmonised. German policies and support schemes exemplify how uncoordinated action hinders the efficient use and development of renewables and distorts the EU's energy market. National support for renewables should be targeted and limited in time. In other words, the aim should be to reach the targets in a cost-effective way.

- Member states should seek together the **best return on investment**. They should create frameworks to agree on an **optimal deployment of renewable infrastructure**. The principle would be to generate renewable electricity where it is most cost-efficient, and then transmit it wherever it is needed the most. It has been estimated that the EU and its member states could have saved $100 billion by installing renewables, solar PV and wind, in optimal places across Europe. Better cross-border coordination and interconnections between countries could have brought additional savings of $40 billion.[35] There is great potential to continue developing solar power - not in Germany - but in southern Europe. This would also have positive economic effects in countries hit hardest by the financial and economic crisis.

  Investments into first generation renewables should be coupled with harnessing available policy and financial instruments to encourage the development and uptake of new high performance and low-cost **storage** and other solutions. Developing storage is pivotal if the EU hopes to increase the share of renewables and keep the network balanced in the face of fluctuating generation. Many companies have already recognised the need to improve battery and storage solutions, and those that will succeed in bringing the solutions to scale, will help transform the energy system for good. **Other technologies** such as heat pumps, geothermal systems and solar heat collectors are also available options. It is in everybody's interest to support the EU's initiatives and to collaborate with one another in developing and deploying new solutions.

- **A functioning smart grid** is needed that would help to integrate existing and new renewables in the network. In addition, **interconnectors** would enable transmission of electricity across borders. The Commission hopes that the 10% interconnection target for electricity by 2020 and the 15% target by 2030 will boost market integration, reduce the need for new power plants and the risk of grid instability, decrease energy prices, and improve the reliability of renewable energy supply. While the interconnection targets are artificial, they can serve as a driver for establishing interconnections where they make economic sense. To succeed, countries need to recognise the benefits of collaboration: the EU cannot afford to have member states oppose building interconnectors because neighbours' renewable electricity would create competition on its market – a challenge Germany has met *vis-à-vis* its own neighbours. Regional cross-border cooperation provides a starting point for increasing collaboration across the EU. More efforts are also needed to increase coordination between distribution system operators (DSOs) and transmission system operators (TSOs) to ensure the functioning of the electricity system.

- One of the current EU-level contradictions that needs to be corrected is the unsustainable emphasis on **bio-based raw materials** as a source of renewable energy. The Commission has suggested measures to reduce the dependence on fossil fuels in heating and cooling as well as in the transport sectors by increasing the share of low-emission and renewable energy. It has, however, learned little from past mistakes when it comes to promoting bio-based materials as a solution for energy production. The EU originally pushed for the use of first generation food-based biofuels only to realise that it was not sustainable. In its review of the Renewable Energy Directive, the Commission now incentivises the use of more advanced bio-based materials that could be used for higher-value purposes. However, a more resource-efficient way to produce bioenergy would be, for example, from waste and residues of forest-based industries. As recognised also by the Commission, bio-based materials should only be used if they deliver high GHG savings compared to fossil fuels. Thus, if for example biodiesel produces even higher unwanted nitrogen (NOx) emissions than ordinary diesel, as suggested by some research,[36] it should not play a major role in the transition to a future-proof and cleaner transport system. The Council, with Germany on board, and the European Parliament have an important task to improve the Commission's proposal on when and which bio-based materials should be used for energy. If this is not done, the EU carries a risk of promoting an unsustainable use of bio-based materials for energy in the member states, leading to higher emissions and unwanted consequences for the environment, climate, people and the economy.

- As recognised in the Commission's 'Clean Energy for All Europeans' package, renewable-dominated energy systems can function if consumers are encouraged to **adapt demand** to the available supply of electricity. With the help of digital tools and household appliances connected to the power grid, consumers would be able to indicate the approximate time at which they want their laundry or dishes to be washed. The appliances would be turned on or off depending on price signals. Similarly, industry could play a major role in organising production processes and adjusting demand and consumption in accordance with the supply of renewable energy. Smarter electricity management systems can help industries manage production when abundant electricity is available and prices fall. The technology exists. So far, however, neither German nor other companies have managed to use them. Much more efforts are needed domestically and at the EU-level to encourage and benefit from 'demand response' measures.

- A new EU-wide balance needs to be found regarding support schemes for renewables. Meanwhile, **citizens** who are interested in investing in renewable energy should be empowered to do so. The German energy transition demonstrates how citizens can be catalysts and multipliers of change. Their role needs to be recognised and supported. Awareness raising is needed across the EU about cost-efficient investments. Return on investment and grid access for citizens are essential incentives that help them contribute to and benefit from the transition.

5. Contradictory reliance on fossil fuels

Increasing the share of renewables has been coupled with an increase in the use of fossil fuels to guarantee stable electricity supply in Germany. In practice this has meant keeping and maintaining conventional power plants that use coal or gas to provide needed back-up for renewables. In addition, while often forgotten, coal and gas are major sources of energy for the heating sector, and transition in the transport sector is only slowly gaining attention. Germany's reliance on fossil fuels raises questions not only about the direction of the energy transition, but also about its alignment with the EU's climate and energy goals.

5.1. Elephant in the room: coal

1) Germany remains a **major coal importer but also a producer**, with significant soft coal, lignite, reserves.[37] When Germany's former Environment Minister, Peter Altmaier, inaugurated in September 2012 a new lignite-fuelled power plant west of Cologne, he argued the country would require conventional fossil-fuelled power plants for decades to come to complement intermittent wind and solar power and that "if one builds a new state-of-the-art lignite power plant to replace several older and much less efficient plants… this should also be acknowledged as a contribution to our climate protection efforts."[38] Since coal power plants have an expected life span of at least 50 years, Germany's coal investments signal that the country has tied itself to an unsustainable energy source for years to come. Germany's reliance on coal sends a contradictory message as to the objectives of its energy transition.

Today, this problem has been recognised by the government, who hopes, for example, to put the old and inefficient lignite plants on standby as a reserve capacity. The German plan for 'strategic reserves' is a targeted capacity mechanism, which would help to secure supply during peak demand by letting conventional power stations make profits in times of scarcity. In principle this could work as a temporary measure, if managed well. It is, however, essential to ensure that it will not encourage the maintenance or even the build-up of new fossil-based power plants. Given the challenges with national capacity mechanisms, the European Commission is currently investigating whether German plans comply with state aid rules and are sufficiently open for demand response operators.[39]

2) Germany's reliance on coal and unwillingness to set a date for ending this dependence has **implications** not only for itself, but also for the EU and beyond. According to the European Environment Agency (EEA), air pollution and greenhouse gases from industry in 2012 cost Europe between EUR 59 and EUR 189 billion.[40] 26 of the 30 facilities that cause the highest damage are power-generating facilities, mainly coal, located in Germany and Eastern Europe. Four out of the five largest industrial polluters in Europe are German lignite plants that run near full capacity for most hours, as a back-up for renewables, and keep the country's emissions high.[41] As a result, as long as there is no real change in policy and investment decisions related to coal, Germany pays a high price for people's health and environment, and thus on economy.

According to a recent WWF study, 3,630 Germans died from coal-related illnesses in 2013,[42] the highest figure among EU member states. That same year, Germany's coal plants caused 2,490 premature deaths in its neighbouring countries. Phasing out coal in Germany could annually save 1,860 lives domestically and around 2,500 lives across the border. Furthermore, whenever Germany buys cheap coal-fired energy from Poland, it contributes to harming the health of its own people and that of neighbours: Polish power plants caused 4,690 premature deaths abroad in 2013.

The EEA makes clear that the EU's coal-fired power stations must be closed if the EU wishes to reach its 2050 target of cutting greenhouse gas emissions by 80-95%.[43] It also warns that extending the life of large fossil fuel power plants or building new ones is in contradiction with the EU's decarbonisation scenarios as set out in the EU's Energy Roadmap 2050.[44] Thus, it should be in the EU's and Germany's interest to avoid carbon-lock in and fossil fuel overcapacity.

Germany needs an exit plan from coal

While the efficiency of the coal plant sector in Germany has increased, and subsidised hard coal production will be phased out by 2018, this is not enough. Cutting the energy sector's emissions by over 60% by 2030, as set out in Germany's Climate Action Plan 2050, would require closing down, in principle, all coal-fired power plants. However, the plan falls short from suggesting how this would be done. Much work lies ahead to address the strong opposition of coal mining regions and trade unions.

- Germany needs an **exit plan from coal and a date for a coal phase-out**.[45] The German government must take the necessary measures to reduce lignite use and remove the most polluting power plants to deliver on its commitment to reduce GHG emissions. If the EU's European Trading System (ETS) is not effective in helping Germany reduce CO2 emissions in a line with its objectives, Germany should explore the possibility to adopt a common carbon floor price with France and other EU member states to supplement the ETS.

- The German government must launch a **constructive dialogue** about the rationale, vision and operational measures of a fair transition with all stakeholders including business, coal-industry workers, consumers as well as environmental NGOs and experts. Such an open discussion should address the high costs of coal use for people's health and environment. Taking the agenda forward will require drawing lessons from and building on examples such as the 'Climate discourse' in the state of North Rhine-Westphalia.[46]

- Germany should be careful about protecting an industry of the past at any cost. Protecting **jobs** of coal miners comes at a high cost for society and the economy, and will not enhance Germany's industrial competitiveness. Employment in the coal mining sector is already decreasing steadily, with only 46,000 jobs in 2015.[47] Efforts are still needed in helping workers to develop new skills. Establishing a national fund to support regions, affected by the reduction of coal-fired power generation, to create new jobs would also help. There are valuable regional experiences that should be built upon and which can provide lessons also for other EU member states on how to carry out a managed transition.

- Germany also needs to ensure that the closure of its remaining nuclear plants in southern Germany will not be followed by increasing **imports** of coal-generated electricity powered generation e.g. from the Czech Republic, which is currently enhancing its lignite excavation.

5.2. Gas as a transition fuel

Is gas then a sound alternative to coal as a mid-term solution? As noted in section 3, Germany uses a significant amount of gas to generate electricity and heat. With lower CO2 emissions than coal or oil, gas can provide a cleaner back-up for intermittent renewables. This explains Germany's interest for gas and why it is also positioning itself as Europe's future gas hub. Increasing the use of gas, however, is not without problems, ranging from dependence on Russia to uncertain demand prospects. While these concerns are at times touched upon in the domestic debate, much more critical and future-oriented discussions are needed.

1) Germany's and other EU member states' **dependence on Russian gas** has warranted greater EU collaboration on energy security and the need to diversify gas routes and suppliers.[48] Russia's illegal annexation of Crimea and instigation of war in Eastern Ukraine have triggered fundamental questions about relying on a trade partner that breaks international norms. Also the memories of the 2006 and 2009 winters, when Russia stopped gas exports to Ukraine, resulting in supply problems in many member states, have fuelled today's concerns about the security of gas supplies.

In this context, Germany's current push for the construction of a new gas pipeline with Russia (Nordstream 2) appears to undermine the EU's energy security objectives. Germany is already the EU's largest importer of Russian gas. Increasing reliance on Russian gas via an existing route would run counter to the EU's efforts to diversify

routes and suppliers. The project has also raised serious political, economic and legal concerns across the EU.[49] Against the backdrop of Russia's invasion of Ukraine and annexation of Crimea, there are fears that increasing the share of Russian gas in Germany to 60% could give Moscow greater political leverage over Germany and thus the EU as a whole. In addition, it can be argued that under customary and public international law the EU and its member states are obliged not to facilitate an annexation or the waging of war.[50] Nordstream 2 supports, arguably, Russia's military objectives, by contributing to its efforts to reduce gas transits via Ukraine and isolate the country. Thus, Germany's insistence that this is purely a commercial deal fails to recognise the wider implications and commitments, which it has made jointly with its EU partners.

2) One can wonder whether the **demand estimates** for gas are in line with energy trends, and climate and energy objectives.[51] While gas will be a needed alternative in the transition to a low-carbon future, what will be the real demand if Germany and the other EU member states deliver on pledges to improve energy efficiency, use alternative energy sources in an effective way, increase the use of electricity across society and modernise their heating systems?

In 2014, Germany consumed 646 TWh of natural gas, 90% of which was imported.[52] While the efforts to lower coal consumption will likely increase gas consumption in the power sector in the medium-term, Germany is well-placed to do more to reduce the use of gas for heating. Through building retrofits and the use of alternative heating sources such as heat pumps, power-to-heat (excess electricity stored as heat), and heat from biomass, Germany could reduce its gas demand by 117 TWh.[53] Another study suggests that reaching Germany's climate targets would require installing 5 to 6 million heat pumps by 2030.[54] While waste should only become an energy source as a last resort, cities like Malmö, where 60% of heat is produced from waste, provide interesting case studies for exploring the potential of alternative solutions. In addition, there is a plenty of experience in using combined heat and power as well as geothermal systems in Europe, which could also prove interesting for Germany.

Germany: it is time for a new approach on gas

While gas-fired turbines represent a flexible and cleaner alternative to coal plants, Germany's gas prospects and planned investments may not be consistent with the country's and the EU's objectives and efforts to achieve more secure, cheaper and sustainable energy.

- Rather than increasing the share of fossil fuel in its energy mix, Germany should use the current low oil and gas prices as an opportunity to raise taxes on both, and take the **extra revenue to support the transition** into a greener energy system.

- While it is commonly agreed that natural gas is an important fuel in any energy transition, it is not the only solution. Germany should aim to improve housing in order to increase **energy efficiency** and exploit **alternative domestic sources of energy**, including combined heat and power systems, heat pumps, and geothermal systems.

- Germany should acknowledge and openly discuss the political, economic and legal concerns surrounding the **Nordstream 2** gas pipeline project as well as its implications for the EU's energy security. It should recognise its share of responsibility for the security of supply for Europe as a whole, and the German regulators should consider the wider European interests when assessing energy security. The project's commercial viability should be challenged in light of Germany's climate and energy commitments, availability of alternative sources of energy, and projections for energy use in the power, transport and heating sectors. It is in Germany's interest to promote projects that unite rather than divide the EU, and pushing for a pipeline that is widely opposed across the EU is a questionable strategy.

- If Germany can justify the need for additional gas imports for its electricity, heating and transport sectors, and is willing to invest in the required infrastructure, why not explore **alternative routes and suppliers** in line with the EU's energy security plans? Options include Norwegian gas or liquefied natural gas (LNG) imports from the United States and the Gulf.

5.3. A closer look at the transport sector

Today, fossil fuels (namely oil products) account for 94% of the energy consumed in the German transport sector. As shown in graph 3, transport-related emissions have not declined but rather increased over the past years. Given Germany's major role as a car manufacturer, and thus vested interests in the sector, any technological developments would have impacts not only on Germany but globally. Against this backdrop, it is worth flagging some concerns and possibilities.

While the Japanese and US car manufacturers have supported research on hybrid and electric cars in recent decades, and Chinese have made a massive investment in electric vehicles in the past five years, German car manufacturers have focused on developing combustion engines that run on **diesel**. The argument has been that diesel is a 'cheap and easy way' to reduce carbon emissions and increase energy security. As a result, in 2014, diesel vehicles accounted for about 52% of new cars sold in the EU according to the European Environment Agency. However, while industry has invested in diesel technologies and governments across the EU have supported the development and use of diesel cars with lower taxes and lower air pollution standards, the fuel's overall impact on climate, environment and people's health has been ignored. Diesel emits four times more NOx pollution and 22 times more tiny particles than petrol, and according to latest research, emits also more CO2 emissions.[55] The resulting air pollution has had significant impacts on people's health. NOx emissions yearly cause 68,000 premature deaths in the EU28.[56]

In the aftermath of the '**Dieselgate**', which revealed large scale cheating by German and other European car manufacturers and shed light on the worse than expected real life on-road emissions, there is increasing pressure on the industry to transform. Several EU member states and cities, including Stuttgart in Germany, have already indicated their intention to ban or limit diesel cars. Car manufacturers such as Chinese-owned Volvo are leading the way and have decided to produce only electric and hybrid cars from 2019 onwards. The competition is on. A major question for the German car industry is whether it will join or oppose the change – and for the German government whether it will stop protecting its car industry and implement concrete measures to reduce transport emissions.[57]

Germany can enable and benefit from the transport transition

- Despite the industry's opposition, the government must resist the temptation to protect its industry and undermine EU efforts to place stricter car emission standards. The public sentiment has changed. The significant **environmental and health impacts** cannot be brushed away. They must be addressed head on.
- If the German car industry wishes to survive and people in the sector hope to have jobs in the future, the key is to future proof the industry and rapidly **transition out of fossil fuels**. Voluntary retrofits to diesel cars as suggested by the industry is not the answer.[58] It is too little even as a short-term response.
- More comprehensive vision and measures are needed to push for **low-emission mobility**. This includes having for example the infrastructure in place to incentivise people to walk, cycle, use public transport and car-sharing. Advancements in electric mobility must be supported by having charging infrastructure in place, and ensuring that the energy system is able to cope with the increasing demand for electricity.

The EU needs to provide a clear framework for reducing fossil fuels

- The EU should more readily react if member state **investment decisions** are not aligned with its climate and energy objectives, including efforts to increase energy security, promote energy efficiency and reduce emissions. It is also in Germany's interest that any new infrastructure project for fossil fuels in the EU is checked against these objectives.

  For example, while natural gas can help to phase out coal in a short- to medium-term, making cost-effective investments for its use, in line with the EU's climate and energy objectives, requires collaboration between member states. They should work together to implement existing pieces of legislation, complete the internal energy market and ensure that needed infrastructure will enable solidarity whenever a country faces supply disruptions. Investments in new gas infrastructure should be based on joint efforts to understand - not national - but European future demand.

  As increasing gas imports from Russia is not in line with the EU's political or energy security commitments, Germany needs to be reminded of the strategic implications of its domestic action for the EU, Russia and Ukraine.

- At the EU level, reforming the **emissions trading system (ETS)** and having an adequate price for CO2 would affect the profitability of coal and provide the needed push for phasing it out, including in Germany. While the ETS could be a key instrument for reducing EU's CO2 emissions, it does not work because the scheme has been oversupplied with allowances, which has led to a collapse in the carbon price. Another challenge is that ETS is affected by other EU policies, including those on energy efficiency and renewables that also aim to reduce emissions. The reform should thus look at the climate and energy framework as a whole, carefully analyse the impact of different policies on ETS and the carbon price, and ensure coherence between the policies. This should be followed by permanently retiring allowances to achieve a meaningful carbon price. The ETS funding mechanisms should support member states in modernising their energy systems. Under no circumstances should funds serve to support new or existing coal-fired power plants as is the case in Poland and the Czech Republic. As the reform debate goes on in the EU institutions, it is in the interest of countries such as Germany to aim to achieve a functioning ETS and funding mechanisms that promote investments in clean, carbon-free technologies. It would support also Germany's aim to stimulate development and deployment of renewables and help to upgrade the electricity grid infrastructure. Having member states adopt national measures such as a common carbon floor price to supplement the ETS is not ideal but may be needed in Germany and other member states, if the ETS reform does not deliver.

- The **EU's Industrial Emissions Directive** regulates emissions from industrial installations for other pollutants like NOx, and the proposed emission standards could also play a role in the push for a coal phase-out. The overall impact of this piece of legislation is still, however, unknown because some built-in flexibilities encourage plant refurbishment instead of closure. If this instrument, together with the ETS, does not deliver on phasing out polluting plants, the EU should consider imposing higher emission performance standards on existing power stations and an age-based phasing-out policy.

- The EU must also get its approach on **capacity mechanisms** right. These schemes allow member states to subsidise energy projects in the name of the security of supply. They have been criticised for giving member states a free hand to subsidise fossil fuel use and conventional capacity as a backup for intermittent renewable energy, thus slowing down decarbonisation of the EU's energy system. They also run the risk of seriously undermining efforts to build an EU power market at the expense of consumers. While Germany's strategic reserves in principle do not have to distort the market, it is essential to ensure that they are managed well. In its 'Clean energy for all citizens' package, the Commission has put forward a set of good guiding principles that could serve as a basis for the European Parliament and the member states to agree on a common approach. They should agree that when it evaluates a national scheme, the Commission

should make clear that any effort to balance the grid must start by rewarding those that reduce demand when needed. These schemes should:

- be based on cross-border collaborations;
- encourage the building of needed interconnectors between countries;
- encourage utilising renewables or existing storage solutions;
- be based on reliable and unbiased demand projections that reflect current trends and EU climate objectives.
- Include a CO2 emissions cap for the capacity that is accepted.

While Commission's recognition of the importance of demand-response efforts and regional cooperation is a step in the right direction, ensuring that capacity mechanisms will not undermine the EU's climate and energy objectives, and that the member states will stick to the rules will remain challenges to be tackled.

- The EU is stronger *vis-à-vis* **external partners** when member states act together. Collaborating when exploring alternative routes and suppliers for gas is key. For example, when negotiating energy deals with Russia, it is in the member states', including Germany's, interest to collaborate. The member states' decision to allow the Commission to check that intergovernmental agreements comply with EU law before they are signed is a needed first step in the right direction. In case of politically sensitive projects that raise questions on security of supply, as with Nordstream 2, the Commission should be given a mandate to negotiate with Russia. Generally, because of Russia's past efforts to use energy as a political tool and ongoing aggression in Europe, Russian investments in EU energy infrastructure and implications for security of supply must be analysed and discussed openly. In addition, EU-wide energy security considerations should be incorporated in the evaluations of national regulatory authorities and the Agency for the Cooperation of Energy Regulators (ACER) should be empowered to assess these evaluations.

6. Final recommendations for Germany and the EU

Germany together with the other 27 member states have agreed on a vision to achieve more secure, cheaper and sustainable energy, and couple this with forward-looking climate action under the EU's Energy Union. Germany has an important responsibility in making sure the EU achieves its objectives in terms of increased energy security, increased energy efficiency, and the decarbonising of its economy. It is in the interest of both Germany and the rest of the EU that its domestic measures are aligned with these objectives. Germany has had a first mover advantage: with its vision, it could be a key player in leading climate action not only in Europe but globally. However, it can only provide a credible and attractive model for others if it gets its own house in order.

6.1. Key messages for Germany

The sections above have considered some of the contradictions and challenges of the German energy transition. In effort to draw lessons from past mistakes and make the energy transition a success story, there are three fundamental considerations:

1) Germany's policies and investment decisions must be made **future-proof**. They should consider trends such as global competition for fossil fuels. They should be based on the EU's climate and energy objectives including efforts to increase energy security (including replacing Russian gas with other alternatives), increase EU's energy efficiency and reduce emissions. New trends in energy use must also be considered such the electrification of our lifestyles; the improvement of heating by switching from gas and oil to renewables; the rising use of hybrid, electric or hydrogen cars on roads; the increase in renewable-generated power or electricity. Policies should be used to encourage behavioural changes by making the clean and energy efficient choice the default option for people be it in the use of electricity, heating or transport. Eventually, plans for gas and/or electricity infrastructure and interconnectors must be aligned with these considerations.

2) Germany can become a central player in the fight against climate change on a global and European stage, and should take this role seriously. For example, at the Marrakesh climate conference, Germany led by example when it disclosed its Climate Action Plan for 2050. It was a demonstration of what long-term thinking can consist of. However, **implementation** will remain a key challenge. The credibility of Germany's climate leadership will depend on its domestic progress and its ability to put in place coherent measures to achieve its targets. For both Germany and the EU, the message is quite simple: to keep their momentum on climate change mitigation, they must manage a smart energy transition and develop a replicable model. In a nutshell, what is required is a comprehensive climate and energy approach that can deliver in parallel on reducing global emissions, tackling local air pollution, securing energy supplies, promoting wider socio-economic interests and increasing competitiveness.

3) According to critics, the German energy transition has failed to recognise the importance of **lower energy consumption**. If Germany is serious about building a more sustainable energy system, it must start by making energy efficiency the main priority. Lowering energy consumption has the potential to boost the local economy and jobs. It reduces energy prices and lowers GHG emissions. Estimates indicate that for every 1% reduction in energy consumption, gas imports are cut by 2.6%. Energy efficiency is thus the path towards reduced dependency on foreign energy imports. Once you achieve your energy efficiency objectives, you can better understand and plan for future energy supply and demand. Germany should seriously consider the EU's calls to reduce electricity and energy consumption through efficiency and greater demand-response efforts. It should appreciate the economic, societal and environmental benefits this would bring. This must be combined with greater efforts to phase out conventional power plants – otherwise efficiency may lead into oversupply of fossil fuel generation.

6.2. Key messages to the EU

As has been demonstrated above, EU cooperation can help Germany and other EU member states in finding the most efficient ways to reduce emissions and transform energy systems. In addition to what has been suggested above, the EU should consider the following:

1) The Commission must help member states in creating **effective and coherent approaches to national energy transitions**. The starting point is to ensure that EU policies that impact energy security, sustainability and competitiveness are coherent and provide an adequate framework for action. While countries remain free to set their energy mixes, the EU influences these and provides investment signals via targets, financial support and environmental regulation – and should use this role wisely. In addition, the EU should encourage member states to share best practices on meeting their climate and energy goals and collaborate when it brings value to them and the EU as a whole. As *Energiewende* has demonstrated, collaboration with other member states and alignment with agreed policies and targets is a key to a successful energy transition. Acting alone is short-sighted and often costly. Lastly, if the EU is serious about creating an Energy Union, it must strengthen governance and the implementation of existing energy legislation across member states. The Commission's energy package provides a good basis to guide member states. However, unless they buy into the benefits of an Energy Union and endorse a European approach beyond narrow national interests, implementation will remain extremely difficult.

2) While ETS is the closest thing the EU has in terms of providing a price for polluting practices, in an ideal world Europe would have a market-based system where **energy prices reflect their true cost**. This would require removing subsidies from all energy sources, fossil fuels and mature renewable technologies. It would require internalising and taking into account the external costs of each energy source in terms of harm to people's health, society, or the environment.

3) **Empowering European consumers**, be they citizens or businesses, could turn them into strong advocates of an Energy Union. The Commission's effort during the review of the Renewable Energy Directive and the New Electricity Market Design initiative to put pro-active consumers and citizens at the heart of the electricity market is commendable. While giving people transparent information on energy prices, enabling them to switch suppliers, providing them smart meters or incentivising more efficient consumption is good, the potential for empowerment is greater than that. The EU framework should enable citizens to invest and contribute to the energy transition. Individual households, schools, municipalities, government buildings and small businesses could all play a role in the transition if they were given a right to produce and store renewable energy and disseminate it on the grid. At the same time, turning citizens into producers of electricity must be cost-effective and there should not be guaranteed prices that are higher than market prices, as has been the case in Germany.

4) In the end, the EU's efforts to reduce GHG emissions will do little to mitigate change, unless it is supported by **global action**. The EU needs to keep the momentum on implementing global climate agreements and removing fossil fuel subsidies across the world. The EU's diplomatic push must simultaneously build on showcasing the benefits of reducing global emissions, fighting climate change and air pollution locally, securing energy supplies, promoting wider socio-economic interests and increasing competitiveness. It needs attractive case studies from member states, regions, cities and different economic sectors, demonstrating how the transition can be carried out in a sustainable and affordable way. With Germany's Climate Action Plan now published, the question is whether it can provide one of these attractive narratives and case studies for others to follow.

7. Conclusions

While in its current form the *Energiewende* does not provide a model for others to follow, in many ways the German experiences provide valuable lessons not only for Germany but also for other member states. The German example recalls the importance of a comprehensive vision for a sustainable energy system and an all-inclusive strategy for its achievement. The key question now is what will be done with these lessons.

The German decision to phase out nuclear and increase renewables without considering and communicating the consequences, as well as its failure to collaborate with its neighbours initially, demonstrate the need for a more comprehensive approach to the energy transition. This assessment is partly reflected in Germany's Climate Action Plan 2050. The country, however, still needs to discuss openly its vision and needed measures to achieve its goals. It needs to further explain expected benefits to citizens and businesses. It should take into consideration how regional and EU collaboration can support both its electricity and energy transitions. Germany would be the first to benefit from a more future-proof approach. Cooperating across borders – i.e. sharing resources and developing regulatory frameworks with other member states – can encourage sharing of best practices, help build a more reliable domestic energy system at lower costs and balance fluctuating power generation.

At a European level, the *Energiewende* illustrates the challenges the EU faces with the Energy Union: vested national interests, fragmented energy markets and non-compliance with agreed principles and commitments. While member states tend to act based on their short-sighted national interests, and even against common goals when it suits them, the German energy transition reminds of the rationale for further collaboration. When member states fail to cooperate and coordinate their actions, there are high costs to be borne by citizens and businesses. The energy transition also exemplifies the cross-border impacts of member states' energy policies. It demonstrates the merits of connecting national energy markets and enabling EU-wide competition to reduce energy costs. It reveals the benefits that member states can draw from shared infrastructure investments. It reminds that only by aligning member states' national policies can the EU address shared challenges and promote commonly agreed climate and energy targets.

It is widely recognised that the transition to a greener, more sustainable economy and energy systems has started. The real winners of the future will be those that jump on forthcoming opportunities today. Germany's domestic policies have already created a favourable platform for investments in greener and cleaner technologies. Building on this advantage can help increase German and EU industrial competitiveness and job creation. Our policy frameworks and tools at both domestic and EU levels must therefore catch up with these developments. They should provide a smart, comprehensive framework for further action for business, cities and civil society. Even though markets will have to support the energy transition, it remains a political choice that requires political commitment. The Energy Union needs the full support of the EU member states to deliver. Germany and other member states should see themselves as a part of the puzzle, and recognise the economic, social and environmental benefits that greater collaboration can bring. It will allow them to carry out their energy transition. It is high time to recognise that by being a constructive contributor to the Energy Union, Germany will be able to carry out its energy transition in a lasting and cost-effective way.

Annika Hedberg is Senior Policy Analyst at the European Policy Centre (EPC).

Bibliography

AGEB (2017), "Evaluation Tables on the Energy Balance for the Federal Republic of Germany 1990 to 2015", available at: http://www.ag-energiebilanzen.de/10-1-Evaluation-Tables-on-the-Energy-Balance.html (last accessed on: 18 August 2017).

Agora Energiewende (2017),"Deutschlands Klimaziel 2020 ist noch weiter weg als gedacht", 7 September 2017, available at: https://www.agora-energiewende.de/de/presse/pressemitteilungen/detailansicht/news/deutschlands-klimaziel-2020-ist-noch-weiter-weg-als-gedacht-1/News/detail/ (last accessed on: 28 September 2017).

Agora Energiewende (2016), "Eleven Principles for a Consensus on Coal", available at: https://www.agora-energiewende.de/en/topics/-agothem-/Produkt/produkt/270/Eleven+Principles+for+a+Consensus+on+Coal/ (last accessed on 24 September 2017).

Agora Energiewende (2016), "Energiewende: What do the new laws mean?", available at: https://www.agora-energiewende.de/fileadmin/Projekte/2016/EEG-FAQ/Agora_FAQ-EEG_EN_WEB.pdf (last accessed on: 18 August 2017).

Agora Energiewende (2015), "The European Power System in 2030: Flexibility Challenges and Integration Benefits", available at: https://www.agora-energiewende.de/fileadmin/Projekte/2014/Ein-flexibler-Strommarkt-2030/Agora_European_Flexibility_Challenges_Integration_Benefits_WEB_Rev1.pdf (last accessed on: 26 September 2017).

Agora Energiewende (2017), "Heat transition 2030", available at: https://www.agora-energiewende.de/fileadmin/Projekte/2016/Sektoruebergreifende_EW/Heat-Transition-2030_Summary-WEB.pdf (last accessed on 24 September 2017).

Agora Energiewende (2015), "Report on the German power system", available at: https://www.agora-energiewende.de/fileadmin/Projekte/2014/CP-Deutschland/CP_Germany_update_1015_web.pdf (last accessed on: 18 August 2017).

Agora Energiewende (2015), "Understanding the Energiewende", available at: https://www.agora-energiewende.de/fileadmin/Projekte/2015/Understanding_the_EW/Agora_Understanding_the_Energiewende.pdf (last accessed on: 27 September 2017).

Bloomberg, "Germany Can't Bear the $32 Billion-a-Year Green Costs, Says Minister Says", 21 January 2014, available at: http://www.bloomberg.com/news/articles/2014-01-21/germany-can-t-bear-32-billion-a-year-green-costs-minister-says (last accessed on: 16 August 2017).

Bössner, Stefan (2015), "Strengthening the European electricity market through improved Franco-German cooperation", the Jacques Delors Institute, available at: http://www.delorsinstitute.eu/011-21095-Strengthening-the-European-electricity-market-through-improved-Franco-German-cooperation.html (last accessed on: 18 August 2017).

Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit (2016), "Climate Action Plan 2015: Cabinet adopts guide to climate neutral Germany", 14 November 2016, available at: http://www.bmub.bund.de/en/press/press-releases/detailansicht-en/artikel/climate-action-plan-2050-cabinet-adopts-guide-to-climate-neutral-germany/ (last accessed on: 16 August 2017).

Bundesnetzagentur (2017), "Beendete Ausschreibungen 2017", available at: https://www.bundesnetzagentur.de/DE/Sachgebiete/ElektrizitaetundGas/Unternehmen_Institutionen/Ausschreibungen/Wind_Onshore/BeendeteAusschreibungen/BeendeteAusschreibungen_node.html and https://www.bundesnetzagentur.de/DE/Sachgebiete/ElektrizitaetundGas/Unternehmen_Institutionen/Ausschreibungen/Solaranlagen/BeendeteAusschreibungen/Ausschreibungen2017/Ausschreibungen2017_node.html (last accessed on: 26 September 2017).

Clean Energy Wire (2016), "Car giant Germany struggles to ignite Energiewende in transportation", 9 May 2016, available at: https://www.cleanenergywire.org/dossiers/energy-transition-and-germanys-transport-sector (last accessed on: 18 August 2017).

Clean Energy Wire, (2016), "EEG Reform 2016 – switching to auctions for renewables", 8 July 2016, available at: https://www.cleanenergywire.org/factsheets/eeg-reform-2016-switching-auctions-renewables (last accessed on: 18 August 2017).

Clean Energy Wire (2017), "Germany's greenhouse gas emissions and climate targets", 1 February 2017, available at: https://www.cleanenergywire.org/factsheets/germanys-greenhouse-gas-emissions-and-climate-targets (last accessed on: 6 September 2017).

Clean Energy Wire (2016), "Government reaches agreement on Climate Action Plan 2050", 11 November 2016, available at: https://www.cleanenergywire.org/news/german-government-reaches-agreement-climate-action-plan-2050/government-reaches-agreement-climate-action-plan-2050 (last accessed on: 18 August 2017).

Clean Energy Wire (2016), "Renewable energy levy set to rise in 2017", 29 July 2016, available at: https://www.cleanenergywire.org/news/renewable-energy-levy-set-rise-2017-think-tank (last accessed on: 18 August 2017).

Clean Energy Wire (2015), "The solo draws to close", 25 June 2015, available at: https://www.cleanenergywire.org/dossiers/germanys-energy-transition-european-context (last accessed on: 18 August 2017).

Clean Energy Wire (2016), "Troubled pillar of the Energiewende", 30 September 2016, available at: https://www.cleanenergywire.org/dossiers/bioenergy-germany (last accessed on: 18 August 2017).

Climate Policy Initiative (2016), "Policy and investment in German renewable energy", available at: https://climatepolicyinitiative.org/wp-content/uploads/2016/04/Policy-and-investment-in-German-renewable-energy-Summary.pdf (last accessed on: 16 September 2017).

Deutsche Welle (2015), "German C02 emission targets at risk", 19 November 2015, available at: http://www.dw.com/en/german-co2-emissions-targets-at-risk/a-18862708 (last accessed on: 18 August 2017).

European Association for Coal and Lignite (EURACOAL), "Germany", available at: https://euracoal.eu/info/country-profiles/germany/ (last accessed on 24 September 2017).

European Association for Coal and Lignite (EURACOAL) (2013), "Coal Industry Across Europe - 5th Edition",available at: https://euracoal.eu/library/publications/ (last accessed on: 18 August 2017).

European Commission, "2050 Energy strategy", available at: https://ec.europa.eu/energy/en/topics/energy-strategy/2050-energy-strategy (last accessed on: 18 August 2017).

European Commission (2016), "Commission proposes new rules for consumer centred clean energy transition", 30 November 2016, available at: https://ec.europa.eu/energy/en/news/commission-proposes-new-rules-consumer-centred-clean-energy-transition (last accessed on: 17 August 2017).

European Commission (2016), "Commission published new market design rules proposal", available at: http://ec.europa.eu/energy/en/news/commission-publishes-new-market-design-rules-proposal (last accessed on: 16 August 2017).

European Commission (2017), "State aid: Commission opens in-depth investigation into German plans for electricity capacity reserve", 4 April 2017, available at: http://europa.eu/rapid/press-release_IP-17-903_en.htm (last accessed on: 24 September 2017).

European Commission (2016), "Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources", available at: http://eur-lex.europa.eu/resource.html?uri=cellar:3eb9ae57-faa6-11e6-8a35-01aa75ed71a1.0007.02/DOC_1&format=PDF (last accessed on: 16 August 2017).

European Environment Agency (EEA) (2016), "Air quality in Europe - 2016 report".

European Environment Agency (EEA) (2016), "Decommissioning fossil fuel power plants between now and 2030 essential for Europe's low carbon future", available at: http://www.eea.europa.eu/highlights/decommissioning-fossil-fuel-power-plants (last accessed on: 18 August 2018).

European Environment Agency (EEA) (2014), "Industrial air pollution has high economic costs", available at: http://www.eea.europa.eu/media/newsreleases/industrial-air-pollution-has-high (last accessed on: 18 August 2017).

Eurostat (2017), "Consumption of energy", available at: http://ec.europa.eu/eurostat/statistics-explained/index.php/Consumption_of_energy (last accessed on: 16 August 2017).

Eurostat (2017), "Electricity prices for domestic consumers – bi-annual data", available at: http://ec.europa.eu/eurostat/web/energy/data/database (last accessed on: 18 August 2017).

Eurostat (2015), "Energy, transport and environment indicators – 2015 edition", available at: http://ec.europa.eu/eurostat/documents/3217494/7052812/KS-DK-15-001-EN-N.pdf/eb9dc93d-8abe-4049-a901-1c7958005f5b (last accessed on: 18 August 2017).

Eurostat (2017), "Greenhouse gas emissions by sector", available at: http://ec.europa.eu/eurostat/web/environment/air-emissions-inventories/database (last accessed on: 17 August 2017).

Federal Foreign Office, "Energiewende – pleasantly warm, renewable and efficient", available at: http://www.energiewende-global.com/en/heat.html (last accessed on: 20 September 2017).

Federal Institute for Geosciences and Natural Resources (BGR) (2014), "Energy Study 2014: Reserves, Resources and Availability of Energy Resources", available at: http://www.bgr.bund.de/EN/Themen/Energie/Downloads/energiestudie_2014_en.pdf?__blob=publicationFile&v=3 (last accessed on: 18 August 2017).

Federal Ministry of Economic Affairs and Energy (BMWi) (2015), "The Energy of the Future: Fourth "Energy Transition" Monitoring Report – Summary", available at: https://www.bmwi.de/Redaktion/EN/Publikationen/vierter-monitoring-bericht-energie-der-zukunft-kurzfassung.pdf?__blob=publicationFile&v=14 (last accessed on: 18 August 2017).

Federal Ministry of Economic Affairs and Energy (BMWi) (2015), "The Energy of the Future: Fifth "Energy Transition" Monitoring Report – Summary", available at: https://www.bmwi.de/Redaktion/EN/Publikationen/monitoring-report-2016-summary.pdf?__blob=publicationFile&v=8 (last accessed on: 21 August 2017).

Federal Ministry for Economic Affairs and Energy (BMWi) (2017), "For a future of green energy", available at: https://www.bmwi.de/Redaktion/EN/Dossier/renewable-energy.html (last accessed on: 18 August 2017).

Federal Ministry for Economic Affairs and Energy (BMWi) (2017), "Zahlen und Fakten Energiedaten. Nationale und Internationale Entwicklung", available at: https://www.bmwi.de/Redaktion/DE/Binaer/Energiedaten/energiedaten-gesamt-xls.xls?__blob=publicationFile&v=41 (last accessed on: 20 August 2017).

4 traders.com (2012), "RWE AG: Environment Minister: Germany Needs More Coal, Gas Power Plants", 15 August 2012, available at: http://www.4-traders.com/RWE-AG-436529/news/RWE-AG-Environment-Minister-Germany-Needs-More-Coal-Gas-Power-Plants-14461100/ (last accessed on: 18 August 2017).

Fraunhofer-Institute für Windenergie und Energiesystemtechnik (IWES) (2014), "Erdgassubstitution duch eine forcierte Energiewende", available at: https://www.gruene-bundestag.de/fileadmin/media/gruenebundestag_de/themen_az/energie/PDF/Erdgassubstitution_final.pdf (last accessed on: 18 August 2017).

The Guardian (2013), "EU to impose anti-dumping tariffs on Chinese solar panels", 4 June 2013, available at: https://www.theguardian.com/business/2013/jun/04/eu-tarriffs-dumping-china-solar-panels (last accessed on: 18 August 2017).

The Guardian (2016), "Germany takes steps to roll back renewable energy revolution", 11 October 2016, available at: https://www.theguardian.com/environment/2016/oct/11/germany-takes-steps-to-roll-back-renewable-energy-revolution (last accessed on: 16 August 2017).

Hedberg, Annika (2015), "EU's quest for energy security – What role for the Energy Union?", European Policy Centre, available at: http://epc.eu/documents/uploads/pub_5374_eu_s_quest_for_energy_security.pdf (last accessed on: 18 August 2017).

Hedberg, Annika (2016), "Nord Stream II – yes or no? – Political decision of a political Commission", European Policy Centre, available at: http://www.epc.eu/pub_details.php?cat_id=4&pub_id=6628 (last accessed on: 18 August 2017).

Heymann, Eric (2016), "German 'Energiewende': Many targets out of sight", Deutsche Bank Research, available at: https://www.dbresearch.com/PROD/DBR_INTERNET_EN-PROD/PROD0000000000406742/German_%E2%80%98Energiewende%E2%80%99%3A_Many_targets_out_of_sight.pdf (last accessed on: 18 August 2017).

Initiative Neue Soziale Martkwirtschaft (INSM) (2016), "EEG & Co. treiben Energiewendekosten auf 520 Milliarden Euro", 10 October 2017, available at: http://www.insm.de/insm/Presse/Pressemeldungen/Pressemeldung-Studie-EEG.html (last accessed on: 16 August 2017).

International Court of Justice (2004) "Summary of the Advisory Opinion" on Israel-Palestine Wall, 9 July 2004.

International Energy Agency (IEA) (2014), "France: Electricity and Heat for 2014", available at: https://www.iea.org/statistics/statisticssearch/report/?country=FRANCE&product=electricityandheat&year=2014 (last accessed on: 14 August 2017).

International Energy Agency (IEA) (2014), "Germany: Balances for 2014", available at: https://www.iea.org/statistics/statisticssearch/report/?year=2014&country=GERMANY&product=Balances (last accessed on: 25 August 2017).

International Energy Agency (IEA) (2014), "Germany: Natural gas for 2014", available at: https://www.iea.org/statistics/statisticssearch/report/?country=GERMANY&product=naturalgas&year=2014 (last accessed on 18 August 2017).

International Energy Agency (IEA) (2014), "Italy: Electricity and Heat for 2014", available at: https://www.iea.org/statistics/statisticssearch/report/?country=ITALY&product=electricityandheat&year=2014 (last accessed on: 14 August 2017).

International Energy Agency (IEA) (2014), "Sweden: Electricity and Heat for 2014", available at: http://www.iea.org/statistics/statisticssearch/report/?country=SWEDEN&product=electricityandheat&year=2014 (last accessed on: 10 September 2017).

IRENA (2015), "Renewable Power Generation Costs in 2014", available at: https://www.irena.org/DocumentDownloads/Publications/IRENA_RE_Power_Costs_2014_report.pdf (last accessed on: 26 September 2017).

TheJournal.ie (2017), "Three German Giants start free retrofit program for millions of diesel cars", 31 July 2017, available at: http://www.thejournal.ie/bmw-audi-mercedes-diesel-engine-recall-3517654-Jul2017/ (last accessed on 28 September 2017).

Jungjohann, Arne and Morris, Craig, (2014), "The German Coal Conundrum: The status of coal power in Germany's energy transition", Heinrich Böll Foundation North America, available at: https://us.boell.org/sites/default/files/german-coal-conundrum.pdf (last accessed on: 18 August 2017).

KFW (2016), "The energy transition will not work without a heating transition", available at: https://www.kfw.de/PDF/Download-Center/Konzernthemen/Research/PDF-Dokumente-Fokus-Volkswirtschaft/Fokus-englische-Dateien/Focus-No.-129-June-2016-Heating-transition.pdf (last accessed on: 16 August 2017).

KlimaDiskurs.NRW (2017), "Bolstering joint climate action through dialogue", available at https://www.theclimategroup.org/sites/default/files/devel-generate/wro/etp_klimadiskurscasestudy_aug2017.pdf (last accessed on 24 September 2017).

Lang, Matthias (2013), "German Renewable Surcharge Increases by 19% to 6.24 ct/kWh in 2014", German Energy Blog, 15 October 2013, available at: http://www.germanenergyblog.de/?p=14559 (last accessed on: 18 August 2017).

Morris, Craig (2014), "Can the energy transition make Germany independent of Russian gas?", Energytransition.org, 30 September 2014, available at: https://energytransition.org/2014/09/energy-transition-russian-gas-independence/ (last accessed on: 18 August 2017).

Palash, S. M., Kalam, M. A., Masjuki, H. H., Masum, B. M., Rizwanul Fattah, I. M., Mofijur, M. (2013), "Impact of biodiesel combustion on NOx emissions and their reduction approaches", Renewable and Sustainable Energy Reviews, Volume 23, p. 473-490. Available at: http://www.sciencedirect.com/science/article/pii/S1364032113001524 (last accessed on 18 August 2017).

Pisca, Iulia (2016), "Outlook for EU gas demand and import needs to 2025", Clingendael International Energy Programme (CIEP), available at: http://www.clingendaelenergy.com/inc/upload/files/CIEP_paper_2016_2A_Demand_web.pdf (last accessed on: 18 August 2017).

Power Engineering International (2013), "Study assesses Germany's energy policy impact on angry neighbours", 1 March 2013, available at: http://www.powerengineeringint.com/articles/2013/02/Study-assesses-Germanys-energy-policy-impact-on-angry-neighbours.html (last accessed on: 18 August 2017).

Prognos (2017), "Interim report. Low carbon options and gas infrastructure – Chances of efficiency and renewable energies for gas infrastructure planning and security of supply in Europe.", available at: https://www.prognos.com/uploads/tx_atwpubdb/20170407_Prognos_Report_Low_Carbon_options_2016_19.1.17.pdf (last accessed on 18 August 2017).

PwC (2015), "Energiewende Outlook: Transportation sector", available at: http://www.pwc.de/de/energiewende/assets/energiewende-outlook-transportation-2015.pdf (last accessed on: 16 August 2017).

Reuters (2015), "Badly located renewable power plants cost Europe $100 billion: Davos report", 20 January 2015, available at: http://www.reuters.com/article/2015/01/20/us-utilities-europe-davos-idUSKBN0KT2BC20150120 (last accessed on: 16 August 2017).

Rutten, Daan (2014), "The Energiewende and Germany's industrial policy", Clingendael International Energy Programme (CIEP), available at: http://www.clingendaelenergy.com/inc/upload/files/Ciep_paper_2014-07_web_1.pdf (last accessed on: 18 August 2017).

Sandbag (2016), "Top 10 European polluters still dominated by German lignite", 1 April 2016, available at: https://sandbag.org.uk/blog/2016/apr/1/top-10-european-polluters-still-dominated-german-l/ (last accessed on: 18 August 2017).

Schulz, Sabrina and Schwarzkopff, Julian (2015), "G7 Coal Phase Out: Germany", E3G, available at: https://www.e3g.org/docs/Germany_G7_coal_analysis_September_2015.pdf (last accessed on: 18 August 2017).

Transport & Environment (2017), "Dirty diesel also worse for the climate than petrol cars – study", 18 September 2017, available at: https://www.transportenvironment.org/press/dirty-diesel-also-worse-climate-petrol-cars-study (last accessed on 25 September 2017).

Umwelt Bundesamt (2017), "Daten zur Umwelt 2017", available at: https://www.umweltbundesamt.de/sites/default/files/medien/376/publikationen/daten_zur_umwelt_2017_indikatorenbericht.pdf (last accessed on: 6 September 2017).

WWF (2016), "Europe's dark cloud: How coal-burning countries make their neighbours sick", 5 July 2016, available at: http://www.wwf.eu/?uNewsID=272916 (last accessed on: 18 August 2017).

Endnotes

[1] A version of this paper is also published as a part of a Konrad-Adenauer-Stiftung publication "Assessing the Energiewende – An International Report" (2017)
[2] Agora Energiewende (2015), (2015), "Understanding the Energiewende", pp.11-12., available at: https://www.agora-energiewende.de/fileadmin/Projekte/2015/Understanding_the_EW/Agora_Understanding_the_Energiewende.pdf (last accessed on: 27 September 2017).
[3] Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit (2016), "Climate Action Plan 2015: Cabinet adopts guide to climate neutral Germany", 14 November 2016, available at: http://www.bmub.bund.de/en/press/press-releases/detailansicht-en/artikel/climate-action-plan-2050-cabinet-adopts-guide-to-climate-neutral-germany/ (last accessed on: 16 August 2017).
[4] Eurostat (2017), "Consumption of energy", June 2017, available at: http://ec.europa.eu/eurostat/statistics-explained/index.php/Consumption_of_energy (last accessed on: 16 August 2017).
[5] Eurostat (2017), "Greenhouse gas emissions by sector" [Dataset], available at: http://ec.europa.eu/eurostat/web/environment/air-emissions-inventories/database (last accessed on: 17 August 2017).
[6] European Commission (2016), "Commission proposes new rules for consumer centred clean energy transition", 30 November 2016, available at: https://ec.europa.eu/energy/en/news/commission-proposes-new-rules-consumer-centred-clean-energy-transition (last accessed on: 17 August 2017).
[7] Federal Ministry for Economic Affairs and Energy (BMWi) (2017), "Zahlen und Fakten Energiedaten. Nationale und Internationale Entwicklung" [Dataset, p.5], available at: https://www.bmwi.de/Redaktion/DE/Binaer/Energiedaten/energiedaten-gesamt-xls.xls?__blob=publicationFile&v=41 (last accessed on: 20 August 2017). See also International Energy Agency (IEA) (2014), "Germany: Balances for 2014" [Dataset], available at: https://www.iea.org/statistics/statisticssearch/report/?year=2014&country=GERMANY&product=Balances (last accessed on: 25 August 2017).
[8] Federal Ministry for Economic Affairs and Energy (BMWi) (2017), "Zahlen und Fakten Energiedaten. Nationale und Internationale Entwicklung" [Dataset, p. 6], available at: https://www.bmwi.de/Redaktion/DE/Binaer/Energiedaten/energiedaten-gesamt-xls.xls?__blob=publicationFile&v=41 (last accessed on: 20 August 2017).
[9] Federal Foreign Office, "Energiewende - pleasantly warm, renewable and efficient", available at: http://www.energiewende-global.com/en/heat.html (last accessed on: 20 September 2017); KFW (2016), "The energy transition will not work without a heating transition", 9 June 2016, available at: https://www.kfw.de/PDF/Download-Center/Konzernthemen/Research/PDF-Dokumente-Fokus-Volkswirtschaft/Fokus-englische-Dateien/Focus-No.-129-June-2016-Heating-transition.pdf (last accessed on: 16 August 2017).
[10] International Energy Agency (IEA) (2014), "Germany: Balances for 2014" [Dataset], available at: https://www.iea.org/statistics/statisticssearch/report/?year=2014&country=GERMANY&product=Balances (last accessed on: 25 August 2017).
[11] International Energy Agency (IEA) (2014), "Germany: Electricity and Heat for 2014" [Dataset], available at: https://www.iea.org/statistics/statisticssearch/report/?country=GERMANY=&product=electricityandheat (last accessed on: 14 August 2017). Germany's updated figures for electricity can be accessed here: Federal Ministry for Economic Affairs and Energy (BMWi) (2017), "For a future of green energy", March 2017, available at: https://www.bmwi.de/Redaktion/EN/Dossier/renewable-energy.html (last accessed on: 18 August 2017).
[12] International Energy Agency (IEA) (2014), "Italy: Electricity and Heat for 2014" [Dataset], available at: https://www.iea.org/statistics/statisticssearch/report/?country=ITALY&product=electricityandheat&year=2014 (last accessed on: 14 August 2017).
[13] International Energy Agency (IEA) (2014), "France: Electricity and Heat for 2014" [Dataset], available at: https://www.iea.org/statistics/statisticssearch/report/?country=FRANCE&product=electricityandheat&year=2014 (last accessed on: 14 August 2017).
[14] Federal Ministry for Economic Affairs and Energy (BMWi) (2017), "For a future of green energy", available at: https://www.bmwi.de/Redaktion/EN/Dossier/renewable-energy.html (last accessed on: 27 September 2017).
[15] International Energy Agency (IEA) (2014), "Germany: Electricity and Heat for 2014" [Dataset], available at: https://www.iea.org/statistics/statisticssearch/report/?country=GERMANY=&product=electricityandheat (last accessed on: 14 August 2017). Germany's updated figures for electricity can be accessed here: Federal Ministry for Economic Affairs and Energy (BMWi) (2017), "For a future of green energy", March 2017, available at: https://www.bmwi.de/Redaktion/EN/Dossier/renewable-energy.html (last accessed on: 18 August 2017).
[16] International Energy Agency (IEA) (2014), "Germany: Electricity and Heat for 2014" [Dataset], available at: https://www.iea.org/statistics/statisticssearch/report/?country=GERMANY=&product=electricityandheat (last accessed on: 14 August 2017).
[17] PwC (2015), "Energiewende Outlook: Transportation sector", available at: http://www.pwc.de/de/energiewende/assets/energiewende-outlook-transportation-2015.pdf (last accessed on: 16 August 2017).
[18] Clean Energy Wire (2017), "Germany's greenhouse gas emissions and climate targets", 1 February 2017, available at: https://www.cleanenergywire.org/factsheets/germanys-greenhouse-gas-emissions-and-climate-targets (last accessed on: 6 September 2017).
[19] Umwelt Bundesamt (2017), "Daten zur Umwelt 2017" p.22, available at: https://www.umweltbundesamt.de/sites/default/files/medien/376/publikationen/daten_zur_umwelt_2017_indikatorenbericht.pdf (last accessed on: 6 September 2017).
[20] Agora Energiewende (2017),"Deutschlands Klimaziel 2020 ist noch weiter weg als gedacht", 7 September 2017, available at: https://www.agora-energiewende.de/de/presse/pressemitteilungen/detailansicht/news/deutschlands-klimaziel-2020-ist-noch-weiter-weg-als-gedacht-1/News/detail/ (last accessed on: 28 September 2017).
[21] Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit (2016), "Climate Action Plan 2015: Cabinet adopts guide to climate neutral Germany", 14 November 2016, available at: http://www.bmub.bund.de/en/press/press-releases/detailansicht-en/artikel/climate-action-plan-2050-cabinet-adopts-guide-to-climate-neutral-germany/ (last accessed on: 16 August 2017).
[22] Climate Policy Initiative (2016), "Policy and investment in German renewable energy", p.1, available at: https://climatepolicyinitiative.org/wp-content/uploads/2016/04/Policy-and-investment-in-German-renewable-energy-Summary.pdf (last accessed on: 16 September 2017).
[23] Reuters (2015), "Badly located renewable power plants cost Europe $100 billion: Davos report", 20 January 2015, available at: http://www.reuters.com/article/2015/01/20/us-utilities-europe-davos-idUSKBN0KT2BC20150120 (last accessed on: 16 August 2017).
[24] See Bundesnetzagentur (2017), "Beendete Ausschreibungen 2017", available at: https://www.bundesnetzagentur.de/DE/Sachgebiete/ElektrizitaetundGas/Unternehmen_Institutionen/Ausschreibungen/Wind_Onshore/BeendeteAusschreibungen/BeendeteAusschreibungen_node.html and https://www.bundesnetzagentur.de/DE/Sachgebiete/ElektrizitaetundGas/Unternehmen_Institutionen/Ausschreibungen/Solaranlagen/BeendeteAusschreibungen/Ausschreibungen2017/Ausschreibungen2017_node.html (last accessed on: 26 September 2017).

[25] More on regional cooperation and power system integration, see e.g. Agora Energiewende (2015), "The European Power System in 2030: Flexibility Challenges and Integration Benefits", available at: https://www.agora-energiewende.de/fileadmin/Projekte/2014/Ein-flexibler-Strommarkt-2030/Agora_European_Flexibility_Challenges_Integration_Benefits_WEB_Rev1.pdf (last accessed on: 26 September 2017).
[26] The Guardian (2016), "Germany takes steps to roll back renewable energy revolution", 11 October 2016, available at: https://www.theguardian.com/environment/2016/oct/11/germany-takes-steps-to-roll-back-renewable-energy-revolution (last accessed on: 16 August 2017).
[27] Heymann, Eric (2016), "German 'Energiewende': Many targets out of sight", Deutsche Bank Research, p. 6, available at: https://www.dbresearch.com/PROD/DBR_INTERNET_EN-PROD/PROD0000000000406742/German_'Energiewende'%3A_Many_targets_out_of_sight.pdf (last accessed on: 16 August 2017).
[28] Eurostat (2017), "Electricity prices for domestic consumers - bi-annual data", [Dataset], available at: http://ec.europa.eu/eurostat/web/energy/data/database (last accessed on: 18 August 2017).
[29] Eurostat (2015), "Energy, transport and environment indicators - 2015 edition", p. 20, available at: http://ec.europa.eu/eurostat/documents/3217494/7052812/KS-DK-15-001-EN-N.pdf/eb9dc93d-8abe-4049-a901-1c7958005f5b (last accessed on: 18 August 2017).
[30] Bloomberg, "Germany Can't Bear the $32 Billion-a-Year Green Costs, Says Minister Says", available at: http://www.bloomberg.com/news/articles/2014-01-21/germany-can-t-bear-32-billion-a-year-green-costs-minister-says (last accessed on: 16 August 2017).
[31] Initiative Neue Soziale Martkwirtschaft (INSM) (2016), "EEG & Co. treiben Energiewendekosten auf 520 Milliarden Euro", 10 October 2017, available at: http://www.insm.de/insm/Presse/Pressemeldungen/Pressemeldung-Studie-EEG.html (last accessed on: 16 August 2017).
[32] IRENA (2015), Renewable Power Generation Costs in 2014, available at: https://www.irena.org/DocumentDownloads/Publications/IRENA_RE_Power_Costs_2014_report.pdf (last accessed on: 26 September 2017).
[33] European Commission (2016), "Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources", available at: http://eur-lex.europa.eu/resource.html?uri=cellar:3eb9ae57-faa6-11e6-8a35-01aa75ed71a1.0007.02/DOC_1&format=PDF (last accessed on: 16 August 2017).
[34] European Commission (2016), "Commission published new market design rules proposal", available at: http://ec.europa.eu/energy/en/news/commission-publishes-new-market-design-rules-proposal (last accessed on: 16 August 2017).
[35] Reuters (2015), "Badly located renewable power plants cost Europe $100 billion: Davos report", 20 January 2015, available at: http://www.reuters.com/article/2015/01/20/us-utilities-europe-davos-idUSKBN0KT2BC20150120 (last accessed on: 16 August 2017).
[36] Palash, S. M., Kalam, M. A., Masjuki, H. H., Masum, B. M., Rizwanul Fattah, I. M., Mofijur, M. (2013), "Impact of biodiesel combustion on NOx emissions and their reduction approaches", Renewable and Sustainable Energy Reviews, Volume 23, p. 473-490. Available at: http://www.sciencedirect.com/science/article/pii/S1364032113001524 (last accessed on 18 August 2017).
[37] European Association for Coal and Lignite (EURACOAL) (2013), "Coal Industry Across Europe - 5th Edition", p. 5-15, 29-33. Available at: https://euracoal.eu/library/publications/ (last accessed on: 18 August 2017).
[38] 4 traders.com (2012), "RWE AG: Environment Minister: Germany Needs More Coal, Gas Power Plants", 15 August 2012, available at: http://www.4-traders.com/RWE-AG-436529/news/RWE-AG-Environment-Minister-Germany-Needs-More-Coal-Gas-Power-Plants-14461100/ (last accessed on: 18 August 2017).
[39] European Commission (2017), "State aid: Commission opens in-depth investigation into German plans for electricity capacity reserve", 4 April 2017, available at: http://europa.eu/rapid/press-release_IP-17-903_en.htm (last accessed on: 24 September 2017).
[40] European Environment Agency (EEA) (2014), "Industrial air pollution has high economic cost", 21 November 2014, available at: http://www.eea.europa.eu/media/newsreleases/industrial-air-pollution-has-high (last accessed on: 18 August 2017).
[41] Sandbag (2016), "Top 10 European polluters still dominated by German lignite", 1 April 2016, available at: https://sandbag.org.uk/blog/2016/apr/1/top-10-european-polluters-still-dominated-german-l/ (last accessed on: 18 August 2017).
[42] WWF (2016), "Europe's dark cloud: How coal-burning countries make their neighbours sick", 5 July 2016, available at: http://www.wwf.eu/?uNewsID=272916 (last accessed on: 18 August 2017).
[43] European Environment Agency (EEA) (2016), "Decommissioning fossil fuel power plants between now and 2030 essential for Europe's low carbon future", 7 October 2016, available at: http://www.eea.europa.eu/highlights/decommissioning-fossil-fuel-power-plants (last accessed on: 18 August 2018).
[44] European Commission, "2050 Energy strategy", available at: https://ec.europa.eu/energy/en/topics/energy-strategy/2050-energy-strategy (last accessed on: 18 August 2017).
[45] For suggestions on reaching a consensus and a common approach, see Agora Energiewende (2016), "Eleven Principles for a Consensus on Coal", available at https://www.agora-energiewende.de/en/topics/-agothem-/Produkt/produkt/270/Eleven+Principles+for+a+Consensus+on+Coal/ (last accessed on 24 September 2017).
[46] KlimaDiskurs.NRW (2017), "Bolstering joint climate action through dialogue", available at https://www.theclimategroup.org/sites/default/files/devel-generate/wro/etp_klimadiskurscasestudy_aug2017.pdf (last accessed on 24 September 2017).
[47] Euracoal, "Germany", available at https://euracoal.eu/info/country-profiles/germany/ (last accessed on 24 September 2017).
[48] See Hedberg, Annika (2015), "EU's quest for energy security - What role for the Energy Union?" European Policy Centre, 3 March 2015, available at: http://epc.eu/documents/uploads/pub_5374_eu_s_quest_for_energy_security.pdf (last accessed on: 18 August 2017).
[49] More information: Hedberg, Annika (2016), "Nord Stream II - yes or no? - Political decision of a political Commission", European Policy Centre, 14 June 2016, available at: http://www.epc.eu/pub_details.php?cat_id=4&pub_id=6628 (last accessed on: 18 August 2017).
[50] See Article 2(4) of the UN Charter and e.g. International Court of Justice (2004) "Summary of the Advisory Opinion" on Israel-Palestine Wall, 9 July 2004. Paras 154-159.
[51] See e.g. Prognos (2017), "Interim report. Low carbon options and gas infrastructure - Chances of efficiency and renewable energies for gas infrastructure planning and security of supply in Europe.", p.142-143, available at: https://www.prognos.com/uploads/tx_atwpubdb/20170407_Prognos_Report_Low_Carbon_options_2016_19.1.17.pdf (last accessed on 18 August 2017).
[52] International Energy Agency (IEA) (2014), "Germany: Natural gas for 2014", available at: https://www.iea.org/statistics/statisticssearch/report/?country=GERMANY&product=naturalgas&year=2014 (last accessed on 18 August 2017).

[53] Fraunhofer-Institute für Windenergie und Energiesystemtechnik (IWES) (2014), "Erdgassubstitution duch eine forcierte Energiewende", June 2014, available at: https://www.gruene-bundestag.de/fileadmin/media/gruenebundestag_de/themen_az/energie/PDF/Erdgassubstitution_final.pdf (last accessed on: 18 August 2017).

[54] Agora Energiewende (2017), "Heat transition 2030", p.1., available at: https://www.agora-energiewende.de/fileadmin/Projekte/2016/Sektoruebergreifende_EW/Heat-Transition-2030_Summary-WEB.pdf (last accessed on 24 September 2017).

[55] Transport & Environment (2017), "Dirty diesel also worse for the climate than petrol cars - study", 18 September 2017, available at: https://www.transportenvironment.org/press/dirty-diesel-also-worse-climate-petrol-cars-study (last accessed on 25 September 2017).

[56] European Environment Agency (EEA) (2016), "Air quality in Europe - 2016 report".

[57] Research and recommendations on needed measures in the transport sector can be found, for example, at Agora Verkehrswende website, available at: https://en.agora-verkehrswende.de/ (last accessed on 28 September 2017).

[58] TheJournal.ie (2017), "Three German Giants start free retrofit program for millions of diesel cars", 31 July 2017, available at: http://www.thejournal.ie/bmw-audi-mercedes-diesel-engine-recall-3517654-Jul2017/ (last accessed on 28 September 2017).

European Policy Centre
14-16 rue du Trône, 1000 Brussels, Belgium
Tel: +32 (0)2 231 03 40 - Fax: +32 (0)2 231 07 04
email: info@epc.eu - twitter: @epc_eu

www.epc.eu

Europe for Citizens
Programme

With the support of the Europe for Citizens
Programme of the European Union.