

European Energy and Climate Policy



REPORT by Hella Engerer, Franziska Holz, Philipp M. Richter, Christian von Hirschhausen, and Claudia Kemfert

European Natural Gas Supply Secure Despite Political Crises

3

INTERVIEW with Claudia Kemfert

»Europe Needs To Further Diversify Its Gas Imports«

16

REPORT by Claudia Kemfert, Christian von Hirschhausen, and Casimir Lorenz

European Energy and Climate Policy Requires Ambitious Targets for 2030

17

REPORT by Christian von Hirschhausen and Felix Reitz

Nuclear Power: Phase-Out Model Yet To Address Final Disposal Issue

27

REPORT by Pao-Yu Oei, Claudia Kemfert, Felix Reitz, and Christian von Hirschhausen

Coal Power Endangers Climate Targets: Calls for Urgent Action

36

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European Natural Gas Supply Secure Despite Political Crises

by Hella Engerer, Franziska Holz, Philipp M. Richter, Christian von Hirschhausen, and Claudia Kemfert

Natural gas is a significant contributor to European energy supply. Hence, the political crisis between Russia and Ukraine increases fears of the consequences of Russia suspending natural gas supplies to Ukraine and the European Union. The last time this had occurred was in the winter of 2009 when Russia and Ukraine disputed about the price of natural gas and transit costs. However, the European Union has subsequently increased the security of its gas supply. Progress has been made in implementing the measures proposed by the European Commission, particularly the diversification of supply sources and the expansion of natural gas infrastructure to secure supply from various countries. The opportunities to ease temporary supply bottlenecks have improved significantly within the Union in recent years. Nevertheless, Russia remains a major supplier of natural gas to the EU. The Russian gas company Gazprom plays a key role in Eastern Europe and is also gaining importance in Germany. However, this dependency is not a one-way street: Russia generates high export revenues from its natural gas trade and currently has few alternatives to exporting to the EU.

Model calculations by DIW Berlin show that Europe can largely cope with a supply disruption by Russia via Ukraine. Some Eastern European countries, however, would struggle to fully offset a complete suspension of Russian supply. To further increase supply security in Europe in the medium term, it will be necessary to continue diversifying gas supplies, particularly by making more efficient use of existing infrastructure, and expanding pipelines and capacity to import liquefied natural gas. Additionally, Europe should consider setting up strategic gas reserves. Another important step would be to continue to improve energy efficiency in all sectors and consistently expand renewable energy sources as part of the European energy and climate strategy.

As of end July 2014, it is unclear how the open conflict between Russia and Ukraine will develop and to which extent the Russian natural gas supply to Europe will be affected. In light of this, there is a particular focus on identifying alternatives to natural gas supply from Russia and on ways to reduce demand and increase energy efficiency. Nowadays, the Central and Western European countries can be more relaxed about temporary supply disruptions compared to the situation some years ago. Nevertheless, such a disruption would have a significant short-term impact on the Eastern European countries in the EU, such as Estonia, Latvia, Lithuania, and Bulgaria, and, of course, also Ukraine.

The prevailing geopolitical tensions threaten to damage the good, long-standing, and mutually beneficial relations between the EU and Russia. Almost one quarter of the EU's natural gas consumption is imported from Russia; in turn, the Russian economy depends heavily on exports of and other raw materials. Russia currently has no alternative to exporting its natural gas to the EU, due to lack of infrastructure, for example to China.

In connection with the EU-wide debate on adaptation strategies, the recent proposal by the Polish government for a European Energy Union is based, among other things, on the idea of jointly purchasing natural gas, promoting domestic fossil resources, and completing the internal market (see Box 1).¹ The reasoning behind the proposal is that the majority state-owned Gazprom company can exert market power on the design of contracts and charge very different prices for natural gas.² The Polish vision of an Energy Union has been well received by some EU member states but has also been target for criticism from the European Commission and others. This criticism refers largely to the incomplete

¹ The Polish proposal is available online at www.energypost.eu/roadmap-towards-energy-union-europe/.

² This is especially problematic if the supply contracts contain what are known as destination clauses.

Box 1

The European Energy Union: A (Not Entirely New) Idea Causes Controversy

In mid-April 2014, the Polish Prime Minister Donald Tusk presented a proposal for an EU Energy Union¹ which the member states of the European Union become the subject of controversial debate, particularly in terms of security of supply. The initiative aims to deepen cooperation on energy policy between a number of EU countries, especially with regard to jointly purchasing fossil fuels from non-member countries, promoting domestic fossil fuels (mainly coal and natural gas, including shale gas), and accelerating completion of the internal market for natural gas. Other important components of the proposal include solidarity mechanisms between neighboring EU countries and diversifying sources of supply.

Bearing in mind that Russia and natural gas giant Gazprom frequently offer very different contracts to the individual EU countries, sometimes with anti-competitive clauses for gas sales and pricing, it makes sense for the EU to coordinate more closely in order to achieve greater supply security. The proposal for a European Energy Union has therefore received a positive response from some European capitals; among others, German Chancellor Angela Merkel supports the initiative “in principle.”² However, a more detailed analysis reveals that the initiative is primarily an attempt to allocate additional financial resources to countries with a high proportion of fossil energy resources for the development

of these resources—this includes coal in Poland. This clearly contradicts climate targets pursued at the European level. A further criticism is the lack of any reference to other objectives from the European energy and climate change package, including the further deployment of renewable energies and improving energy efficiency.

The current thrust toward an Energy Union is not the first in the recent history of European energy policy: the former President of the EU Commission Jacques Delors proposed a “European Energy Community” in 2010 which also envisaged greater coordination of joint natural gas purchases.³ In addition, this proposal was focused more on creating an internal market for a sustainable, low-carbon energy economy. Other attempts to form an “Energy Community,” for example, a “European Community for Renewable Energy (ERENE),” had similar objectives.⁴

It remains to be seen whether the Polish proposal for a European Energy Union is destined to last longer than its predecessors. Certainly, the current EU Energy Commissioner Günther Oettinger flatly rejected the idea in his final days of office and pointed out that the proposed regulations had already been widely adopted at the EU level.⁵

¹ The Polish proposal is available to download online at www.energypost.eu/roadmap-towards-energy-union-europe/.

² See “Merkel unterstützt Tusks Energieunion,” *Wirtschaftswoche-online*, April 25, 2014, www.wiwo.de/politik/europa/energiepolitik-merkel-unterstuetzt-tusks-energieunion/9808990.html.

³ www.notre-europe.eu/media/europeanenergycommunity-andou-ra-hancher-vanderwoude-ne-march10.pdf?pdf=ok.

⁴ www.ereue.org/web/149.html.

⁵ “Oettinger erteilt Energieunion Absage,” *Frankfurter Allgemeine Zeitung (FAZ)*, May 15, 2014, www.faz.net/aktuell/wirtschaft/wirtschaftspolitik/eu-energiekommissar-oettinger-erteilt-energieunion-absage-12939975.html.

implementation of regulations already in place, such as the third Internal Gas Market Directive³ and the Regulation on the security of gas supply.⁴ Furthermore, the

Polish proposal appears not compatible with the objectives of the European energy and climate change package proposed in January 2014, in particular, with regard to CO₂ reduction targets, the expansion of renewable energy, and energy efficiency improvements.⁵

³ Directive 2009/73/EC of the European Parliament and of the Council of July 13, 2009 concerning common rules for the internal market in natural gas and repealing Directive 2003/55/EC, eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:211:0094:0136:en:PDF.

⁴ Regulation (EU) No. 994/2010 of the European Parliament and of the Council of October 20, 2010 concerning measures to safeguard security of gas supply and repealing Council Directive 2004/67/EC, eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:295:0001:0022:EN:PDF.

⁵ C. Kemfert, C. Lorenz, and C. von Hirschhausen, “Europäische Energie- und Klimapolitik braucht ambitionierte Ziele für 2030,” *Wochenbericht des DIW Berlin*, no. 10 (2014): 175–185.

Box 2

Strategic Investments by Gazprom in the European Natural Gas Industry

To date the Russian gas giant OAO Gazprom has an export monopoly on natural gas. Over the past 25 years, through its various subsidiaries, Gazprom has bought shares in a variety of pipelines and gas storage facilities in the natural gas industry in Eastern and Western Europe. This forward integration follows the economic rationale of getting closer to markets and customers. But the Russian state is also pursuing political strategic objectives through Gazprom. This is particularly evident in its pricing policy which is determined by political factors: for example, after the overthrow of President Yanukovich and the annexation of Crimea by Russia, the price of natural gas for Ukraine was pushed up from a "friendship price" of 280 US dollars per thousand cubic meters to a monopoly price of 485 US dollars per thousand cubic meters.

Gazprom has invested widely in natural gas supply in a number of countries, including Slovakia, Romania, Bulgaria, and Hungary.¹ It controls export pipelines to Central and Western Europe and also has holdings in the national pipelines of almost all Eastern European countries as well as in Austria, Germany, and Italy. Moreover, Gazprom has stakes in the natural gas storage infrastructure: it has already invested heavily in Latvia, Austria, and Serbia and plans to purchase additional storage facilities in the Czech Republic, the Netherlands, and the UK.

Gazprom has been particularly active in Germany since reunification: it owns a comprehensive transport and storage infrastructure, until recently jointly with Wintershall but now as sole owner.

¹ F. Holz et al., "European Gas Infrastructure: The Role of Gazprom in European Gas Supplies," DIW Berlin, Politikberatung Kompakt, no. 81 (2014), study commissioned by the Greens political group in the European Parliament.

In a recent study, DIW Berlin examined the importance of Russian natural gas exports to Europe and the role of the Russian natural gas company Gazprom (see Box 2).⁶ The present report is based on the findings of this anal-

ysis as well as on many years of research conducted by DIW Berlin on the issue of supply security.⁷

Previous Experience: How Can Security of Supply Be Increased?

Countries particularly affected by the temporary interruption of Russian gas supplies to Europe via Ukraine in 2009 were those that were unable to bridge short-term supply shortages due to poor connections with the European gas network and low storage capacity, such as Bulgaria. To tackle such supply disruptions, in October 2010, the European Union adopted the Regulation on the security of gas supply. The aim was to complement the isolated precautionary measures taken up until then by individual member states with a more Community-based strategy.

At the time the Regulation was adopted, the European Commission acknowledged the increasing importance of natural gas for European energy supply and the growing dependence on imports due to a decline in domestic production. As a result, the EU tends to be vulnerable to supply disruptions. This applies all the more because some member countries, such as Estonia, Latvia, and Lithuania, are effectively gas islands due to lack of infrastructure links: they completely rely on natural gas supplies from Russia. Against this background, the Commission proposed a series of supply-side measures, including:

- Diversifying supply routes and sources inside and outside the Union and, thus, investing in capacity for liquefied natural gas (LNG),
- Expanding cross-border connecting pipelines with the added option of reverse flows,
- Increasing storage capacity for natural gas.

In addition, as part of an emergency plan, strategic gas stocks or strategic minimum stocks of mineral oil as an alternative fuel could be used. It should also be possible to order a change to different fuels, the interruption of contracts where possible, and the exclusion of customers from supply. For "protected customers"—mainly private households—natural gas companies must safeguard supply for 30 days even under extreme conditions.

⁶ F. Holz et al., "European Gas Infrastructure: The Role of Gazprom in European Gas Supplies," DIW Berlin, Politikberatung Kompakt, no. 81 (2014), study commissioned by the Greens / European Free Alliance in the European Parliament.

⁷ H. Engerer, M. Horn, and A. Neumann, "Bei erneutem Gasstreit zwischen Ukraine und Russland: Wäre Europa jetzt gewappnet?," Wochenbericht des DIW Berlin, no. 2 (2010); C. von Hirschhausen et al., "Supply Security and Natural Gas," in F. Lévêque et al. (eds.): *Security of Energy Supply in Europe: Natural Gas, Hydrogen, and Nuclear* (Cheltenham: 2009).

In recent years, the European Union has made progress in developing its natural gas infrastructure. Further expansion plans, as specified in the Third Energy Package, are presented each year by the European gas network operators at both national and European level in their Ten-Year Network Development Plans.⁸ Although these plans do not constitute binding timetables for expanding the pipeline and liquefied natural gas infrastructure, they give the industry, regulators, and policy-makers an indication of further investment needs.

The infrastructure developments implemented in recent years were an important step toward making gas flows within the Union more flexible and improving intra-European deliveries in the event of a crisis. Disruptions in supply can still not be ruled out for individual regions of Eastern Europe but the EU is now less vulnerable to crises.

Almost a Quarter of Europe's Natural Gas Consumption Supplied by Russia

According to the International Energy Agency (IEA), in 2012, the European Union imported 112 billion cubic meters of natural gas via pipelines from Russia—this is equivalent to almost a quarter of the EU's total natural gas consumption of approximately 472 billion cubic meters (see Table 1).⁹ Russia therefore is the largest supplier of natural gas to the EU although the amount imported varies from country to country.¹⁰ Germany covers about 38 percent of its consumption with natural gas from Russia which corresponds to 35 percent of all German natural gas imports (see Figure 1). The Eastern European countries of the EU are heavily dependent on imports from Russia, in particular the Baltic States, the Czech Republic, and Bulgaria. The diversity of supply in these countries has not increased markedly even in recent years. In contrast, Romania, which has its own reserves, and Poland, whose energy supply is mainly based on coal, are less dependent on imports from Russia.

In Western Europe, the UK, Belgium, the Netherlands, and the Iberian Peninsula are hardly or not at all reliant on Russian imports. In France, imports of Russian natural gas only account for 16 percent of total natural gas consumption. Italy, on the other hand, obtains one

Table 1

Production, Net Imports, and Consumption of Natural Gas in the EU in 2012

In billion m³

	Production	Net imports	Domestic consumption
Austria	1.9	7.8	9.0
Belgium	0.0	16.7	16.8
Bulgaria	0.4	2.5	2.7
Denmark	6.4	-2.7	3.9
Czech Republic	0.2	7.5	8.3
Estonia	0.0	0.7	0.7
Finland	0.0	3.7	3.7
France	0.5	42.7	44.1
Germany	12.3	69.6	82.1
Greece	0.0	4.5	4.5
Hungary	2.2	7.3	10.2
Ireland	0.4	4.4	4.7
Italy	8.6	67.6	74.9
Latvia	0.0	1.7	1.5
Lithuania	0.0	3.3	3.4
Luxembourg	0.0	1.2	1.2
Netherlands	80.1	-34.3	46.0
Poland	6.2	12.2	18.1
Portugal	0.0	4.6	4.6
Romania	10.6	2.9	13.6
Sweden	0.0	1.1	1.1
Slovakia	0.2	4.8	5.3
Slovenia	0.0	0.9	0.9
Spain	0.1	32.3	32.5
UK	41.1	37.1	78.3

Sources: IEA, *Natural Gas Information 2013*, OECD/IEA, Paris; IEA, *Natural Gas Information Statistics, Online Database*, OECD/IEA, Paris.

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Most EU member countries are net importers of natural gas.

quarter of its total consumption from Russia, a significantly higher share.

Norway is the second largest supplier to the EU and its natural gas supplies account for one fifth of Europe's consumption, playing a particularly important role in the UK, Belgium, the Netherlands, France, and Germany. The supply through gas pipelines from the North African countries of Algeria and Libya also play a key role, especially in Southern Europe.

Most Russian natural gas exports reach EU countries via three major pipelines: the pipeline through Ukraine, the Yamal pipeline via Belarus, and the Nord Stream pipeline through the Baltic Sea (see Table 2). There are other smaller pipelines, particularly in countries neighboring Russia, such as Finland and the Baltics (Latvia). The importance of Ukraine as a transit country for natural gas supplies from Russia to the European Union has declined in recent years due to the Nord Stream pipeline which provides a direct link between Russia and Ger-

⁸ See for example FNB Gas, *Netzentwicklungsplan Gas 2013 der deutschen Fernleitungsnetzbetreiber* (2013); and ENTSO-G, *Ten-Year Network Development Plan (TYNDP) 2013-2022* (Brussels: 2013).

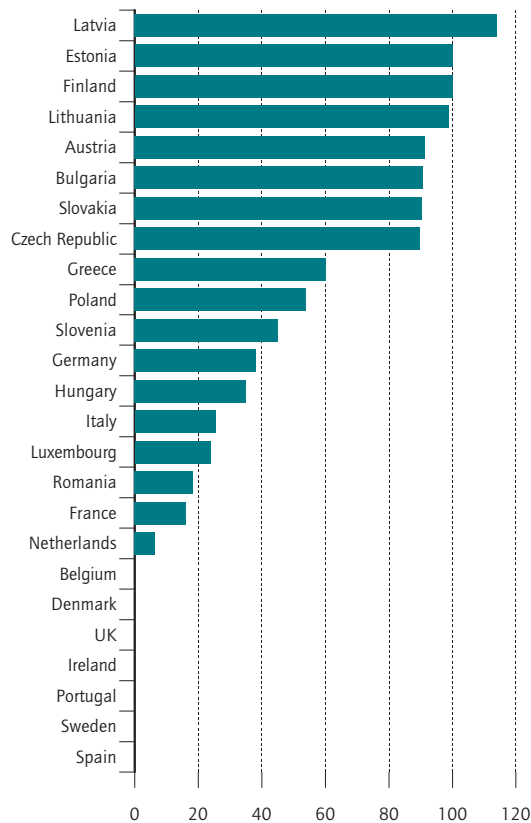
⁹ International Energy Agency, *Natural Gas Information 2013* (2013).

¹⁰ Malta and Cyprus are not considered in the following, Croatia is only included from 2013, following its accession to the EU.

Figure 1

Share of Imports from Russia in Natural Gas Consumption in 2012

In percentage



Source: IEA, Natural Gas Information 2013, OECD/IEA, Paris.

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Russian gas imports most important in Eastern Europe.

many and which has a capacity of 55 billion cubic meters (see map).

If the conflict between Russia and Ukraine were to lead to a temporary disruption in supply, some deliveries could be redirected to the Nord Stream pipeline and the Yamal pipeline via Belarus and Poland (with a capacity of 33 billion cubic meters). Consequently, Germany, as a buyer of gas from all three major Russian pipelines, could reroute some of its Russian imports.

Opportunities for Importing LNG Expanded Significantly

Besides importing natural gas by pipeline, European countries also import LNG by ship from non-European

Table 2

Export Pipelines from Russia to Europe

Name	From	To	Capacity in billion m ³
Ukrainian corridor	Russia	Ukraine	112
	Belarus	Ukraine	25
	Ukraine	Romania, and on to Bulgaria	36.5
		Greece	
		Turkey	
		Hungary, and on to Serbia	
	Ukraine	Bosnia-Herzegovina	19.5
		Slovakia	
		Czech Republic	
		Austria	
Yamal-Europe	Russia	Belarus	33
	Belarus	Poland	40
	Poland	Germany	33
	Poland	Germany	33
Nord Stream	Russia	Germany	55
		Germany	

Sources: Gazprom website; ENTSO-G, The European Natural Gas Network (Capacities at Cross-Border Points on the Primary Market), Brüssel, Juli 2013; Datenbank des Global Gas Model.

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There are alternatives to the transit via Ukraine.

countries, in particular Qatar, Nigeria, and Algeria (see Figure 2). In 2012, 58 billion cubic meters of LNG were imported, which is equivalent to 12 percent of Europe's natural gas consumption. In particular, the UK, Spain, France, and Italy have increased their capacity to import LNG in recent years. By 2013, the EU's total capacity to import LNG had already reached 184 billion cubic meters or almost 40 percent of all gas consumed in the EU (see Figure 3).¹¹ Further facilities, including in the Baltic States and Poland, with a capacity of over 30 billion cubic meters are currently under construction and should be completed by the end of 2015. This will lead to a substantial increase in European capacity to import LNG.

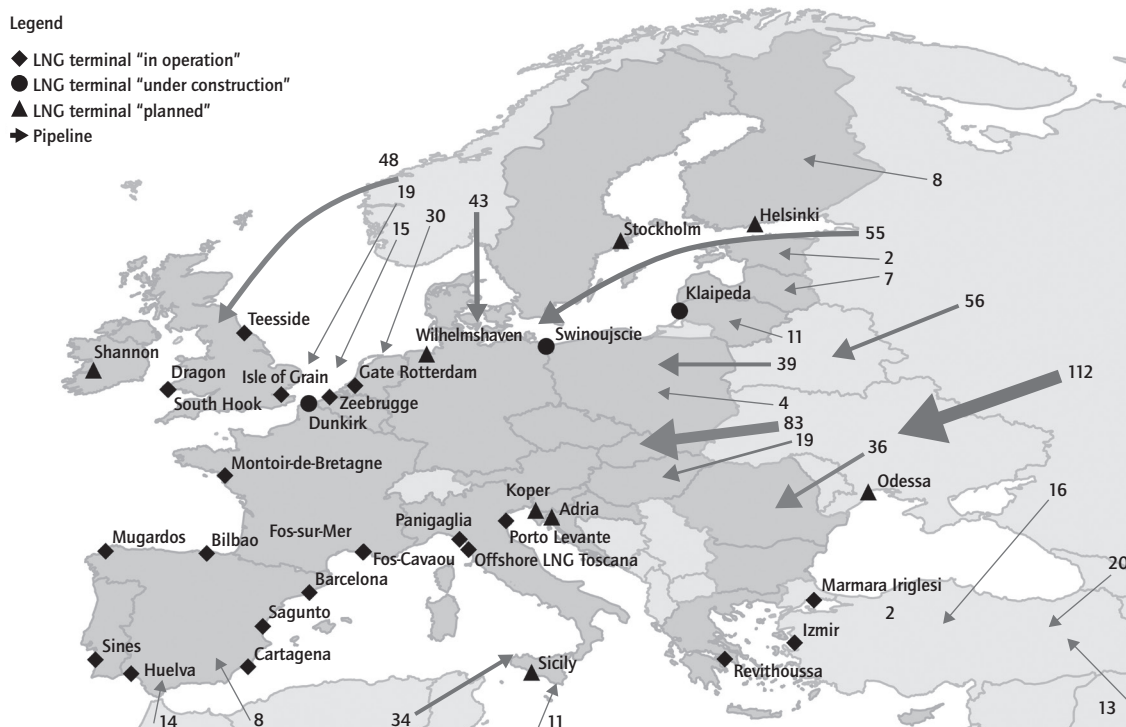
Natural Gas Storage Extensive but Regionalized

By the end of 2012, the European Union had a storage capacity for natural gas of 92 billion cubic meters; this is approximately 12 billion cubic meters more than in 2009. Two-thirds of the storage facilities are exhausted

¹¹ Gas Infrastructure Europe, GLE LNG Investment Database (2013), www.gie.eu/index.php/maps-data/lng-investment-database.

Map

Most Important Pipeline Import Routes to, and LNG Terminals in, Europe

In billion m³

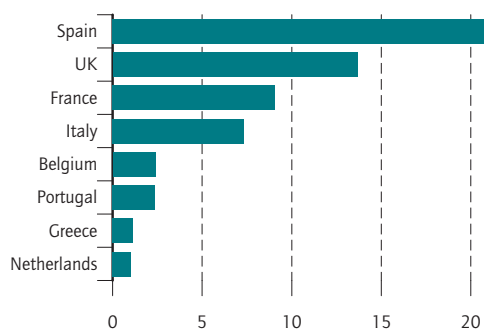
Source: map template by Eurostat; graphic by DIW Berlin, based on GIGNL (2013); ENTSO-G (2013).

© DIW Berlin

Europe has a variety of options for purchasing its natural gas.

Figure 2

EU LNG Imports in 2012

In billion m³

Sources: IEA, *Natural Gas Information* 2013, OECD/IEA, Paris.

© DIW Berlin

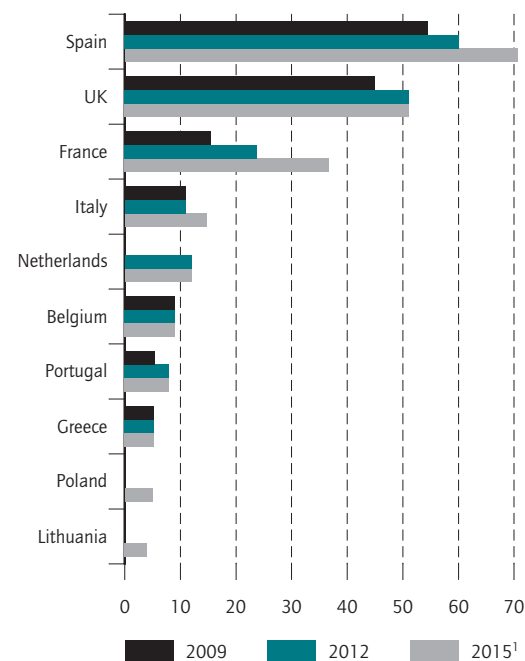
Spain, UK, France, and Italy all record high LNG imports.

oil and natural gas deposits, almost a fifth are aquifers. More than half of European storage capacity is located in Germany, France, and Italy (see Figure 4 and Table 3).

There are also countries with no storage capacity, including Estonia, Lithuania, and Finland, which lack the necessary geological conditions for underground storage; Greece only has small storage capacity at its LNG terminal. Most Eastern European countries failed to expand their storage capacity for natural gas in response to the conflict over natural gas supplies between Russia and Ukraine and the accompanying supply disruptions in winter 2009.¹² Thus, in Eastern Europe, natural gas storage continues to make only a marginal contribution to the region securing its own supply in the short term. The Baltic States are a special case since they

12 For natural gas storage facilities and geological conditions in individual countries see Energy Charter Secretariat, *The Role of Underground Gas Storage for Security of Supply and Gas Markets* (Brussels: 2010). Bulgaria has poor geological conditions for expanding its storage capacity.

Figure 3

EU Import Capacity for LNGIn billion m³

1 Forecast.

Sources: GIE 2013; GIE LNG Investment Database.

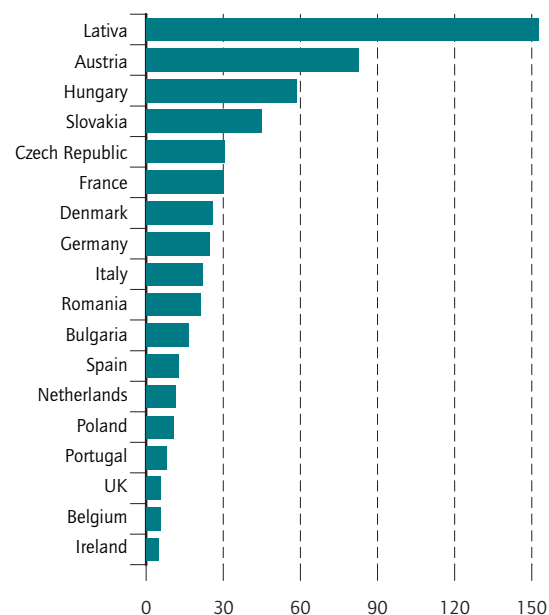
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Capacity for LNG imports continues to rise.

Figure 4

EU Natural Gas Storage Capacity as Share of Natural Gas Consumption in 2012

In percent



Source: IEA, Natural Gas Information 2013, OECD/IEA, Paris.

© DIW Berlin

The importance of storage facilities varies among the member states.

Table 3

Storage Capacity at the End of 2012In billion m³

	Total	Depleted oil and gas fields	LNG storage	Aquifers	Caverns	Other
Austria	7.5	6.5				1.0
Belgium	0.9		0.2			0.7
Bulgaria	0.5	0.5				
Czech Republic	2.5	2.4		0.2	0.1	
Denmark	1.0			0.6	0.4	
France	12.8	0.1	1.0	11.7		
Germany	20.3	9.6		0.9	9.9	
Hungary	6.1	6.1				
Ireland	0.2	0.2				
Italy	16.3	16.3				
Latvia	2.3			2.3		
Netherlands	5.3	5.0	0.8		0.2	
Poland	1.9	1.5			0.4	
Portugal	0.4				0.4	
Romania	2.9	2.9				
Slovakia	2.9	2.9				
Spain	4.1	3.1		1.1		
UK	4.3	3.7	0.1		0.6	
Total	92.3	60.8	2.1	16.7	11.9	1.7

Source: IEA, Natural Gas Information 2013, OECD/IEA, Paris.

© DIW Berlin

Storage capacity for natural gas is regionally concentrated.

are a gas island and, as such, completely dependent on Russian natural gas imports. Latvian storage capacity is also used to supply the other Baltic countries.¹³ Germany's share of storage capacity in natural gas consumption is 25 percent, placing it in the mid-range of the EU Member States.

At the beginning of March 2014, storage facilities in the European Union were about half full which was higher than in previous years due to the mild winter. This level corresponds to about one-sixth of annual EU import demand or approximately 40 percent of imports from Russia. After the mild winter, it was possible to bridge supply disruptions of Russian imports for several months during the warm season.¹⁴

Unlike oil, for which, according to guidelines set by the International Energy Agency, member countries must keep minimum reserves of 90 days' consumption, there are no EU-wide mandatory storage levels for natural gas although some member countries already have strategic reserves in place.¹⁵ It would be worth considering setting up an EU-wide strategic gas reserve. The EU Regulation on security of natural gas supply allows for the possibility of cross-border access to storage capacity and also advocates the expansion of connecting pipelines between the member states. A more efficient use of the existing infrastructure is also essential.

Reverse Flows in Pipelines: Further Expansion Prudent and Feasible

In recent years, additional cross-border pipelines have been built in the EU. At the same time, this has created increased opportunities for reverse flows. Measures adopted by the EU in 2010 stipulated that member states are to create capacity for reverse flows in all cross-border connecting pipelines by the end of 2013 (see Table 4).¹⁶ To a large extent, this measure has now been implemented enabling the Community to respond more flexibly to supply bottlenecks.¹⁷ There is still a need for

¹³ The natural gas supply to the Russian enclave of Kaliningrad is also transported via Lithuania. Consequently, a disruption of Russian supplies to Lithuania is unlikely.

¹⁴ Gas Infrastructure Europe, GSE Aggregated Inventory (AGSI+) (2014), transparency.gie.eu.

¹⁵ This is the case in Hungary, Romania, Italy, Portugal, and Spain. See United Nations for Europe Commission For Europe, Study on Underground Gas Storage in Europe and Central Asia (Geneva: 2013), 46 ff.

¹⁶ Reverse flows involve transporting natural gas against the original direction of the flow. This is made possible by technical additions or upgrading.

¹⁷ However, it is uncertain whether reverse flows can be achieved via Slovakia to Ukraine. In addition to low capacity in smaller pipelines, reverse flows could also be established in the main pipeline with up to 30.1 billion cubic meters per annum. However, there are various political problems, see www.nytimes.com.

Table 4

Direction of Flows in Pipelines between EU Member States in Central and Eastern Europe

From	To	Reverse flows possible?
Austria	Slovenia	yes
Austria	Slovakia	yes
Austria	Hungary	yes
Poland	Germany	yes
Czech Republic	Germany	yes
Slovakia	Czech Republic	yes
Hungary	Croatia	yes
Latvia	Estonia	yes
Latvia	Lithuania	yes
Bulgaria	Greece	no
Romania	Bulgaria	no
Hungary	Romania	no
Slovenia	Croatia	no
Czech Republic	Poland	no
Poland	Slovakia	No pipeline
Lithuania	Poland	No pipeline

Sources: ENTSO-G, *The European Natural Gas Network (Capacities at Cross-Border Points on the Primary Market)*, Brussels, July 2013; updates by DIW Berlin.

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Reverse flows can and should be developed further.

expansion especially between certain member states in Eastern and South-Eastern Europe; Bulgaria in particular is still poorly integrated into the European network, i.a. due to delays in constructing a connection between Romania and Bulgaria.

Natural Gas Has Long-Term Key Role in Europe's Energy Mix

The European Commission believes that natural gas will continue to play an important role in Europe's energy mix in the long term. The so-called Reference Scenario until 2050, presented in 2013, assumes a constant proportion of natural gas primary energy consumption of 24 percent.¹⁸ The importance of natural gas in the power sector would decrease in line with a general reduction of energy consumption. In the transport sector too, natural gas consumption is not likely to increase. According to the reference scenario, however, it would retain its importance in the industrial and household sectors.

com/2014/05/05/world/europe/gazprom-seen-stanching-flow-of-gas-to-ukraine.html?_r=0.

¹⁸ European Commission, EU Energy, Transport and GHG Emissions Trends to 2050 – Reference Scenario 2013 (Brussels: Directorates-General for Climate, Energy and Transport, 2013).

In 2011, the European Commission had introduced even more ambitious climate and energy scenarios in its Climate and Energy Roadmaps, with a reduction in CO₂ emissions of 40 or even 80 percent by 2050, compared to 35 percent in the Reference Scenario 2013.¹⁹ A 40-percent reduction in CO₂ emissions would only slightly reduce natural gas consumption. In a scenario with greater decarbonization and an 80-percent reduction of greenhouse gases, the use of all fossil energy sources—including natural gas—in the electricity sector would fall to practically zero. Natural gas would only be used by end consumers, i.e., by industry and households. In this case, consumption could be halved between 2010 and 2050.

Natural gas consumption in the individual EU countries develops very differently due to the availability of domestic fossil resources and the potential of renewables. All scenarios for the UK, the Netherlands and France, for example, include a drop in natural gas consumption, while for countries such as Spain—currently with a rather low share of natural gas—it is assumed there will be an increase in consumption.

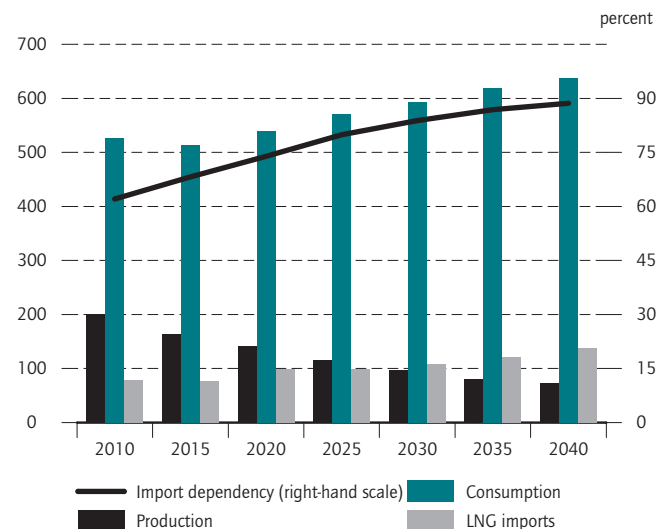
European Gas Supply by 2040: More Dependent on Imports, but Fewer from Russia

DIW Berlin's *Global Gas Model* calculates various scenarios for the long-term development of European natural gas consumption and natural gas imports.²⁰ DIW Berlin's reference scenario takes into account the requirements of the Commission's Energy Roadmap 2050 with its 40-percent reduction in greenhouse gas emissions in Europe, and the 2012 New Policies Scenario developed by the International Energy Agency.

Natural gas production in EU countries has been declining for more than a decade; production from conventional fields is falling and only a small number of new fields are being tapped. 15 years ago, the UK was still one of the largest gas-producing countries in Europe with an annual production of more than 100 billion cubic meters; since 2004, it has been a net importer, now producing less than 50 billion cubic meters an-

Figure 5

EU Natural Gas Sector in Global Gas Model Reference Scenario In billion m³



Source: calculations by DIW Berlin.

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The import dependency of natural gas will continue to increase with falling domestic production.

nually. Germany's already low production levels have also fallen significantly in recent years and even production in the Netherlands, the largest natural gas producer in the EU, is expected to decline significantly in the coming years.²¹

This long-term trend is likely to continue (see Figure 5). Only the Netherlands and Romania within the EU and Norway outside the EU are expected to produce natural gas after 2040. Even the exploitation of shale gas deposits, such as in Poland, could, at best, delay this development. Due to uncertain resource estimates, the high production costs of extracting shale gas, and the strict environmental regulations, significant unconventional production in Europe is rather unlikely at the moment.²²

Stagnating and even declining natural gas consumption in the European Union after 2030 will mean that it will have to rely on importing more than 80 percent of its natural gas consumption. Many EU countries will further diversify their natural gas imports by importing LNG and through new pipelines connections. This

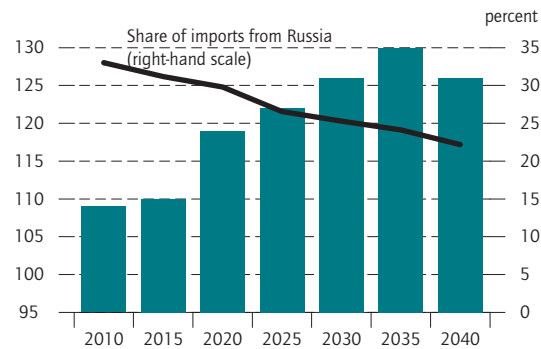
¹⁹ European Commission, Energy Roadmap 2050, COM(2011)0885 final, (Brussels: 2011); and Roadmap for Moving to a Low-Carbon Economy in 2050, COM/2011/0112 final (2011).

²⁰ See also F. Holz, P. M. Richter, and C. von Hirschhausen, "Structural Shift in Global Natural Gas Markets—Demand Boom in Asia, Supply Shock in the US," DIW Economic Bulletin, no. 11.12 (2013); F. Holz et al., "The Role of Natural Gas in a Low-Carbon Europe: Infrastructure and Regional Supply Security in the Global Gas Model," DIW Discussion Paper, no. 1273 (Berlin: 2013); and P. M. Richter, "From Boom to Bust? A Critical Look at US Shale Gas Projections," DIW Discussion Paper, no. 1338 (Berlin: 2013).

²¹ IEA, Energy Policies of IEA Countries - The Netherlands (2014).

²² F. Holz et al., "The Role of Natural Gas in a Low-Carbon Europe: Infrastructure and Regional Supply Security in the Global Gas Model," DIW Discussion Paper, no. 1273 (Berlin: 2013).

Figure 6

European Natural Gas Imports from RussiaIn billion m³

Source: calculations by DIW Berlin.

© DIW Berlin

The percentage of imports from Russia will fall.

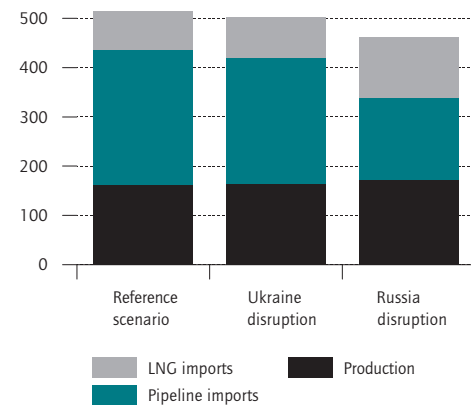
applies particularly to those countries in Eastern Europe that are currently heavily dependent on Russian imports. Accordingly, Russia's share of European natural gas imports should decline in the coming decades (see Figure 6).

A further expansion of reverse flow capabilities in Eastern European countries will improve their integration into the European network and provide access to natural gas from Western and Northern Europe (Norway). Previous import countries in Western Europe will then become transit countries for gas supplies, in particular toward Eastern Europe. Consequently, Germany could pass on a portion of its direct imports from Norway and Russia (Nord Stream pipeline) toward Eastern Europe to Poland, the Czech Republic, and Austria.

Construction of Non-European Pipelines Progressing

Moreover, the Eastern European EU countries will open up sources of supply outside the EU itself, both of LNG and of natural gas via pipelines. For example, the construction of a LNG terminal in Świnoujście (Poland) is almost complete; in Lithuania a floating LNG terminal will be commissioned in fall 2014 (in Klaipėda). In South-Eastern Europe, the southern gas corridor has replaced original plans to construct the Nabucco pipeline. Even before 2020, natural gas from the Caspian Sea (Azerbaijan) will be delivered via Turkey to Greece, and potentially the Balkan Peninsula as well. The findings from DIW Berlin's model suggest that this corridor should be further expanded in the coming years to

Figure 7

Structure of European Gas Supply in 2015 by ScenarioIn billion m³

Source: calculations by DIW Berlin.

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To a great extent, any disruptions to Russian imports can be overcome...

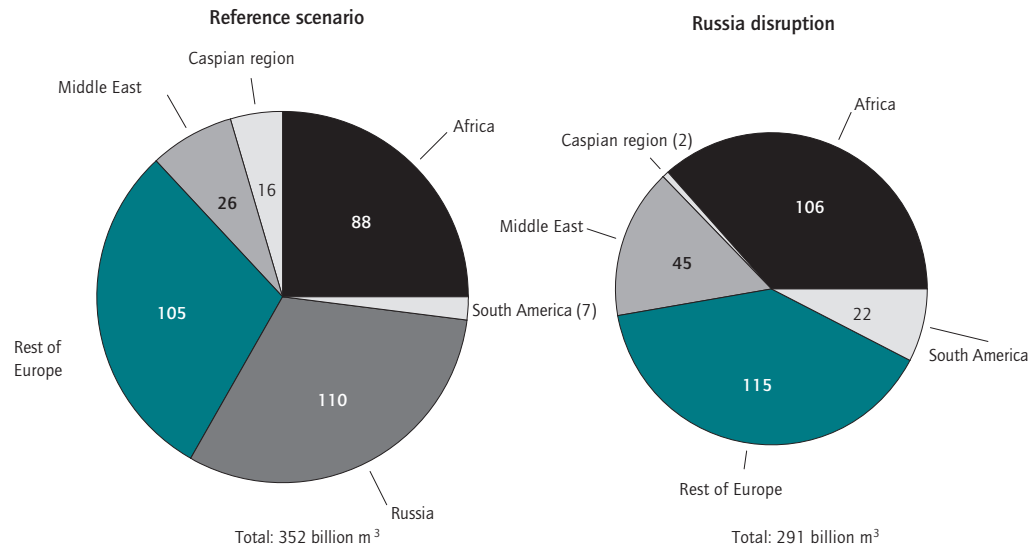
satisfy stable to increasing demand from South-Eastern Europe.

Overall, the model calculations for Europe show stable, slightly increased natural gas consumption in the coming decades, which will mainly be covered by imports through pipelines. Even if there is a rising dependence on imports, natural gas supply will be secured through a greater diversification of sources and supply routes.

In the long term, the importance of Europe's demand for natural gas in the global natural gas market will fall and the importance of emerging Asian economies, such as India and China, will rise. LNG exports to Asian countries will increase in the coming decades. In addition, new pipelines will improve connections between the Asian market and traditional suppliers, such as between China and Russia. However, more than half of Russia's natural gas exports will still go to Europe until 2050, depending on the scenario. As a result, Europe will remain an important market for Russia.

Europe's LNG imports will initially rise and then remain constant from 2020 onwards. Nevertheless, the LNG import terminals will play an important role with regard to security of supply: they enable short-term imports of natural gas if there are delivery problems through pipelines.

Figure 8

Composition of European Imports by Supplier in 2015In billion m³

Source: calculations by DIW Berlin.

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...by supplies from North Africa and Norway.

Opportunities for Short-Term Diversification

Using its *Global Gas Model*, DIW Berlin has examined two potential scenarios for 2015 in which imports of natural gas from Russia are disrupted.²³ Both scenarios are deemed possible given the current crisis. The model calculations are therefore based on projected values for the coming year and on infrastructure projects currently under construction. This includes, for example, the South Stream connection between Russia and Bulgaria with a small initial capacity of 15 billion cubic meters.

The scenario calculations provide an insight into the importance of imports from Russia for gas supply to individual European countries, as well as current diversification options, given the existing supply infrastructure:

- In the *Ukraine Disruption scenario*, Russia interrupts supplies to and through Ukraine;
- In the *Russia Disruption scenario*, Russia interrupts its entire natural gas exports to Europe (including Tur-

key, but excluding Belarus which is in a customs union with Russia).

Particularly in the *Russia Disruption scenario*, the European Union's entire natural gas consumption will decrease significantly, primarily in Eastern European member states which do not yet have sufficient alternative sources of supply and the infrastructure in place. In the *Ukraine Disruption scenario*, as expected, the easternmost member states (mainly Hungary, Romania, and Croatia) and Ukraine will be most affected by a lack of access to LNG and reverse flow capabilities. A substantial portion of Russian supply disruptions would be compensated by imports of LNG which would increase by 60 percent in the Russia Disruption scenario (see Figure 7). The additional supplies of LNG could come from South America (mainly Trinidad and Tobago), and from the Middle East or from Africa (Nigeria and Algeria). Natural gas production in Europe could only be increased to a limited degree in the short term (see Figure 8).

Due to limited production and transportation capabilities additional natural gas would be supplied from Norway and North Africa by pipeline. Natural gas producers in the Caspian region (currently including Turkmenistan among others) can only supply natural gas to Europe through the Russian pipeline network—via

²³ F. Holz et al., "European Gas Infrastructure: The Role of Gazprom in European Gas Supplies," DIW Berlin, Politikberatung Kompakt, no. 81 (2014), study commissioned by the Greens political group in the European Parliament; P. M. Richter and F. Holz, "All Quiet on the Eastern Front? Disruption Scenarios of Russian Natural Gas Supply to Europe," DIW Discussion Paper, no. 1383 (Berlin: 2014).

Ukraine—due to existing infrastructure limitations and cannot therefore be considered alternatives to Russia.

Supply Disruptions Have Strongest Impact on Eastern Europe

The Eastern European EU member states of Romania, Hungary, and Croatia, in particular, would be affected by both scenarios in which Russian imports are disrupted as, even with significantly increasing prices, they do not have sufficient access to alternative sources of supply for natural gas due to technical constraints (see Figure 9). These countries would be the only European importers to suffer a decline in consumption of approximately 25 percent if supply via the Ukraine transit pipeline were to be disrupted. For them, the establishment and expansion of reverse flow capabilities and connectivity to other suppliers is of the utmost urgency.

In the *Russia Disruption scenario*, consumption in several countries would decline partly due to strongly increasing prices. As expected, Russia's direct neighbors in the Baltic States and Finland would be subject to the most significant constraints; natural gas consumption would fall markedly in these countries (by approximately 70 percent). Hungary, Croatia, Bulgaria, and Romania would follow with a decline of about 30 percent. But natural gas consumption in Central and Western Europe (Poland, Germany, Austria, the Czech Republic, Slovakia, and Italy) would also fall slightly by approximately 10 percent due to rising prices. Despite currently relying on a large proportion of Russian imports for its supply, this region is able to fall back on alternative sources. Even the traditional transit countries, the Czech Republic, Slovakia, and Poland, now have access to alternative suppliers—partly due to reverse flows.

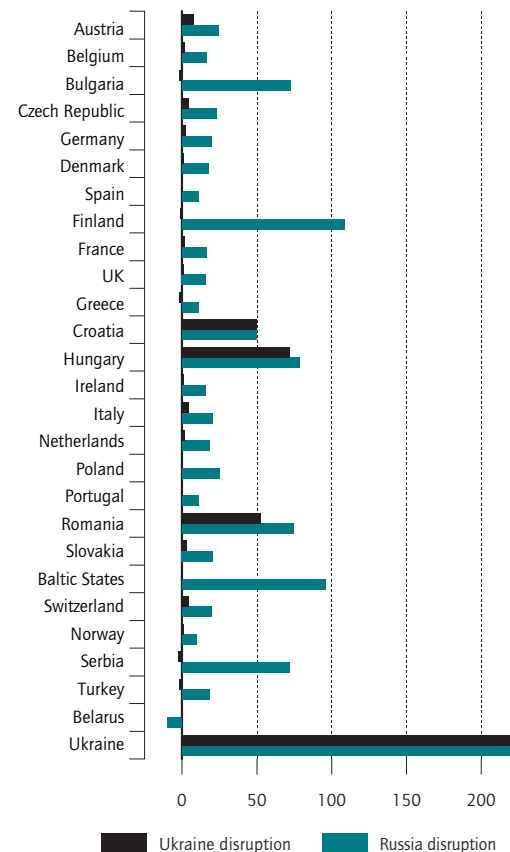
The extensive import capacity for LNG in Western Europe can only partly compensate for disruptions to supplies from Russia. A large number of regasification plants have been constructed in recent years, particularly in Spain and the UK. However, only limited volumes of natural gas leaving those countries can be transported to Central and Eastern Europe. The capacity of the connection between the Iberian Peninsula and France in particular is still low. Only limited exports are possible also from France eastwards—further evidence of the need to set up more reverse flows for the traditional delivery directions (see Figure 10).²⁴

²⁴ See also the decision of the Council of Ministers from March 2014 which states that, "Such interconnections should also include the Iberian peninsula and the Mediterranean area," http://www.consilium.europa.eu/uedocs/cms_Data/docs/pressdata/en/ec/141749.pdf, 10.

Figure 9

Price Impact of Disruption Scenarios on European Countries

In percentage



Source: calculations by DIW Berlin.

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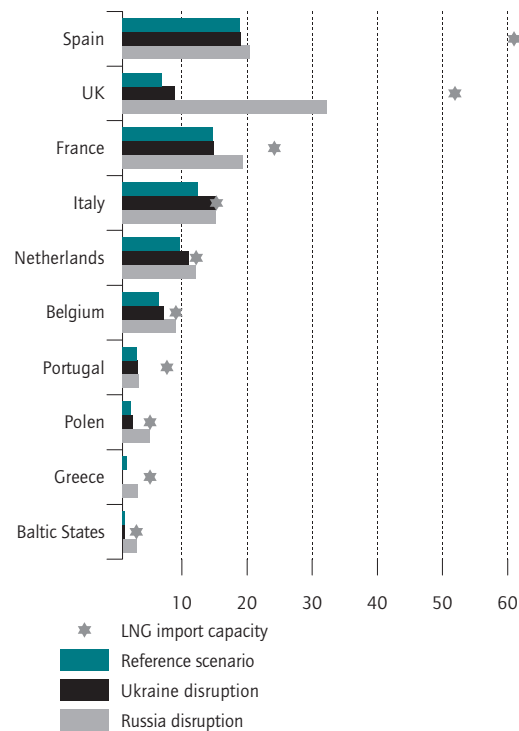
Eastern European countries must expect high price increases.

Conclusions

Natural gas is of particular importance to energy supply. Europe covers a large share of its natural gas consumption needs from Russian imports. As a result of political crises, in particular between Russia and Ukraine, the question is to what extent can natural gas supplies to Europe continue to be secured.

In recent years, European countries have made progress in their efforts to diversify sources and supply routes for natural gas and in expanding the internal natural gas infrastructure. However, more needs to be done in some Eastern European countries to secure supply. This could be achieved in the medium term by increasing the

Figure 10

EU LNG Imports in 2015: Scenario ComparisonIn billion m³

Source: calculations by DIW Berlin.

© DIW Berlin

LNG could partially compensate for a cutoff in supply.

interconnectedness of the European natural gas infrastructure, by expanding cross-border pipeline connections and reverse flows, and by significantly stepping up construction of the southern gas corridor.

In the short term, the European Union can overcome disruptions to the supply of natural gas; storage capacity has been increased and more opportunities for reverse flows have been created. The EU should continue its efforts to diversify sources and supply routes in the medium to long term. At the same time, it should be noted that natural gas consumption in Europe will stagnate in the long term.

The controversial proposal for a European Energy Union is currently being discussed in the context of supply security. Particularly against the backdrop of Russia and its natural gas giant Gazprom often charging very different prices for natural gas and offering contracts that hinder competition, it would certainly not harm Europe to improve its coordination in respect to supply security.

The Polish proposal for an Energy Union also suggests making greater use of domestic energy sources, especially coal technologies. However, this is not compatible with the Union's medium-term climate objectives.

Europe must focus far more on securing supply by continuing to diversify its energy sources. LNG will play a greater role in the medium term. It is, therefore, important that Europe persists with its expansion of pipeline infrastructure. In addition, a strategic natural gas reserve should be considered in all EU countries.

European natural gas supply is secure in the short term despite the current political crisis between Russia and Ukraine—but for this to remain the case in the long term, energy efficiency should continue to be improved in all sectors and renewable energy sources consistently expanded in the course of the energy transition.

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JEL: Q34, L95, C6

Keywords: Natural gas, supply security, Europe, modeling



Prof. Dr. Claudia Kemfert
Head of the Department of Energy, Transportation, Environment at DIW Berlin

SEVEN QUESTIONS TO CLAUDIA KEMFERT

»Europe Needs To Further Diversify Its Gas Imports«

1. Professor Kemfert, fears that the Ukrainian crisis could lead to a disruption in the supply of Russian natural gas to Europe are rising. How great do you consider this risk to be? Obviously, it's quite difficult to judge whether this could really happen. At the moment the possibility of supplies being curbed cannot be ruled out, as Putin's recent letter to European heads of state clearly demonstrates. We've already experienced the gas taps being turned off during the gas crises of 2006 and 2009. However, we are better prepared now than we were then, albeit in a variety of ways.
2. How can such temporary supply bottlenecks be eliminated? Europe has been preparing for such eventualities since 2009, primarily through increased diversification, i.e., by purchasing natural gas from alternative suppliers. Some European countries are building more liquefied natural gas terminals with a view to reducing their dependence on Russian gas. Additional pipelines have also been built in other gas-producing countries. This enables us to better overcome potential supply bottlenecks. We are, however, not quite where we'd like to be. A longer-term disruption to supply would still have a negative impact on a number of Eastern European countries, particularly because pipeline capacity is still underdeveloped and strategic gas reserves are not geared to deal with such developments.
3. What else needs to be done to secure gas supply? First, the pipeline system needs to be made more efficient. In particular, more opportunities need to be created for reverse flows of gas, from west to east, for example. In addition, storage capacity must be used more effectively and efficiently and, in the medium term, more must be done to save energy.
4. How dependent are we on Russian gas? The EU currently imports almost a quarter of its demand for natural gas from Russia, although individual European countries import widely differing quantities. In Germany, for example, this figure is around 38 percent but some Eastern European countries and also Finland actually import almost 100 percent of their gas requirements from Russia.
5. Russia has brokered a contract with China to supply significant amounts of gas. What does this mean for Europe? Just as Europe is diversifying, Russia too, is looking for more customers and partners. This is an entirely legitimate strategy that it has been pursuing for some time. The more important question is whether and which Asian pipelines will actually be built and what price China is willing to pay in the long term. This will not significantly affect the situation in Europe as Russia has sufficient gas available to supply various countries. Furthermore, Europe is also focusing on diversification and finding alternatives.
6. What role will natural gas play in the EU's long-term energy mix strategy? Gas will play a significant long-term role in the EU's energy mix, particularly because it acts as a bridging technology for the expansion of renewable energy sources. Natural gas power plants provide a flexible source of power which can be used in combination with renewable energy. In addition, natural gas continues to be important for the heating and industrial sectors and will play an increasingly significant role in future mobility.
7. How is natural gas consumption likely to develop in the EU? We can assume that gas consumption will stagnate. Although we will see a rise in consumption in some sectors, nonetheless, more and more energy will be saved due to improvements in energy efficiency. The field of building energy, in particular, will see an increase in energy savings in the future.

Interview by Erich Wittenberg.

European Energy and Climate Policy Requires Ambitious Targets for 2030

by Claudia Kemfert, Christian von Hirschhausen, and Casimir Lorenz

In January 2014, the European Commission proposed a framework for its climate and energy policy up to 2030 which includes targets for reducing greenhouse gases and increasing the use of renewable energy sources, but no specific goals for improving energy efficiency. By 2030, greenhouse gas emissions should be 40 percent lower than in 1990. Another element of the proposal is the introduction of a market stability reserve for the EU Emissions Trading System, the impact of which would be too little, too late, however. With regard to renewable energy use, the Commission has proposed a target of a 27-percent share of gross final energy consumption throughout Europe. This appears unambitious bearing in mind developments to date. In addition, there is no mandatory division of these targets among the individual member states. The Commission's calculations are based on implausible technological and economic assumptions in the power sector. Nuclear power costs are underestimated, and it is assumed there will be a breakthrough in carbon capture technologies that seems unlikely from today's perspective. In contrast, cost assumptions in the renewable energy field remain too high and outdated.

In light of previous experience, specific goals for 2030 are required on three levels: greenhouse gas emissions reductions, renewable energy, and energy efficiency. According to the Commission's Impact Assessment, energy system costs would hardly increase even with more ambitious objectives. In addition, creating an appropriate framework would result in positive developments in investment, exports, and employment. The German government should continue its commitment to an ambitious European policy to reduce greenhouse gas emissions, to increase the use of renewable energy, and to enhance energy efficiency.

European energy and climate policy is currently regulated by a legislative package adopted in 2009. The 2020 climate and energy package consists of three key targets to be achieved by 2020: a reduction of at least 20 percent in greenhouse gas (GHG) emissions from 1990 levels, a 20-percent cut in primary energy consumption compared to a reference development, and an increase in the renewable energy share to 20 percent of gross final energy consumption.¹

In January 2014, the European Commission proposed a framework for its climate and energy policy in the period from 2020 to 2030. A key component was the Commission's Communication to the European Parliament: A policy framework for climate and energy in the period from 2020 to 2030 (White Paper).² This document is based, inter alia, on a Green Paper adopted in March 2013 and subject to public consultation³ and also a comprehensive Impact Assessment⁴ which outlined the findings of energy and macroeconomic modeling. As part of the Communication, additional documents were submitted including a proposal for introducing a market stability reserve (MSR) to reform the EU Emissions Trading System (EU ETS) (see box).⁵

¹ J. Diekmann, "Erneuerbare Energien in Europa: Ambitionierte Ziele jetzt konsequent verfolgen," Wochenbericht des DIW Berlin, no. 45 (2009): 784-792.

² European Commission, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: A policy framework for climate and energy in the period from 2020 to 2030, COM(2014)15 final (Brussels: January 22, 2014).

³ European Commission, Green Paper: A 2030 framework for climate and energy policies, COM(2013) 169 final (Brussels: March 27, 2013).

⁴ European Commission, Commission Staff Working Document: Impact Assessment, SWD(2014) 15 final (Brussels: January 22, 2014).

⁵ European Commission, "2030 climate and energy goals for a competitive, secure and low-carbon EU economy," press release IP/14/54, Brussels, January 22, 2014.

Box

European Commission Climate and Energy Policy Proposals until 2030

European climate and energy policy is regulated by the 2020 climate and energy package until 2020. The package includes specific targets for a reduction in GHG emissions, improvements in energy efficiency, and the use of renewable energy sources ("20-20-20" targets). Long-term development is marked out in the Roadmap for moving to a low-carbon economy in 2050 (Energy Roadmap),¹ according to which EU GHG emissions should be reduced by 80 to 95 percent by 2050 against 1990 levels.

The Commission's recently proposed policy framework for climate and energy in the period from 2020 to 2030 bridges the 2020 Package and the 2050 Roadmap. As its centerpiece, the framework envisages a Europe-wide GHG emissions reduction target of 40 percent by 2030 compared to 1990 as well as an EU-wide renewable energy target of at least 27 percent of final energy consumption. The European Commission has also submitted the following documents:

- Communication: A policy framework for climate and energy in the period from 2020 to 2030,²

- Accompanying Impact Assessment,³
- Communication⁴ and comprehensive report⁵ on energy prices and costs in Europe,
- Report on energy economy developments in Europe,⁶
- Guidelines for member states on public intervention in electricity markets,⁷
- Proposal for the introduction of a market stability reserve for the European Emissions Trading System.⁸

(Brussels: January 22, 2014).

³ European Commission, Commission Staff Working Document: Impact Assessment, SWD(2014) 15 final (Brussels: January 22, 2014).

⁴ European Commission, Communication: Energy prices and costs in Europe, COM(2014) 21 final (Brussels: January 22, 2014).

⁵ European Commission, Commission Staff Working Document: Energy prices and costs report, SWD(2014) 0020 (Brussels: January 22, 2014).

⁶ European Commission, "Energy Economic Developments in Europe," European Economy, no. 1 (2014).

⁷ European Commission, Communication: Delivering the internal electricity market and making the most of public intervention, COM(2013)7243 final (Brussels: November 5, 2013).

⁸ European Commission, Proposal for a decision of the European parliament and of the council concerning the establishment and operation of a market stability reserve for the Union greenhouse gas emission trading scheme and amending Directive 2003/87/EC, COM(2014) 20/2 (Brussels, 2014).

¹ European Commission, Communication: Roadmap for moving to a low-carbon economy in 2050, COM(2011)112 final (Brussels: March 8, 2011).

² European Commission, Communication: A policy framework for climate and energy in the period from 2020 to 2030, COM(2014)15 final

European Commission Proposes 2030 Framework for Climate and Energy Policies

The Commission's most recent Communication differs significantly from the 2020 climate and energy package which sets out specific climate, renewable energy, and energy efficiency targets. The 2030 framework proposes a 40-percent reduction in GHG emissions from 1990 levels. Further, the requirements had to be tailored both to sectors that were covered by the EU ETS and sectors that were not. As has been the practice to date, the target for the sectors not included in the EU ETS is to be distributed among the member states. The aim for renewable energy use is to produce a 27-percent share of gross final energy consumption across Europe. The Commission considers this to be consistent with achieving a 40-percent emissions reduction target. From the point of view of renewables, however, no

specific objectives are stipulated for the individual EU member states and, consequently, they cannot be made directly responsible for meeting this particular target. Neither does the Commission propose a specific goal with regard to increasing energy efficiency, instead referring to an ongoing review of energy efficiency directives, the findings of which must first become available before a target can be set.

One possible explanation for the inconsistent targets in the 2030 framework compared to the 2020 package could be the UN Conference of the Parties on Climate Change (taking place in Paris at the end of 2015) placing the Commission under pressure to set GHG emissions targets quickly; there is unlikely to be quite such a sense of urgency among the different member states to set renewable energy and energy efficiency targets, however.

The European Commission remains committed to its long-term target of reducing GHG emissions by between 80 and 95 percent by 2050 against 1990 levels. However, the question remains as to whether the current proposals are enough to ensure the 2050 targets are met.⁶

Commission's Proposal Based on Scenarios and Impact Assessment

The Commission's current proposals refer to a reference scenario that was published at the end of 2013 and an Impact Assessment of the resulting policy scenarios. Alongside key energy indicators, the Impact Assessment also evaluates the development of macroeconomic variables. The basis of the proposal is the reference scenario "EU Energy, Transport and GHG Emissions Trends to 2050".⁷ The scenario builds on statistical data from 2010 and assumes a continuation of current economic trends and future demographic developments. Further, policy proposals that had been agreed or already implemented by spring 2012 were also taken into consideration. The reference scenario establishes that by 2030 there will be a 32.4-percent reduction in GHG emissions compared to 1990 levels, a 24.4-percent share of final energy consumption generated by renewable energy sources, and also energy savings of 21 percent compared to the 2007 reference development forecast (see table). It should be noted, however, that, according to the reference scenario, the reduction in GHG emissions to be achieved by 2050 is only 44 percent. A reduction of emissions between 80 and 95 percent by 2050 compared to 1990 would require further measures by 2030.

The policy scenarios that build on the reference development include a range of targets for GHG emissions (–35 percent to –45 percent) and renewable energy (no target, 30 or 35 percent).⁸ None of the scenarios assume separate targets for increasing energy efficiency. Two groups of scenarios are set out: in the first group, enabling conditions such as sectoral measures for improving efficiency or a particularly comprehensive network expansion are required in order for the targets to be met. The second scenario group does not include such enabling conditions. It is interesting to note that none of the scenarios without enabling conditions meet the

EU's long-term target of an 80- to 95-percent reduction in GHG emissions by 2050.

The findings of the Impact Assessment do not point to any clear conclusions with regard to the advantages of following particular policies. Energy system costs, for example, are very similar in all scenarios: average annual energy system costs are 34 billion euros (1.6 percent) higher in the most ambitious scenario than in the reference scenario. Annual investment is 93 billion euros higher than in the reference scenario (816 billion euros) and furthermore 27-billion-euro can be saved over the reference scenario due to reduced fuel imports.

Ambitious targets in the fields of climate change, renewable energy, and energy efficiency may result in a positive net impact on the overall economy, for example, due to increased investment activity or decreased imports of fossil fuels from abroad.⁹ Depending on the model used and the assumed use of CO₂ revenue, the EC's Impact Assessment shows either slightly positive or negative net impact on GDP and employment. The most ambitious scenario results in the most significant growth in income and employment (45-percent emissions reduction, 35-percent share of renewable energy sources, and increased efficiency measures). According to this scenario, compared to the reference development, a positive employment effect of 1.25 million people can be expected throughout Europe by 2030.

Most Ambitious Scenarios Not Favored by European Commission

The Commission's model analyses illustrate that the scenarios with particularly ambitious targets for emissions reductions and the expansion of renewable energy would probably be only slightly more expensive and possibly even bring macroeconomic advantages. Bearing this in mind, the Commission's proposal to link a 40-percent GHG emissions target with a renewable energy target of just 27 percent is difficult to comprehend. Further, more ambitious 2030 objectives improve the chances of the 2050 climate target being met. Particularly the renewable energy target of 27 percent which, although described as "binding" is only formulated at EU level, appears to be unambitious and the Commission is yet to set any target at all for energy efficiency. These circumstances certainly do not instill confidence in a secure and sustainable energy supply up to 2050.

⁶ In a recent Wochenbericht, DIW Berlin outlined a number of reasons for a proactive energy and climate policy and indicated that Europe was not the only country in the world to have implemented an ambitious energy and climate policy to date. K. Neuhoﬀ et al., "Energie- und Klimapolitik: Europa ist nicht allein," DIW Wochenbericht, no. 6 (2014): 91–108.

⁷ European Commission, EU Energy, Transport and GHG Emissions Trends to 2050. Reference Scenario 2013 (2013).

⁸ European Commission, Impact Assessment.

⁹ J. Blazejczak, D. Edler, and W.-P. Schill, "Improved Energy Efficiency: Vital for Energy Transition and Stimulus for Economic Growth," DIW Economic Bulletin, no. 4 (2014).

Table

Overview of Impact Assessment Scenarios

Scenario name ¹	Under reference conditions				With enabling conditions			
	Reference scenario	THG35 / energy efficiency	THG37	THG40	THG40	THG40 / energy efficiency	THG40 / energy efficiency / RES30	THG45 / energy efficiency / RES35
2030 targets in percent								
Greenhouse gases ²	–	–35	–37	–40	–40	–40	–40	–45
Renewable energy ³	–	–	–	–	–	–	30	35
Model findings for 2030, in percent								
Greenhouse gases ²	–32.4	–35.4	–37	–40.4	–40.6	–40.3	–40.7	–45.1
Renewable energy ³	24.4	25.5	24.7	25.5	26.5	26.4	30.3	35.4
Energy efficiency ⁴	–21.0	–24.4	–22.9	–24.4	–25.1	–29.3	–30.1	–33.7
Impact on energy system (index 2010 = 100)								
Net energy imports	96	90	94	92	89	83	81	78
Energy intensity ⁵	67	64	66	65	64	60	60	57
Economic and social impact								
System costs in reference scenario and changes compared with this scenario in billion euros per annum ⁶	2,067	–3	+6	+7	+2	+22	+22	+34
Investment in reference scenario and changes compared with this scenario in billion euros per annum ^{6,7}	816	+17	+19	+30	+38	+59	+63	+93
Net imports of fossil fuels in the reference scenario and changes compared with this scenario in billion euros per annum ⁶	461	–10	–2	–4	–9	–20	–22	–27
Average price of electricity in reference scenario and changes compared with this scenario in euros per MWh ⁸	176	–2	+1	+6	+3	–1	+2	+20
Emissions trade price in euros per ton of CO ₂	35	27	35	53	40	22	11	14

1 "Energy efficiency" in the scenario name refers to the existence of policy measures to increase energy efficiency.

2 Compared to 1990.

3 Share of gross final energy consumption.

4 Compared to a 2030 forecast.

5 Primary energy/GDP.

6 Annual averages 2011–2030.

7 Excluding transport infrastructure.

8 Prices in end customer segment constant from 2010. In the reference scenario, the relevant value in 2010 was 134 euros/MWh.

Sources: European Commission, Impact Assessment; see also European Commission, Executive Summary of the Impact Assessment. Accompanying the document Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions A policy framework for climate and energy in the period from 2020 up to 2030, SWD (2014) 16 final, Brussels, January 22, 2014.

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Greenhouse gas emissions vary considerably across the scenarios; system costs on the other hand barely differ.

Mitigating Climate Change with Nuclear Energy and Coal-Fired Power Plants with Carbon Capture?

The results of the Commission's scenario calculations depend largely on assumptions made with regard to the availability and future costs of different power generation technologies which, in part, are based on implausible cost estimates and scenario prerequisites: for example, both the reference scenario and the Impact Assessment use over-optimistic estimates for nuclear power and carbon capture that contradict the economic and technological trends of the last decade. Consequently, in all sce-

narios with no targets for the use of renewable energy sources, the share of power generation contributed by nuclear energy is over 20 percent by 2030, although it has proven to be the most expensive technology available and is also plagued by insurance problems and the unresolved issue of final disposal.¹⁰ The Impact Assessment also assumes a high share of coal power due to an

¹⁰ C. v. Hirschhausen, C. Kemfert, F. Kunz, and R. Mendelevitch, "European Electricity Generation Post-2020: Renewable Energy Not To Be Underestimated," DIW Economic Bulletin, no. 9 (2013); and also A. Schröder, F. Kunz, J. Meiss, R. Mendelevitch, and C. v. Hirschhausen, "Current and Prospective Costs of Electricity Generation until 2050," DIW Berlin Data Documentation, no. 68 (2013).

increase in the availability of carbon capture over time (CCTS, carbon capture, transport, and storage); there will be a significant rise in the CCTS share after 2030. However, the assessment ignores the fact that (globally) every attempt to demonstrate and expand this technology to date has failed and the required CO₂ pipeline infrastructure has since been sidelined by the European Commission.¹¹ Further, the Impact Assessment also underestimates the expected cost degression of renewable energy sources.

Already the predecessor documents of the aforementioned Communication, the Energy Roadmap 2050 and the 2013 Green Paper,¹² draw on assumptions based on a boom in nuclear energy and the rapid implementation of CCTS technology.¹³ The cost degression of renewable energy, on the other hand, uses very conservative estimates; consequently, the costs for photovoltaics, for example, have already reached approximately the level forecast by these EU studies for 2050. Despite some minor adjustments to the cost estimates, the Commission's optimistic forecasts for 2020 to 2030 regarding the costs and availability of nuclear and coal-fired power plants (with CCTS) currently remain fundamentally unchanged. Although the capital costs for nuclear power and CCTS were increased slightly,¹⁴ this change has had little impact on the model findings, since the costs are still underestimated. This means that, according to the Commission's scenarios, the reduction targets will be met primarily as a result of the continued high level of nuclear power (97 gigawatts in 2025 and 125 gigawatts in 2050) and also, to a more limited extent, through fossil fuel power plants with carbon capture: the plan is to build a large number of new nuclear power stations and also several fossil fuel-fired power stations with carbon capture technology by 2030, although, taking all relevant factors into consideration, neither of these technologies is either cost-effective or even safe.

¹¹ European Commission, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Long term infrastructure vision for Europe and beyond, 711 final (Brussels: October 14, 2013).

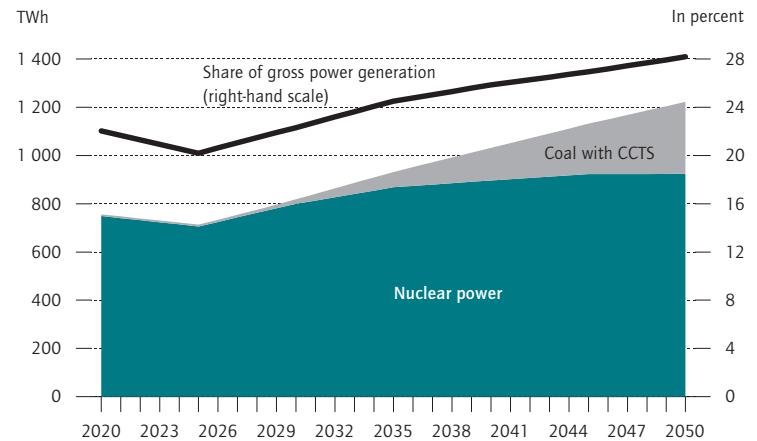
¹² European Commission, Commission Staff Working Paper: Energy Roadmap 2050 Impact Assessment, SEC (2011) 1565 final (Brussels: December 15, 2011); and also European Commission, Green Paper.

¹³ Hirschhausen et al., "European Electricity Generation."

¹⁴ Nuclear power (for 2030) from 3,859 euros/kW to 4,212 euros/kW; CCTS from 2,315 euros/kW to 3,370 euros/kW. See European Commission, EU Energy, Transport and GHG Emissions Trends to 2050. Reference Scenario 2013 (2013); and also European Commission, Energy Roadmap 2050 Impact Assessment.

Figure 1

Annual Electricity Generation from Nuclear Power and Coal-Fired Plants with CCTS in the EC's Reference Scenario



Sources: European Commission, Reference Scenario; calculations by DIW Berlin.

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Gross power production from nuclear and coal-fired power plants with CCTS will increase to 28 percent by 2050.

CO₂ Emissions Considerably Higher in Sample Calculation Without Nuclear Power and CCTS

Due to the underlying optimistic assumptions, the Commission's scenarios expect nuclear energy and CCTS to account for a substantial share of the reduction in emissions in the long term. According to the reference scenario, between 2020 and 2050, around 20 to 28 percent of power generation in Europe will be supplied by nuclear energy and coal-fired power plants with CCTS (see Figure 1). Using a sample calculation in which the energy produced by nuclear power stations and coal-fired plants with CCTS is replaced by energy from gas and coal-fired plants without CCTS from 2020, the result shows a cumulative increase in the energy sector's CO₂ emissions from 2020 to 2050 of 17.8 billion tons against the reference scenario.¹⁵ This equates to 25 percent of the EU's entire emissions budget between 2008 and 2050 (69.5 billion tons).

¹⁵ The sample calculation assumes that, from 2020, the substituted electricity will be produced by coal-fired (40 percent), gas and steam power plants (40 percent), and open gas turbines (20 percent).

Achievement of Long-Term Climate Targets Under Threat

The European Commission's reference scenario assumes that current policy measures alone will reduce emissions by 24 percent by 2020 and 32 percent by 2030 compared to 1990 levels. However, given the dubious assumptions the scenario is based on, there is a real danger that the EU will face major difficulties in achieving its 2030 emissions target and completely miss the 2050 target of reducing GHG emissions by 80 to 95 percent. Although the 2020 objective of a 20-percent reduction will be met due to the economic crisis, the EU's energy, transport, and heating sectors all lack instruments for achieving the 2050 targets. Given the energy sector's durable capital stock and the danger of a carbon lock-in, the question arises as to why a large share of the energy sector's reduction has to be deferred to 2030-2050 in order to meet the long-term emissions reduction target of 80 to 95 percent.

Between 1990 and 2011, GHG emissions in the current EU-28 countries dropped by 18 percent compared to 1990 (see Figure 2). The lion's share of the reduction occurred during the crisis years between 1990 and 1993 (the transformation crisis in former East Germany and Central and Eastern Europe) and 2008 and 2012 (financial and economic crisis), whereas GHG emissions levels remained largely unchanged between 1993 (5.2 billion tons) and 2007 (5.1 billion tons).¹⁶

Achieving emissions reductions in the sectors covered by the EU ETS is more cost effective than in those not part of the scheme, such as transport or households. This makes it relatively easy for the emissions trading sector to meet the current emissions reduction target of 1.74 percent per year, with a large number of surplus permits still remaining in circulation (around two billion tons).

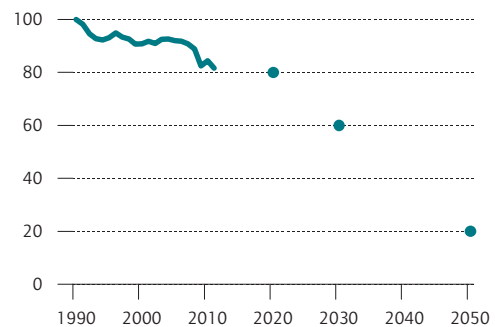
According to the European Commission, the emissions reduction target of 40 percent compared to 1990 levels should be met solely by implementing internal EU measures. This figure does not take into account GHG emissions produced abroad however. Along with a 43-percent reduction in industries covered by the EU ETS, achieving the target is also contingent on a 30-percent reduction in other sectors (against 2005 levels). A particularly problematic area is effort sharing among the member states of the EU with regard to sectors not covered by the EU ETS. Currently, this is based, inter alia, on per capita GDP to reduce impact on the poorer countries.

¹⁶ Since 2011, emissions have been on the increase in Germany as well as a number of other countries.

Figure 2

EU-28 Greenhouse Gas Emissions and Targets for 2020, 2030, and 2050

Index 1990 = 100



Emissions in carbon dioxide equivalents; excluding land use, land-use changes, and forestry.

Sources: Eurostat; calculations by DIW Berlin.

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The reduction in emissions between 1993 and 2007 was minimal.

In view of these distribution issues, protracted negotiations can be expected in the future.

Emissions Trading System Reform Proposal: Impact Too Late and Too Slow

The EU ETS itself will also have to undergo far-reaching structural reforms at least if it is to maintain its position as an international role model. Carbon emissions trading was first introduced in the EU at the beginning of the last decade because the EU-wide carbon tax project did not meet with majority support. The hope was that the system would facilitate an effective and efficient reduction in emissions. Following a pilot phase (2005 to 2007) and trading period with broadly free allocation among the member states (2008 to 2012), the system is now in its third trading period (running until 2020) which involves auctioning a significant share of emissions allowances throughout Europe and harmonizing the rules for free allocation.

If, in terms of promoting investment, the EU ETS has, for the most part, only had a moderate impact since it was introduced in 2005, this impact has been almost completely lost as a result of the economic crisis and the large number of credits from outside the EU. Figure 3 shows the price development of carbon certificates on

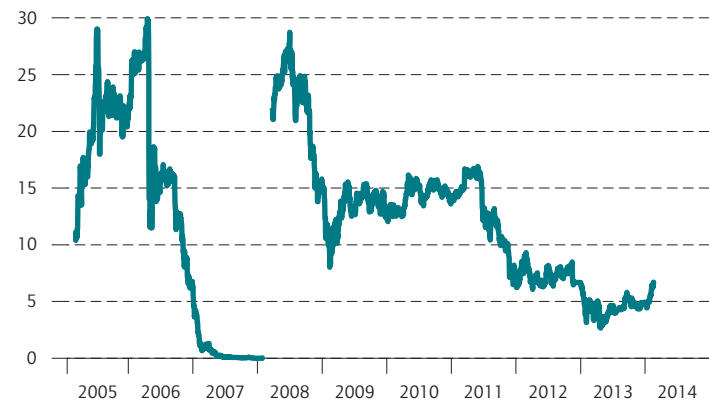
the spot market from 2005 to the present day.¹⁷ Apart from its high level of volatility, the collapse of the carbon price as a result of the 2008 economic crisis is also particularly striking: due to the slump in demand for certificates that was not accompanied by a corresponding adjustment of supply, in summer 2008, the price plummeted; it was only the trading participants' speculation and hedging strategies that prevented the price from hitting zero euros per ton of CO₂.¹⁸ Since then, the accumulated surplus of unused permits has hit around two billion tons. Many market observers as well as the European Commission itself assume that a significant surplus will remain for some years, probably until 2030 (see Figure 4).¹⁹ The Commission anticipates that there will be a slight reduction in the surplus in the near future due to delayed auctioning of allowances, known as backloading. Between 2020 and the end of the observation period, the reduction of the surplus is expected to be marginal, which means that carbon prices are likely to remain low in the long term.

Although the decision to backload endorsed in February 2014 saw 900 million tons of allowances withdrawn from the market, these permits will be released back into the market by 2019, which means that any price effects will only be temporary. Yet the most recent Commission document makes no mention of the structural reforms that have been discussed in this context, such as a reduction of the surplus in the third trading period. Instead, the document proposes a "market stability reserve" with the aim of increasing or reducing the supply of carbon credits from 2021, depending on the state of the market. The plan is to announce the level of surplus certificates on May 15 each year:²⁰ if the cumulative surplus exceeds 833 million permits, up to 12 percent of the surplus certificates to be auctioned in that particular year (i.e., at least 100 million) will be transferred to the reserve. Conversely, if the number of permits in circulation dips below 400 million, the Commission will release 100 million permits from the reserve back into the market the following year. The remaining long-term surplus should correspond to the hedging demand of the power sector. It is assumed that this occurs because power producers have generally always sold their power

Figure 3

Development of Certificate Prices in EU Emissions Trading System (Spot Market)

In euros per ton of CO₂



Source: European Energy Exchange.

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For most of 2013, the carbon price was under five euros per ton.

Figure 4

Expected Surplus Permits in EU Emissions Trading System

In million emissions allowances



Historical values up to 2012; forecasts from 2013.

Source: European Commission, Questions and answers on stability reserve.

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Continued high surpluses are anticipated for the coming years.

production up to three years in advance and issue it with certificates at the point of sale. However, since the market stability reserve is not due to come into effect until 2021 and will only result in a gradual reduction of the surplus thereafter due to the 12-percent adjustment, the mechanism should be more effective.

¹⁷ In 2007 in particular, term prices were significantly higher.

¹⁸ K. Neuhoﬀ and A. Schopp, "Europäischer Emissionshandel: Durch Backloading Zeit für Strukturreform gewinnen," Wochenbericht des DIW, no. 11 (2013): 3–11.

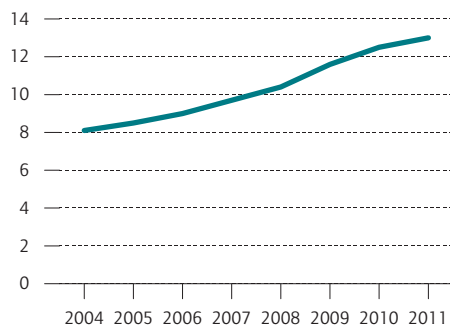
¹⁹ European Commission, Questions and answers on the proposed market stability reserve for the EU emissions trading system, MEMO/14/39 (Brussels: 2014).

²⁰ Permits issued + credits from abroad – verified emissions – permits in the market stability reserve = permits in circulation. Based on this calculation, permits have accumulated since 2008, i.e., since the beginning of the second trading period.

Figure 5

Renewable Energy Share of Gross Final Energy Consumption in EU-28 Countries

In percent



Source: Eurostat.

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The share of renewable energy sources has increased significantly since 2004.

vide a cost-effective and reliable source of carbon-free energy. They also contribute to securing supply and conserving resources. Unlike the Commission's proposal to protect the climate using nuclear power and coal-fired plants with CCTS, renewable energy sources are currently already available and constitute a viable alternative for meeting climate targets with no inherent technological risks.²¹ In view of the high external costs of nuclear power and fossil fuels, renewable energy sources are indispensable for sustainable development.

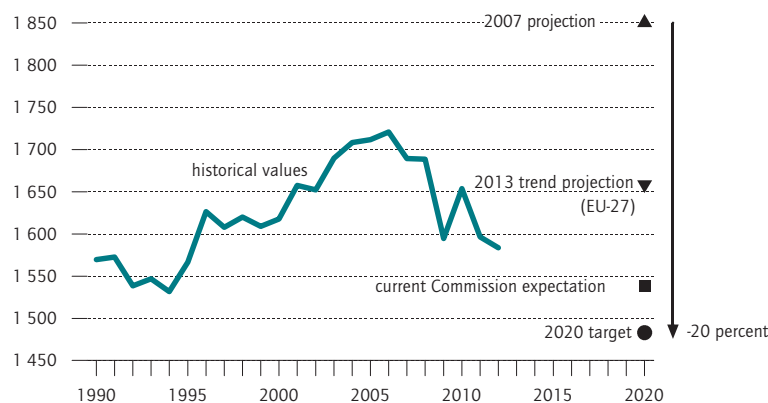
The aim is to increase the share of gross final energy consumption contributed by renewable energy to 20 percent by 2020. In 2011, this figure was only 13 percent (see Figure 5). According to the reference scenario, if no further measures are implemented, a 24-percent share will be reached by 2030. In light of this, the 2030 target of 27 percent proposed by the European Commission could be considered rather low.

The Commission's proposal of an EU-wide binding target is still extremely vague; it is particularly unclear how the target should be met: there is no sharing of the objective across the member states, no coherent approach to implementation, and no sanctions for non-compliance. Although the Commission states in its Communication that there will be a new governance system based on national energy plans to ensure the target is achieved, this governance structure with its iterative voting process between the Commission and the member states still remains unclear.²² In this respect, there is no evidence of the framework having a binding effect.

Figure 6

Primary Energy Consumption in EU-28 Countries and Projections to 2020

In million tons of oil equivalent



Sources: Eurostat; European Commission, Proposal for a Council Directive adapting Directive 2012/27/EU on energy efficiency by reason of accession of Croatia, Brussels, COM(2013) 113 final; calculations by DIW Berlin.

© DIW Berlin

A substantial reduction in primary energy consumption is needed to meet the 2020 target.

More Ambitious Renewable Energy Targets Required

Compared with nuclear power and power generation using fossil fuel-fired plants with CCTS, renewables pro-

Improved Energy Efficiency of Major Importance

Energy efficiency is defined as the ratio of output of goods or services to input of energy.²³ Improvements in energy efficiency are indicated by a rise in energy productivity (economic output per unit of energy used) or a fall in energy intensity (energy use per unit of economic output).²⁴ Improvements in energy efficiency make

²¹ Hirschhausen et al., "European Electricity Generation."

²² A new governance system has been proposed, based on national plans, with the aim of facilitating a competitive, secure, and sustainable energy supply. Improvements are needed with regards to competitiveness, transparency, security of investment, and EU-wide coordination. These plans are to be implemented in an iterative process between the Commission and the member states to facilitate compliance with legal requirements and provide long-term prospects. European Commission, 2030 climate and energy goals.

²³ Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EG and 2010/30/EU and repealing Directives 2004/8/EG and 2006/32/EG.

²⁴ J. Diekmann, W. Eichhammer, A. Neubert, R. Hellwig, B. Schlomann, and H.-J. Ziesing, "Energie-Effizienz-Indikatoren: Statistische Grundlagen,

it easier to meet relative targets pertaining to a higher share of overall consumption contributed by renewables.

In 2008, the Commission agreed a reduction of primary energy consumption of 20 percent by 2020 compared to the reference development.²⁵ The plan is to meet this target primarily through efficiency improvements in the building, services, transport, and energy sectors and also through increased use of cogeneration.

An Energy Efficiency Directive entered into force at the end of 2012.²⁶ The Directive specifies that, in 2020, the EU-28's primary energy consumption should not exceed 1,483 million tons of oil equivalent (Mtoe) (see Figure 6) and final energy should be no more than 1,086 Mtoe. Member states are obliged to implement this Directive in national legislation by June 2014 and submit National Energy Efficiency Action Plans (NEEAPs) describing measures implemented to meet these targets.

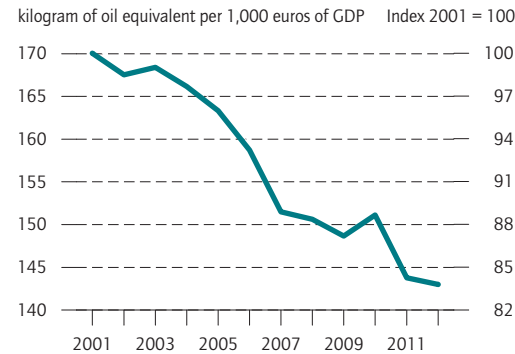
Increased Efforts Required to Meet Current Energy Efficiency Targets

The progress made in the field of energy efficiency to date is noteworthy but does not go far enough (see Figure 7) and varies across the member states (see Figure 8): in Italy, France, and Spain, relative improvements since 2001 are below the EU average whereas Germany and the UK recorded above-average improvements. Poland exhibits comparatively high energy intensity but this has seen a significant decline since 2001.

If the EU does not increase its efforts, it will fail to meet the target of a 20-percent reduction in primary energy consumption by 2020 compared to the reference development (see Figure 6). According to a 2013 trend projection, unless the Energy Efficiency Directive is successfully implemented, a maximum reduction of only 10 percent would be achieved. Currently, with the implementation of the Directive, the Commission anticipates a saving of just 17 percent by 2020.²⁷ Energy savings achieved to date are not only a result of energy efficiency measures but partly also due to the economic crisis. Primary energy consumption in 2012 was at around the same level as in 1990. The Commission's Impact Assessment indicates that reaching a 40-percent GHG re-

Figure 7

Development of Energy Intensity in EU-28 Countries



GDP at 2005 prices.
Source: Eurostat.

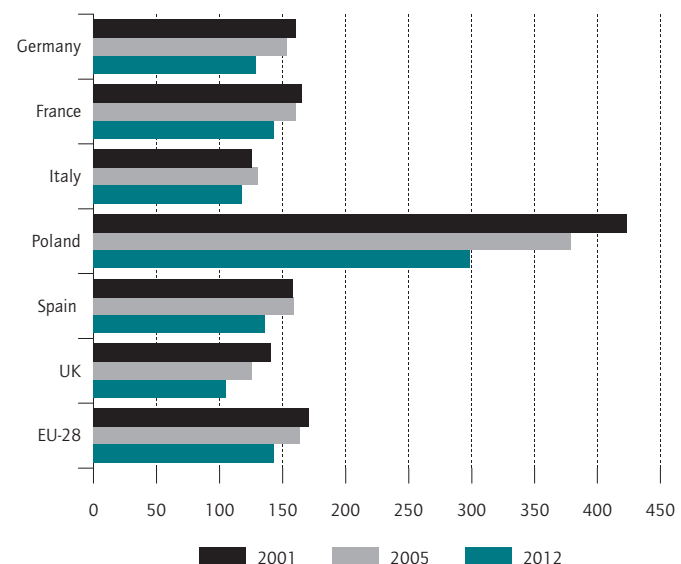
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Energy intensity has declined.

Figure 8

Development of Energy Intensity in Selected Countries

In kilograms of oil equivalent per 1,000 euros of GDP



At 2005 prices.
Source: Eurostat.

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Improvements vary significantly between individual member states.

theoretische Fundierung und Orientierungsbasis für die politische Praxis," Umwelt und Ökonomie, vol. 32 (Physica-Verlag: 1998).

²⁵ European Commission, Energy efficiency: delivering the 20% target, COM(2008) 772 (Brussels: November 13, 2008).

²⁶ Directive 2012/27/EU of 25 October 2012 on energy efficiency.

²⁷ European Commission, Impact Assessment.

duction target by 2030 would still require considerable improvements in energy efficiency.

The Commission's proposal does not include any specific target for energy efficiency improvements by 2030 and states only that the role of energy efficiency will be examined more closely after the Energy Efficiency Directive has been reviewed during the course of this year. The Commission will only consider whether the Directive should be changed or not once this review has taken place.²⁸

In the run up to 2030, efforts to enable energy efficiency to make a major contribution to a sustainable energy system must be redoubled in the run up to 2030. Presently, however, we need to wait for the initial results of the evaluation in summer 2014 before setting new targets.

Conclusion and Economic Policy Implications

In essence, the European Commission's proposed 2030 climate and energy policy framework is composed of a 40-percent GHG reduction target compared to 1990. It also proposes an EU-wide target for the use of renewable energy of 27-percent of gross final energy consumption by 2030. The framework does not, however, include a specific energy efficiency target. With these proposals which can only be considered moderately ambitious, the European Commission is running the risk of jeopardizing its long-term climate targets.

The quantitative Impact Assessment that forms the basis of the Commission's Communication provides no explanation for this restraint: neither total system costs nor energy prices really vary between the scenarios. Further, more ambitious greenhouse and renewable energy targets could result in positive investment, foreign trade, and employment developments if suitable framework conditions were created. This is an opportunity that such cautious proposals fail to take advantage of.

For the power sector, the Impact Assessment depicts an outlook which is risky from a technology policy point of view and questionable from an economic perspective, i.e., climate targets can only be met by, inter alia, increasing the number of nuclear power stations and coal-fired plants with carbon capture. Therefore, despite updated cost estimates, the European Commission's scenario calculations are based on implausible technological and economic assumptions. For instance, the Commission's

estimated nuclear power costs are relatively low, contradicting the actual capital costs of recently built plants and fail to take into account the considerable risks posed by accidents and final disposal. The Impact Assessment also assumes a breakthrough in carbon capture, transport, and storage technologies in the long term. The model calculations for renewable energy, on the other hand, continue to be derived from outdated and excessively high cost assumptions.

On the basis of past experience with the 2020 Climate and Energy Package, ambitious targets will also be necessary for 2030 and beyond on three levels: greenhouse gas reduction, renewable energy, and energy efficiency. GHG emissions should be reduced by at least 40 percent by 2030 and, according to the Commission's analyses, it would also be possible to increase reductions at reasonable costs. Urgent reforms to carbon trading are required to ensure a strong carbon price that will foster low-carbon investment as soon as possible. The impact of the Commission's recent proposal to implement a market stability reserve would be too little, too late, however.

The target of a 27-percent share of renewable energy by 2030 is too low and lacks a binding division between the member states. The proposed implementation (governance process) remains unclear.

The Commission has yet to set a specific 2030 target for improvements in energy efficiency. However, also in future, a significant increase will be essential, which, in the first instance, will require the successful implementation of the Energy Efficiency Directive with its specific 2020 targets. Thereafter, increased efforts would be necessary in the run up to 2030.

In its coalition agreement, the German government confirmed the key elements of the national climate, renewable energy, and energy efficiency targets required for the energy transition. The government should therefore also commit to ambitious policies on a reduction in GHG emissions, greater use of renewable energy sources, and improvements in energy efficiency at European level.

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JEL: Q43, Q47, Q48, Q54

Keywords: Europe, energy, climate, policy, 2030

²⁸ European Commission, 2030 climate and energy goals.

Nuclear Power: Phase-Out Model Yet To Address Final Disposal Issue

by Christian von Hirschhausen and Felix Reitz

Three years after the nuclear disaster at Fukushima, Japan, countries around the world are beginning to look at extending the lifetime of existing power plants and building new reactors again. Advocates of nuclear power argue that it provides an affordable energy source, helps to secure energy supply, and makes a contribution to combating climate change. The European Commission's Reference scenario—which sets the agenda for the EU climate and energy strategy for 2030—assumes a massive expansion of nuclear power, including no less than seven new reactors in Poland alone. In Germany, too, there is a growing number of voices criticizing the imminent nuclear phase-out. In the view of DIW there is, however, no such thing as a "nuclear renaissance": current new-built projects concentrate on a small number of countries, primarily on China. Notably, the discussion ignores the fact that nuclear power has never been produced economically, when taking into account the risks to humans and the environment and the cost of dismantling nuclear power plants, final disposal of nuclear waste and of research and development (R&D). The question of where and how to store high-level radioactive waste is yet to be resolved.

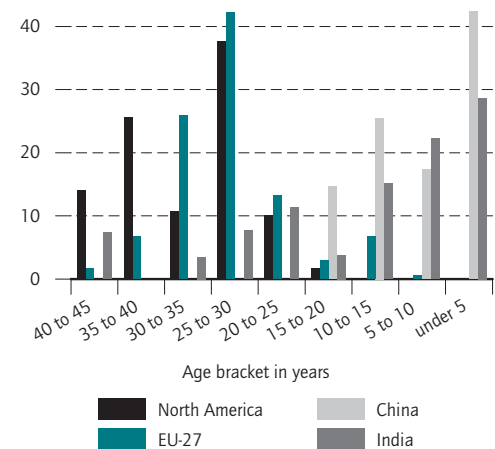
Consequently, phasing out nuclear energy appears to be the safest and most cost-efficient strategy. The European discussion should not be based on model calculations which neglect a large proportion of the costs. Germany can continue undeterred with its nuclear phase-out without endangering supply security; this also applies to the planned decommissioning of the Grafenrheinfeld nuclear power plant in 2015. Questions concerning the dismantling of nuclear power plants and final disposal of radioactive waste have been avoided for too long and urgently need to be addressed now in parallel to the phase-out.

Nuclear power is currently used for energy production primarily in Western industrialized countries, in post-Soviet states, in Japan and Korea, as well as in the emerging countries China and India. The oldest nuclear power park in the world is located in North America (see Figure 1). After two surges in growth following the oil crises in the 1970s, the American nuclear construction boom ended under the shadow of the Chernobyl disaster in 1986; the last reactor to be built was Watts Bar 1 in Tennessee which came online in 1996. Asian countries, however, have continued to regularly construct nuclear power plants. China and India in par-

Figure 1

Age Structure of Nuclear Power Stations in Selected Countries and Regions in 2013

Share of age bracket of total capacity, in percent



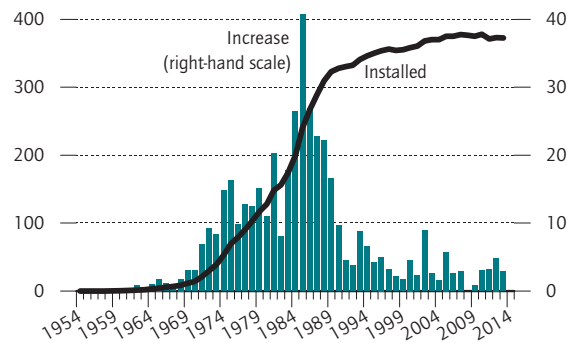
Source: calculations by DIW Berlin based on World Nuclear Association (2013).

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The majority of nuclear power stations in North America and Europe are over 25 years old.

Figure 2

Global Development of Nuclear Power In gigawatts



Source: calculations by DIW Berlin based on World Nuclear Association (2013).

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Installed capacity has only risen slowly since 1990.

particular have a relatively new nuclear power park with an average age of around ten years.

The annual global expansion of nuclear power reached its peak back in the mid-1980s and has since virtually come to a halt (see Figure 2). In 1998, for the first time, more reactors were taken offline than new ones brought online. In four of the last six years, a net reduction in global capacity was observed (2008, 2009, 2011, and 2013). Given the age structure of the power plants currently operating, a further decrease is to be expected: over 80 percent of all reactors are already more than 20 years old, 50 percent are more than 28 years old, and 25 percent are more than 34 years old.

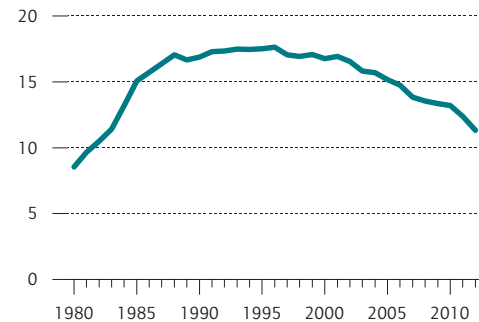
According to the International Atomic Energy Agency (IAEA) reactors with a total capacity of around 70 gigawatts are currently officially under construction, with China accounting for around 28 gigawatts. Although this increase appears to be substantial at first glance, the proportion of nuclear power plant projects actually implemented is traditionally low.¹ Moreover, nuclear power only accounts for a small share of power generated globally (see Figure 3). The 440 nuclear reactors which were in operation worldwide in 2012, with a total capacity of 370 gigawatts, generated just over 2,300 terawatt hours

¹ Investment in nuclear power plants which were never or hardly ever in operation amounts to at least 524 billion euros globally (as of 2012); if all nuclear installations are taken into account, such as failed repository projects or nuclear accidents, the total is over 1,000 billion euros. See J. Döschner, "Das Billionen-Dollar Desaster," www.tagesschau.de/inland/milliardengrab-atomkraft100.html, accessed on March 12, 2014.

Figure 3

Share of Nuclear Power in Global Power Production

In percent



Source: graph by DIW Berlin based on EIA (2014).

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Globally, the share of power generation contributed by nuclear power is on the decline.

of power, corresponding to around 11 percent of global electricity production.² A further decrease in the nuclear share is to be expected: in China alone the capacity of renewable energy sources was increased by 57 gigawatts and coal power by 40 gigawatts in 2012.³ In comparison, the planned increase in China of almost three gigawatts of nuclear power per year is negligible. The hypothesis of the "nuclear power renaissance,"⁴ which might lead us to expect the technology to exhibit high growth rates again after a certain lull, is not confirmed by a global comparison, either.

Nuclear Power Beyond Economic Rationality

The discussion on nuclear power ignores the fact that, taking into account the operational risks and the immense costs of R&D, the dismantling of power plants, and the final disposal of radioactive waste, this form of energy has never been economical. Furthermore, to this day, over six decades since the first civilian use of nucle-

² See EIA, www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=2&pid=2&aid=12, accessed on March 20, 2014.

³ Source: bizzenergytoday.com/china_erneuerbare_%C3%BCberholen_kohle, accessed on March 12, 2014.

⁴ See, for example, P. Joskow and J. Parsons, "The Future of Nuclear Power After Fukushima," *Economics of Energy & Environmental Policy*, vol. 1, no. 2, (2012): 99-114; and Nuttall and Newbery, "European electricity supply security and nuclear power: an overview," in Leveque, Glachant, Barquin, Hirschhausen, Holz, and Nuttall, eds., *Security of Energy Supply in Europe* (2009).

ar power, the question of disposal of high-level radioactive waste remains unresolved.

When evaluating the economic viability of nuclear power, a distinction must be made between operational and social costs, with the latter also including environmental effects and technical risks. Construction of a nuclear power plant may be worthwhile from a microeconomic perspective, for instance from an investor's point of view, as long as the government or the energy customers bear a large share of the social costs. Operation of an existing nuclear power station can be profitable, provided that the government takes responsibility for the safety risks—the cost of which cannot be calculated—as well as for dismantling, final disposal of nuclear waste, and investment in R&D. However, a useful assessment of the cost-effectiveness of using nuclear power can only be made from a public policy perspective.

The actual motives for developing nuclear technology go beyond economic considerations. Due to the link between military and civilian use of nuclear power and also purely (national) political decision-making, the choice to expand nuclear power is not driven by economic rationality. Infrastructural, regulatory, and safety requirements are the result of political decisions. There are various different motives behind these decisions and they can generally be attributed to particularly well-organized interest groups, linked, for instance, to science or the military.⁵

Cost-Effective Nuclear Power? Just a Post-War Myth ...

The common conception, even among experts, of cheap nuclear power is not based on empirical evidence but is driven by the political objectives of the USA and the prospective European nuclear powers of the 1950s which aimed at monitoring the civilian and military use of nuclear power worldwide. In his historical Atoms for Peace Speech to the United Nations General Assembly on December 8, 1953, the President of the United States of America at the time, Dwight D. Eisenhower, developed the concept of collective management of radioactive material under the supervision of an international authority. The International Atomic Energy Agency (IAEA) in Vienna was subsequently founded to prevent the misuse of fissionable material to build atomic bombs. The common notion of cost-effective nuclear

power was thus emphasized by Eisenhower as a basis for fruitful cooperation.⁶

However, Atoms for Peace soon showed visible signs of failure, since neither the Soviet Union nor the emerging countries had any intention of complying with the proposed division of labor. Along with the UK and France, which forged ahead with military and civilian use parallel to the USA, the Soviet Union launched its own nuclear program and steadily advanced this during the Cold War. In other countries, too, the military and civilian use of nuclear power has been introduced, for instance in China, India, and Pakistan. Today countries such as Iran and North Korea are suspected of developing atomic bombs under the guise of civilian use.

In Europe, too, the concept of cost-effective nuclear power was associated with the objectives of political cooperation and economic development. Therefore, the Treaty establishing the European Atomic Energy Community (Euratom) signed in Rome in 1957 was intended to promote international cooperation concerning atomic energy as a basis for modernization and industrialization.⁷

No Prospects for Nuclear Power in Competitive Energy Markets

In view of still unresolved technical and institutional problems such as safety and final disposal, as well as the primacy of politics, it is not surprising that, to date, not a single nuclear power plant in the world has been fully financed and constructed by private investors under competitive market economy conditions. The high requirements regarding R&D, capital investment, insurance against the risks of nuclear accidents, and final disposal of radioactive waste make nuclear power unprofitable from a macroeconomic perspective.⁸

⁶ See Lévêque, *Nucléaire On/Off*, 172; the first reference to cost-efficient nuclear power is made in Eisenhower's speech: "Who can doubt, if the entire body of the world's scientists and engineers had adequate amounts of fissionable material with which to test and develop their ideas, that this capability would rapidly be transformed into universal, efficient, and economic usage," [web.archive.org/web/20070524054513/http://www.eisenhower.archives.gov/atoms.htm](http://www.eisenhower.archives.gov/atoms.htm), accessed on February 19, 2014.

⁷ The signatories even wrote in the preamble of the contract that this had been concluded "...recognising that nuclear energy represents an essential resource for the development and invigoration of industry and will permit the advancement of the cause of peace..." and "...desiring to associate other countries with their work and to cooperate with international organizations concerned with the peaceful development of atomic energy...", see: Euratom Treaty, http://europa.eu/eu-law/decision-making/treaties/pdf/consolidated_version_of_the_treaty_establishing_the_european_atomic_energy_community/consolidated_version_of_the_treaty_establishing_the_european_atomic_energy_community_en.pdf.

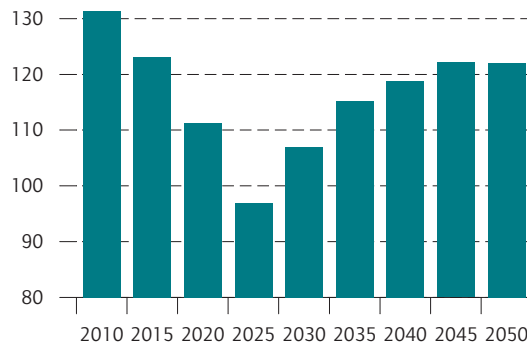
⁸ It is immaterial that estimates of the cost categories sometimes differ significantly, see Green Budget Germany, *Was Strom wirklich kostet* (Berlin: 2012); or W. D'haeseleer, *Synthesis on the Economics of Nuclear Energy. Study for the European Commission, Final Report* (2013), ec.europa.eu/energy/

⁵ F. Lévêque, *Nucléaire On/Off* (Paris: 2013), 171: „L'énergie atomique est fille de science et de la guerre" („Nuclear power is born of science and war.").

Figure 4

EU-Wide Installed Nuclear Capacity Forecast in EU Reference Scenario

In gigawatts



Source: graph by DIW Berlin based on European Commission (2013).

© DIW Berlin

Renewed expansion of nuclear power is to be expected from 2025.

Various organizational models have developed around the world, none of which are based on the market-driven construction of nuclear power stations.⁹ In socialist states such as the Soviet Union and later also its satellites (such as the GDR), China, and other emerging economies, all major developments in the energy industry were always subject to political decisions. But also in market economies the state entrusted either its own companies with the task (the UK and France) or awarded private companies state subsidies or guarantees in order to create incentives for developing nuclear power (Germany and the US).¹⁰ All of the nuclear power plants planned in the US will be located in federal states that provide for a state-guaranteed profit margin. As far as long-term disposal of radioactive waste is concerned, all organizational models in the past 60 years have failed: to this day, there is no successful solution for the final disposal of high-level radioactive waste.

nuclear/forum/doc/final_report_dhaeseleer/synthesis_economics_nuclear_20131127-0.pdf.

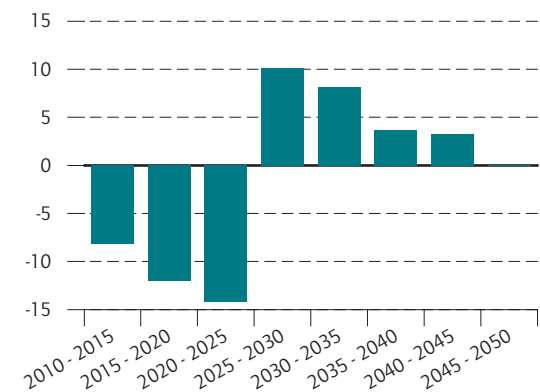
⁹ See. Lévêque, *Nucléaire On/Off*, in particular, part 4; Joskow and Parsons, "The Future of Nuclear Power"; and S. Thomas, *The Realities of Nuclear Power*, International economic and regulatory experience (Cambridge: 1998).

¹⁰ See Thomas, *Realities of Nuclear Power*, in particular, Chapters 4 (the US) and 6 (Germany) and for Germany also J. Radkau and L. Hahn, *Aufstieg und Fall der deutschen Atomwirtschaft* (Munich: 2013).

Figure 5

Forecast Change in Nuclear Power Capacity in EU Reference Scenario

In gigawatts



Source: graph by DIW Berlin based on European Commission (2013).

© DIW Berlin

The further expansion of nuclear power in Europe is unlikely to come to an end until after 2045.

EU Climate and Energy Strategy for 2030: Can Nuclear Power Save the Climate?

Across Europe, opinion is divided on the future of nuclear energy. In addition to Germany, Belgium and Switzerland have also opted for a nuclear phase-out and Italy voted against plans to revive its nuclear program in a referendum in 2011. Lithuanians rejected a proposal to build a nuclear power plant in cooperation with the other Baltic States and Poland; the project is now on the brink of being abandoned. In 2012, the Bulgarian government halted construction of the Belene nuclear power plant with its two planned reactor units since implementation of the project had only been sporadic since the 1980s. Similarly, in 2013, a Slovakian court rescinded the building permits for two nuclear reactors.¹¹ Parallel to this, however, two nuclear new build projects are in progress, one in Finland and one in France.¹² European

¹¹ Paradoxically, however, a halt on construction was legally prohibited by the nuclear regulatory authority responsible (UJD) as a stop on power plant construction would have "...been seriously detrimental to the public interest...." Thus construction is continuing despite the court judgement. See [orf.at//stories/2195771/](http://orf.at/stories/2195771/), accessed on February 21, 2014.

¹² Both of these are European Pressurized Reactors (EPR) developed by Areva and Siemens but both projects are running significantly behind time and over budget: the French operator, EDF does not anticipate commissioning the Flamanville plant (in France) until 2016 at the earliest and Olkiluoto (in Finland) will not be operational before 2017.

countries continuing to implement nuclear new builds include the UK, Poland (with new-build plans for up to three plants each with a capacity of 1.6 gigawatts by 2030¹³), and Hungary where the government is currently negotiating with the Russian Rosatom corporation regarding a new power station to replace the one in Paks.

Particularly in the wake of the nuclear disaster in Fukushima, the European Commission has been striving to improve safety standards and liability conditions, although, in accordance with the Euratom Treaty, the oversight of nuclear power plants remains the responsibility of the individual member states. In an initial step, in 2011, all nuclear reactors were subject to a “stress test” and safety provisions were reviewed. As a result, virtually all nuclear power stations would have to be upgraded at a cost of approximately 25 billion euros for the 132 reactor units investigated.¹⁴ The directive subsequently proposed by the European Commission provides for the institutionalization of nuclear stress tests which, henceforth, should be implemented at least every six years according to predetermined specifications.¹⁵ Additionally, the Commission is currently preparing a proposal aiming to internalize the external risk costs.

EU Reference Scenario Envisages Widespread Nuclear New Builds...

A number of scenario analyses for the EU conclude that nuclear power is cost-effective and perceive it to be a key pillar for power supply in the run-up to 2030 and 2050. This applies to both the Energy Roadmap (Roadmap for moving to a low-carbon economy in 2050) and the December 2013 reference scenario for 2030/2050.¹⁶ The Reference scenario which acts as the basis for the White Paper (A policy framework for climate and energy in the period from 2020 to 2030) forecasts that nuclear power capacity for 2030 will be similar to today's levels (see Figure 4): although, from a current level of 125 gigawatts, the capacity of existing nuclear power stations is forecasted to fall on a level of 97 gigawatts by 2025 and to rise again to 122 gigawatts by 2050. Following a period marked by power plant closures, on aggregate,

capacity is seen to decline by around three gigawatts per annum until 2025. However, this phase will be followed by a radical trend reversal: according to the model, between 2025 and 2030 alone the scenario anticipates a net capacity growth of approximately ten gigawatts (see Figure 5).

...but Based on Implausible Assumptions

However, the situation envisaged in the reference scenario is implausible, particularly with regard to investment costs and resulting economies of scale, the assumed considerations underlying investment decisions, and also in failure to take adequate account of insurance, dismantling and final disposal costs.

Despite slight revisions¹⁷ between 2011 and 2013, the assumptions made in the reference scenario regarding investment costs remained overly optimistic. These figures were revised upwards slightly in the reference scenario compared with the 2050 Roadmap (4,350 euros per kilowatt versus 3,985 euros). However, the assumption is based on a fictional second plant in a standardized serial production and that the construction of further plants of the same type would result in learning curve effects. However, this hypothesis contradicts past experience which indicates that investment costs for nuclear power plants tend to increase over time.¹⁸

The European Commission's calculations largely fail to factor in risks. If the risks stemming from the use of nuclear power were to be internalized, this would result in considerable cost increases. In Germany, there is a limitation on liability in the event of damage caused by natural disasters to the sum of 2.5 billion euros, in France, the cap is 91.5 million euros, and in Eastern European countries the limit is even lower.¹⁹ Given that a nuclear disaster could lead to potential damages worth thou-

¹³ See Polish Nuclear Power Program, www.mg.gov.pl/files/upload/19990/PPEJ_2014_01_28_po_RM.pdf.

¹⁴ See European Commission, Communication from the Commission to the Council and the European Parliament on the comprehensive risk and safety assessments (“stress tests”) of nuclear power plants in the European Union and related activities (2012), 8, eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2012:0571:FIN:EN:PDF.

¹⁵ europa.eu/rapid/press-release_IP13-532_en.htm, accessed on February 21, 2014.

¹⁶ See European Commission, Trends to 2050 – Reference Scenario 2013 (Brussels: 2013).

¹⁷ In response to criticism, the European Commission commissioned an expert report to outline the basis for the estimates, see D'haeseleer, Synthesis on the Economics of Nuclear Energy.

¹⁸ See L. Rangel, F. Lévêque, and A. Grubler, “The cost of the French nuclear scale-up: A case of negative learning by doing,” *Energy Policy* 38 (2010): 5174–5188; and also L. W. Davis, “Prospects for Nuclear Power,” *Journal of Economic Perspectives*, vol. 26 (2012): 49–66. For the first EPR construction in Olkiluoto, the originally estimated costs of around 3.5 billion euros have since been revised upwards to 8.5 billion euros. The cost estimate for Flamanville has now also been upwardly adjusted to 8.5 billion euros.

¹⁹ J. Diekmann, “Verstärkte Haftung und Deckungsvorsorge für Schäden nuklearer Unfälle – Notwendige Schritte zur Internalisierung externer Effekte,” *Zeitschrift für Umweltpolitik und Umweltrecht* (2011): 122. On the internalization of external costs, see also M. Fillipini, “Strom aus dem Reaktor, ist er tatsächlich so günstig?,” *Neue Luzerner Zeitung*, March 3, 2007, 3.

sands of billions of euros, these liability sums seem, however, negligible.²⁰

The calculations also neglect to take into account the prevailing uncertainty with regard to construction and operation, the cost of dismantling nuclear power plants and, particularly, of final disposal. Due to a lack of empirical data on the subject, it is impossible to estimate the real extent of these costs, but they are likely to be significant, particularly in view of the absence of repositories.

The algorithm for power plant expansion used in the Commission's model ignores the risk-induced investment costs of private investors and therefore significantly underestimates the actual financing costs; particularly with regard to capital-intensive technologies such as nuclear power, these costs are of prime importance. The model portrays the ideal nuclear power park (from an investor's perspective). However, it fails to factor in regulatory risks which in the private sector are of considerable significance and de facto reduce interest in capital-intensive and risky investment in nuclear power plants.

Nuclear New Build at Hinkley Point, UK: Dependent on Overt and Hidden Subsidies

The proposed nuclear new-build project at Hinkley Point in the UK illustrates the enormous volume of overt and hidden subsidies required to construct a new nuclear power station today. The Hinkley Point project will be implemented by a consortium consisting of the French energy companies EDF and Areva and two Chinese state-owned corporations.²¹ The project entails the construction of a twin-unit power plant using a French-designed EPR nuclear reactor, the first twin unit of that kind to be built on European soil, with a total output of 3,200 megawatts.²² EDF puts the cost of the project at 16 billion GB pounds;²³ which is the equivalent of approximately 5,000 GB pounds of specific investment per kilowatt (around 8,500 US dollars per kilowatt). The lat-

est package negotiated between the British government and the consortium comprises various direct and hidden subsidies including:

- A "strike price" of 92.50 GB pounds for every megawatt hour of power that the reactors generate over a 35-year period, adjusted to inflation²⁴ (the equivalent of around 157 US dollars per megawatt hour). Should the power station's output have to be reduced for energy-system-related reasons, the operating company would receive financial compensation which de facto equates to a guaranteed minimum payment. In addition, the British government has offered the consortium a credit guarantee to underwrite up to ten billion GB pounds of debt on the project at preferential terms. Consequently, investors do not need to rely as heavily on expensive bank loans which are subject to the relevant risk premiums;²⁵
- The British government will also protect the investor from changes in nuclear liability and insurance obligations at European level;²⁶
- Further, discussions are underway as to whether the completion risk will also be borne by the British government;²⁷
- Finally, the agreement between the British government and the investors also allows for possible increases of the strike price under certain, as yet unspecified, conditions.

When the agreement between the British government and operator consortium was announced, the European Commission launched a formal investigation into proposed state subsidies for the plant. Its initial statement on the project was highly critical.²⁸ According to the Commission, there is no proven need for the project from an energy economy perspective since the power stations are unlikely to be operational until the mid- to late 2020s at the earliest, by which time the imminent excess demand is likely to have diminished again.²⁹

²⁰ Thus the Leipzig Insurance Forum calculated the cost of one Maximum Credible Accident (MCA) in Germany at up to 6,000 billion euros. Versicherungsforen Leipzig GmbH, Berechnung einer risikoadäquaten Versicherungsprämie zur Deckung der Haftpflichtrisiken, die aus dem Betrieb von Kernkraftwerken resultieren (Leipzig: April 1, 2011).

²¹ The two state-owned companies are China General Nuclear Power Group (CGN) and China National Nuclear Corporation (CNNC).

²² The project is an attempt to update the UK's outdated nuclear power stations; in the medium-term, the UK's nuclear program envisages new builds with a total output of 16 gigawatts. See House of Commons/Energy and Climate Change Committee, "Building New Nuclear: the challenges ahead," Sixth Report of Session 2012–13, vol. 1–7.

²³ See uk.reuters.com/article/2013/10/21/uk-britain-nuclear-hinkley-idUKBRE99J03X20131021, accessed on February 18, 2014.

²⁴ UK Government, "Initial agreement reached on new nuclear power station at Hinkley," news release, October 21, 2013, <https://www.gov.uk/government/news/initial-agreement-reached-on-new-nuclear-power-station-at-hinkley>, accessed on February 14, 2014.

²⁵ www.telegraph.co.uk/finance/newsbysector/energy/10611003/Nuclear-setback-as-EC-attacks-Hinkley-Point-subsidy-deal.html, accessed on February 19, 2014.

²⁶ The European Commission is planning to make liability insurance mandatory, which is something that has been discussed publicly by EU Energy Commissioner Oettinger and could be enacted EU-wide.

²⁷ House of Commons/Energy and Climate Change Committee, "Building New Nuclear," 17.

²⁸ See ec.europa.eu/competition/state_aid/cases/251157/251157_1507977_35_2.pdf, accessed on February 4, 2014.

²⁹ ec.europa.eu/competition/state_aid/cases/251157/251157_1507977_35_2.pdf, 18.

Nuclear Phase-Out Still Makes Sense for Germany

With the 13th Act amending the Atomic Energy Act, Germany made a decision that by the end of 2022 it would phase out nuclear power. The first older nuclear power plants were taken offline in response to the March 2011 moratorium and the remaining plants are to be decommissioned in the following order: Grafenrheinfeld by December 2015; Gundremmingen B (2017); Philippsburg 2 (2019); Gundremmingen C, Grohnde, and Brokdorf (2021) followed by Isar 2, Emsland, and Neckarwestheim (all by the end of 2022).

In its coalition agreement, the German government, made up of the CDU/CSU and SPD (Christian Democratic Union/Christian Social Union and Social Democratic Party), explicitly pledges to phase out nuclear energy.³⁰ However, as the decommissioning of the Grafenrheinfeld plant approaches, there is a growing number of voices which, for various reasons, are against the phase-out or have regrets over its high cost. Discussions have once again turned to nuclear power as a cheap source of energy.³¹ However, given the cost structure of nuclear energy, a phase-out still makes sense for Germany. Alongside safety and cost arguments, there are also technical reasons for a phase-out: the way nuclear power stations operate makes them very inflexible and therefore prevents them from contributing to the flexibility of an energy system based on renewables.

From an energy economy perspective, too, a nuclear phase-out is unproblematic. According to DIW Berlin's research findings, security of supply should be guaranteed by the mid-2020s in Germany, even without nuclear power. The findings show that, even after the nuclear phase-out, demand for power can be met across the country even during peak load times as long as available options such as load management or capacity contracts with other countries are used.³² As part of the present analysis, a power sector model is used to simulate, in-

ter alia, critical grid and supply situations for 2023 (i.e., after a complete nuclear phase-out). These calculations indicate that the continued implementation of Germany's Regulation on Reserve Power Plants (Reservekraftwerksverordnung) would ensure a balanced capacity in the German energy system by the mid-2020s; potential trade flows from abroad also help the situation. Even in extreme cases when there is a particularly high or particularly low level of wind, a secure power supply would still be guaranteed for the whole country during peak load times. This will still apply even if, ultimately, the two high-voltage direct-current transmission lines (HGÜ) which are planned to connect the coal-mining regions of the Rhineland and central Germany/Lusatia with southern Germany are not built.

Interim and Final Disposal Problem Yet To Be Addressed

Apart from issues relating to the energy economy, however, a number of technical and organizational questions still need to be resolved before the final nuclear phase-out and beyond. Issues include inadequate accident insurance and liability, suitable final repository locations for the spent fuel elements, and liability for long-term risks. Key issues around final disposal in particular remain unresolved. At its last sitting, the Bundestag adopted the Repository Site Selection Act (Standortauswahlgesetz, StandAG) which aims at finding a repository site for high-level radioactive waste by a federal-state commission to be completed by the beginning of the 2030s;³³ at the same time, the establishment of a new body, the Federal Agency for Radioactive Waste Management (Bundesamt für kerntechnische Entsorgung, BfE), is also in the pipeline. Consequently, the Minister for the Environment in Lower Saxony rescinded his authorization to survey the salt dome in Gorleben (based on German mining law) since it is now mandatory for the selection of repository sites to comply with the aforementioned Repository Site Selection Act.³⁴ This step might be interpreted as a relaunch of the search for a repository site and an admission that Gorleben in Lower Saxony is not the only option. Originally, the German government had planned for all high-level radioactive waste

³⁰ See Coalition Agreement between CDU, CSU and SPD, Deutschlands Zukunft gestalten (2013), 59: "Wir halten am Ausstieg aus der Kernenergie fest. Spätestens 2022 wird das letzte Atomkraftwerk in Deutschland abgeschaltet." "We remain committed to a nuclear phase-out. The last nuclear power station in Germany will be decommissioned by 2022 at the latest."

³¹ This includes the study commissioned by the European Commission on the costs of nuclear power which assumes considerably lower energy prices in Germany for scenarios with nuclear power than without, see D'haeseleer, Synthesis on the Economics of Nuclear Energy, 8. The editor-in-chief of the Wirtschaftswoche criticized Germany for prohibiting "affordable sources of energy such as nuclear power," see R. Tichy, "Strom als Müll," Wirtschaftswoche, no. 6 (2014).

³² See F. Kunz, C. von Hirschhausen, and C. Gerbaulet, "Mittelfristige Strombedarfsdeckung durch Kraftwerke und Netze nicht gefährdet," DIW Wochenbericht, no. 48 (2013).

³³ The "Law on the Search and Selection of a Repository Site for Heat-Generating Radioactive Waste and on Amendments to Other Laws (Repository Site Selection Act—StandAG)" entered into force on July 23, 2013. Section 1 defines the aim of the law: "The objective is to implement a transparent process with a robust scientific basis to identify a location for a repository site for the disposal of domestically-produced high-level radioactive waste in particular, in accordance with Section 9a, Para 3, Clause 1 of the German Atomic Energy Act, which ensures an optimal level of safety for a period of a million years."

³⁴ www.endlagerung.de/language=de/taps=7012/17134, accessed on February 21, 2014.

produced in Germany to be disposed of in the Gorleben salt dome at a depth of around 800 meters.

The final disposal costs for nuclear waste are still not known, but they are estimated to be in the high double-digit billion euro range.³⁵ It is unclear whether the operators³⁶ will have sufficient provisions to cover these costs.³⁷ The possibility cannot be ruled out that this process will also require the investment of more public money.³⁸ Therefore, although the CDU/CSU-SPD coalition agreement states that “we expect the operators to bear the costs for nuclear waste and the dismantling of the nuclear power plants,” at the same time “there must be a new system for the sharing of costs,” including, inter alia, for the dismantling of power plants and safe storage and disposal of radioactive waste. The central and Länder governments are keen to hold talks on these issues.

However, the situation regarding the disposal of low- and intermediate-level radioactive waste is also unclear. Thousands of barrels of low and intermediate-level radioactive waste were deposited in the former salt mines in Morsleben and Asse, for example. Both of these repositories are now in danger of collapsing. The plan is to backfill the Morsleben repository and the nuclear waste deposited there with salt concrete at an estimated cost of 2.2 billion euros³⁹ for radiation protection, according to the Federal Office for Radiation Protection (Bundesamt für Strahlenschutz). On the other hand, the 125,000 storage containers in Asse will be recovered in an even more expensive retrieval operation. Since this process will continue well into the 2030s, the salt mine will be injected with concrete to delay its collapse. Further, at least one new mine shaft will have to be drilled since the existing shafts are not suitable for salvaging the containers. The storage drums, the condition of which can, to a certain extent, only be speculated upon due to their inaccessibility, will then have to be conditioned, i.e., packaged for final disposal. Although the Konrad repository has a permit for the final disposal of low- and intermediate-level radioactive waste, it will, however, not become operational in this decade. Further, its capacity is also limited: the authorized 303,000 cubic meters are not enough to accommodate all the low- and inter-

mediate-level radioactive waste from Asse as well as the other nuclear power stations that are still to be decommissioned. The Federal Office for Radiation Protection is therefore currently planning another interim repository site, including a conditioning plant, to be built as close as possible to Asse. The associated costs are likely to be borne by German tax-payers.

Conclusion and Economic Policy Implications

Globally, nuclear power is being phased out: it does not constitute an economical energy source since a wide range of cost components—insurance, dismantling, and the final disposal of fuel rods, for example—have been overlooked. There is not a single nuclear power station in the world that was built under competitive market conditions. In recent years, the West has observed an overall reduction in the capacity of nuclear power stations, whereas Asia has seen an increase. This can, however, by no means be considered to be a “nuclear energy renaissance”: ongoing expansion projects are concentrated in a small number of countries, primarily China. In Japan, the prospects for nuclear power are uncertain in the wake of the nuclear disaster in Fukushima in 2011. Global installed nuclear capacity is stagnating and its relative share of electricity production is on the decline.

The future significance of nuclear power in Europe is the subject of some controversy. Germany, Switzerland, and Belgium have opted for a nuclear phase-out and the Italian population rejected plans to restart its nuclear program following a referendum on the issue. Costs for the ongoing construction of new reactors in Finland and France have skyrocketed, making these reactors the most expensive power plants ever to be built.

The European Commission’s scenario framework portrays a very optimistic image of nuclear power which, according to DIW Berlin, is based on implausible assumptions, however. The costs shown in the EU reference scenario do not cover the actual social costs, and the cost effectiveness of nuclear power stations derived from these figures does not reflect reality. In view of unresolved safety and final disposal issues, the EU and its member states should refrain from further promoting nuclear energy. The tightening of safety assessments (“stress tests”) for existing nuclear power plants planned by the European Commission should be implemented as soon as possible.

Policy-makers should actively address the issue of final disposal of nuclear waste which has been neglected to date. During the process of dismantling existing pow-

³⁵ Forum ökologisch-soziale Marktwirtschaft, Rückstellungen für Rückbau und Entsorgung im Atombereich – Thesen und Empfehlungen zu Reformoptionen (2012), 10.

³⁶ As of December 31, 2011: approximately 33.5 billion euros, see Forum ökologisch-soziale Marktwirtschaft, Rückstellungen für Rückbau und Entsorgung, 37.

³⁷ See VDI-Nachrichten, January 27, 2012, 5.

³⁸ See Deutschlands Zukunft gestalten, 60.

³⁹ M. Von Deggerich and M. Fröhlingdorf, “Merkels Altlast,” Der Spiegel 43, October 20, 2008, 43–48, www.spiegel.de/spiegel/print/d-61366517.html.

er plants, fierce debates over cost-sharing have materialized: true to the “polluter pays” principle, nuclear power station operators should be required to comply with their obligations as far as possible. Member states are requested to develop robust strategies to address the final disposal issue.

With its nuclear phase-out, Germany is moving toward a sustainable energy policy. The German phase-out makes economic sense and does not jeopardize the country’s security of supply. Currently, there is nothing to stop the Grafenrheinfeld nuclear power station being decommissioned by December 2015 at the latest.

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Keywords: Nuclear energy, power, waste disposal, modeling

Coal Power Endangers Climate Targets: Calls for Urgent Action

Von Pao-Yu Oei, Claudia Kemfert, Felix Reitz, and Christian von Hirschhausen

Coal-fired power plants are responsible for around a third of the total carbon dioxide emissions in Germany. Failure to reduce the persistently high level of coal-based power generation puts Germany's climate targets for 2020 and 2050 at risk and undermines a sustainable energy transition. Calculations by DIW Berlin and other expert opinions prove that, in the long term, lignite in particular will no longer be relevant to Germany's energy mix. However, if the prices for CO₂ emissions allowances in the European Emissions Trading System do not rise considerably in the foreseeable future, a market-driven transition from coal to less CO₂-intensive energy sources such as natural gas is unlikely to occur.

Besides reforming the European Emissions Trading System, various other ways of reducing coal-based power generation are currently under discussion. These include the introduction of minimum efficiency levels or stricter flexibility requirements, national minimum prices for CO₂ emissions allowances, capacity mechanisms, a residual emissions cap for coal-fired power plants, CO₂ emissions performance standard, and network development planning that respects climate targets. These proposals apply to both new and existing coal-fired power plants.

Global coal-based power generation is not compatible with international climate targets. In its Fifth Assessment Report, the Intergovernmental Panel on Climate Change (IPCC) also sees coal-based power generation as having no long-term prospects.¹ In many countries, measures or proposals aimed specifically at reducing coal-based power generation are already in place.² Last year, for example, following a decision to quit coal-fired power generation, the UK introduced CO₂ emissions performance standards (EPS) for new and retrofit coal-fired plants.³ Similar EPS mechanisms also exist in Canada and in the US State of California. Furthermore, in January 2014, the US Environmental Protection Agency (EPA) published a proposal for the introduction of EPS for the USA.⁴ In June 2014, the EPA also announced its Clean Power Plan, which aims to substantially reduce CO₂ emissions, particularly from existing coal-fired power plants.⁵

A public discussion centering around the future role of coal-based power generation can also be found in Germany,⁶

¹ See IPCC, Climate Change 2014: Mitigation of Climate Change. Working Group III, Summary for Policymakers (2014).

² For an overview, see D. Schäuble, D. Volkert, D. Jacobs, and K. Töpfer, "CO₂-Emissionsgrenzwerte für Kraftwerke – Ausgestaltungsansätze und Bewertung einer möglichen Einführung auf nationaler Ebene," IASS Working Paper (April 2014).

³ See British Parliament, Energy Act 2013, chapter 8 (2013), 56–62.

⁴ Federal Register, Standards of Performance for Greenhouse Gas Emissions From New Stationary Sources. Electric Utility Generating Units, vol. 79, no. 5, 8 (January 2014).

⁵ Environmental Protection Agency (EPA), Environmental Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units, Proposed Rule, Docket No. EPA-HQ-OAR-2013-0602, provisional source (pending publication in Federal Register), June 2, 2014.

⁶ See Energy Brainpool, Negative Strompreise: Ursachen und Wirkungen, study commissioned by Agora Energiewende (June 2014); enervis energy advisors, Der „ideale Kraftwerkspark“ der Zukunft, study commissioned by Trianel GmbH (May 6, 2014).

where the focus is on a lignite phase-out.⁷ That said, there has also been some discussion about the future structure of the hard coal industry.⁸ Coal-based power generation is not in line with the emissions targets pursued by the German government; in relation to this, both the Climate Agenda 2020 of the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) and the German government's Climate Protection Plan 2050 are of the essence. This issue of Economic Bulletin takes a look at specific climate protection instruments used to reduce coal-based power generation.⁹

Coal-Based Power Generation Poses a Risk to Climate Targets

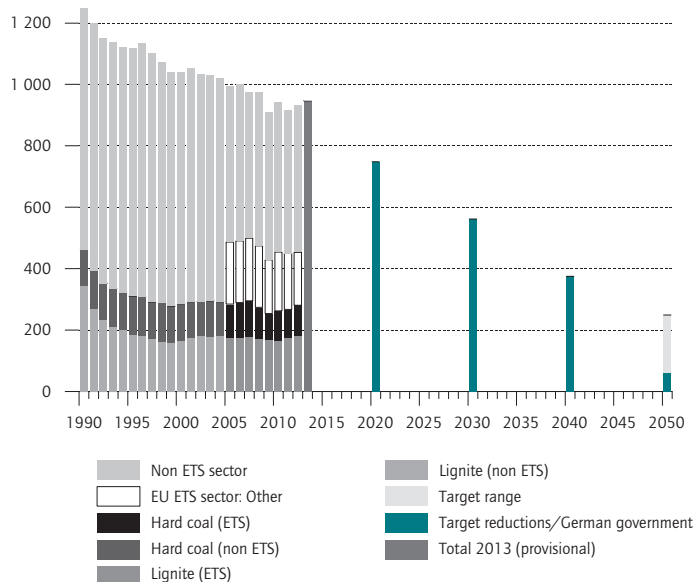
The need for action is pressing: in Germany, a look at greenhouse gas emissions since 1990 shows that CO₂ reductions in recent years were not achieved in the area of coal-based power generation, although this very area is in dire need of reductions in carbon dioxide emissions if climate targets are to be met (see Figure 1).

In 2013, coal-based power generation increased to 283 terawatt hours (TWh) (cf. 2012: 277 TWh and 265 million tons of CO₂, which is equivalent to 84 percent of the total CO₂ emissions produced through power generation in Germany). At the same time, Germany's net electricity exports for 2013 reached an all-time high of 34 TWh (cf. 2012: 23 TWh). In 2013, a total of 122 TWh of electricity was generated in hard-coal-fired power plants (cf. 2012: 116 TWh, which is equivalent to 98 million tons of CO₂).¹⁰

At present, Germany has an installed capacity of around 20 gigawatts at more than 60 lignite-fired power plant units located mainly in the Rhineland (around 10 gigawatts), in central Germany and Helmstedt (around 3 gigawatts) as well as in Lusatia (around 7 gigawatts). For many years now, lignite has accounted for around 25 percent of the total power generation in Germany. In recent years, lignite-based power generation has increased once again, totaling around 161 terawatt hours

Figure 1

Greenhouse Gas Emissions in Germany (MMTCO₂e)



Source: AG Energiebilanzen (2013); UBA (2014).

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The coal industry is not accountable for the CO₂ reductions achieved in recent years.

in 2013.¹¹ The resultant 170 million tons of CO₂ are responsible for half the total CO₂ emissions produced in the power sector.¹²

Against this background, Germany is running the risk of falling drastically short of its goal to cut CO₂ emissions by 40 percent from 1990 levels by 2020. Moreover, according to an analysis by energy experts from Agora Energiewende, the aim should be to cut lignite and hard coal-based power generation by 62 percent and 80 percent, respectively, by 2030.¹³

Lignite No Longer Part of Sustainable Energy Mix in the Medium Term

Producing 1,161 grams of CO₂ per kilowatt hour (kWh) of electricity produced, lignite is by far the biggest producer of greenhouse gas emissions in our energy mix

⁷ See C. Gerbaulet, J. Egerer, P.Y. Oei, and C. von Hirschhausen, "Abnehmende Bedeutung der Braunkohleverstromung: Weder neue Kraftwerke noch Tagebaue benötigt," Wochenbericht des DIW Berlin, no. 48 (2012).

⁸ www.faz.net/aktuell/wirtschaft/wirtschaftspolitik/energie-einsammel-becken-fuer-deutsche-kohlekraftwerke-12816873.html, May 28, 2014.

⁹ This report is based, inter alia, on a comprehensive study conducted by P.Y. Oei, C. Kemfert, F. Reitz, and C. von Hirschhausen, "Braunkohleausstieg - Gestaltungsoptionen im Rahmen der Energiewende" DIW Berlin Politikberatung Kompakt 84.

¹⁰ AGEB, Bruttostromerzeugung in Deutschland von 1990 bis 2013 nach Energieträgern (2014); and P. Icha, "Entwicklung der spezifischen Kohlendioxid-Emissionen des deutschen Strommix in den Jahren 1990 bis 2012" Climate Change 07 (UBA, 2013).

¹¹ AGEB, Bruttostromerzeugung in Deutschland.

¹² UBA, Greenhouse Gas Emissions in Germany 2013 (March 2014).

¹³ Agora Energiewende, The German Energiewende and its Climate Paradox. Causes and Challenges (2014).

(cf. hard coal: 902 g CO₂/kWh; natural gas: 411 g CO₂/kWh).¹⁴ In addition, burning lignite produces local pollutants despite the stricter regulations for nitrogen oxides, sulfur oxides, and dust emissions that have been introduced in the past. Over and above the aforementioned pollutants, there is also the problem of particulate matter and mercury, both of which have become an increasing focus of health research.¹⁵

In an analysis of power plant and grid capacity for the mid-2020s, DIW Berlin reached the conclusion that lignite is becoming less and less relevant for Germany's energy mix.¹⁶ When nuclear power generation comes to an end in 2023, lignite capacity amounting to 17 GW will still be available as set down in the 2013 scenario framework; it must be said, however, that, even during peak load times, supply bottlenecks could still be managed without the use of the lignite-fired power plants in eastern Germany. In light of this, it is all the more surprising that it was precisely the transmission system operators that were recently preparing for lignite-fired power plants to continue operating unhindered (see box).

Controversy Surrounding Energy Policy in Remaining Coal Districts

Given the uncertain future of lignite-based power generation, it is hardly surprising that there is controversy surrounding energy policy in the lignite mining districts that remain. In March of 2014, for instance, the coalition government in the state of North Rhine Westphalia (NRW) announced its decision to reduce the mining area at Garzweiler II so as to prevent the reallocation of further 1,400 residents. This decision is the first of its kind in Germany. The North Rhine-Westphalian government also announced its intention to present a new policy decision on lignite by 2015.¹⁷ In the eastern German

Länder, there are similar controversial debates surrounding decisions to create new opencast mines (Welzow-Süd TF II in Brandenburg, Nochten II in Saxony) or expand existing ones (Vereinigtes Schleenheide in Saxony). A decision taken on Garzweiler by the German Federal Constitutional Court in 2013 has caused this situation to change: unlike in the 20th century, in the era of energy transition fossil fuel mining can no longer be seen as a public interest decision that justifies serious infringements on our fundamental right to own property.¹⁸ Similarly, job security can no longer be cited as grounds for the continuation of the lignite industry.¹⁹

Climate Agenda 2020 and Climate Protection Plan 2050

The German Federal Environment Ministry projects that, unless further measures are taken, greenhouse gas emissions in Germany will be down by as little as 33 percent by 2020 (compared to the target of 40 percent), underlining the urgent need for action on this front.²⁰ The key issue paper singles out conventional power plant complexes as an important focus of the Climate Agenda. The German government is expected to submit a cabinet resolution on this in November 2014. Moreover, the grand coalition is preparing to implement the national Climate Protection Plan 2050 set down in the coalition agreement, where power generation is expected to play a major role.

One approach the German government is pursuing is to establish instruments to combat climate change at different levels (e.g., Germany-wide and at EU level) as well as instruments with different mechanisms (including increased competition in emissions trading and regulatory technical specifications). This would provide the basis for the urgent action required for (national) targets to be met at European level, for example, by working towards an ambitious structural reform of the Eu-

¹⁴ The average CO₂ emission factors refer to power consumption for the year 2010, see UBA, Greenhouse Gas Emissions in Germany. More modern plants, in contrast, emit around 940 g/kWh for lignite, 735 g/kWh for hard coal, and 347 g/kWh for natural gas-based power plants, see UBA, "Klimaschutz und Versorgungssicherheit. Entwicklung einer nachhaltigen Stromversorgung," Climate Change 13 (2009).

¹⁵ Oei, "Braunkohleausstieg - Gestaltungsoptionen im Rahmen der Energiewende"; see also B. Breitschopf and J. Diekmann, Vermeidung externer Kosten durch Erneuerbare Energien - Methodischer Ansatz und Schätzung für 2009 (MEECK), study commissioned by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) as part of the project "Einzel- und gesamtwirtschaftliche Analyse von Kosten- und Nutzenwirkungen des Ausbaus Erneuerbarer Energien im deutschen Strom- und Wärmemarkt," and conducted by the Fraunhofer Institute for Systems and Innovation Research (ISI) and DIW Berlin.

¹⁶ See Gerbaulet et al., "Abnehmende Bedeutung der Braunkohleverstromung."

¹⁷ Here, the decision to call off plans for the last segment is more or less guaranteed. Concentrating sooner on the open-cast mine in Hambach could

even result in the premature closure of Garzweiler II before it reaches the perimeter of the A61 highway. This would prevent as many as 3,000 residents from having to be resettled and the highway moved.

¹⁸ Art. 14 German Basic Law (Grundgesetz). See C. Ziehm, Neue Braunkohlentagebaue und Verfassungsrecht - Konsequenzen aus dem Garzweiler-Urteil des Bundesverfassungsgerichts. Brief report commissioned by a parliamentary group of Bündnis 90/Die Grünen (Alliance 90/the Green Party) (Berlin: May 2014).

¹⁹ In all three mining regions, open-cast mining activities and power plant operation have decreased dramatically. Today, in fact, more people are employed in the renewable energy sector in the affected German Länder (North Rhine-Westphalia, Brandenburg, Saxony, and Saxony-Anhalt) than in the lignite industry. In addition, since more than 70 percent of these employees are aged 40 years or over, a majority would be retiring at the same time as lignite power generation would be being phased out.

²⁰ See BMUB, Aktionsprogramm Klimaschutz 2020. Eckpunkte des BMUB (2014).

Box

More Network Capacity for More Lignite-Fired Power Plants? Proposal for Electricity Network Scenarios 2015

On April 30, 2014, German transmission system operators published the proposal for electricity network scenarios in Germany. The proposal contains network development scenarios that, following public consultation and scrutiny, will form the basis of the future network development plans created by the German Federal Network Agency. The proposal focuses on the continuously high use of lignite in the future and limits that of relatively environmentally compatible natural gas-fired power plants. Transmission system operators are pushing, on no obvious grounds,

the use of an energy mix that is not in line with the medium-term climate targets the German government is working toward.

The scenario proposal contains three scenarios based on different energy mixes. With regard to renewable energy sources, the scenarios concentrate mainly on the German Renewable Energy Sources Act (Erneuerbare-Enerigen-Gesetz, EEG) amendment bill. In the area of conventional power plant capacities, unlike in previous network scenarios, the proposal shows a trend towards continuously high lignite capacities that is somewhat remarkable: instead of planning to close down lignite-fired power plants after 50 years (technical service life), as has been the case to date, the plan is now to factor in the capacities of associated open-cast mines. This would also imply that longer life time or even the construction of new lignite power plants could be given as justification for opening new open-cast mines.

Scenario A contains the construction of two new lignite power plants: one in the Rhineland (Niederaußem) and one in central Germany (Profen). Furthermore, this new role that lignite has taken on in the network planning scenarios has led to an increase in lignite capacity for 2025 from 15.3 GW (as per former network scenarios) to 19.6 GW, which is equivalent to a 4,300 MW increase (Scenario B); the figure for 2035 remains 2,000 MW higher (see Figure).

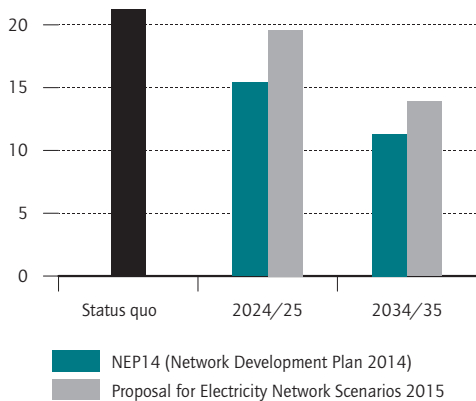
The scenario planning would have a particularly strong impact on the 40 to 48-year-old lignite fired power plant complexes in North Rhine-Westphalia that have low efficiency levels (32-37 percent) and high specific CO₂ emissions (1,200 to 1,300 g per kWh): leaving these power plants online past their intended life time would lead to a huge increase in CO₂ emissions and is not compatible with the pollution control laws of the state of North Rhine-Westphalia, either.¹

¹ See Oei et al., "Braunkohleausstieg - Gestaltungsoptionen im Rahmen der Energiewende".

Figure

Capacity Assumptions for Electricity Network Planning

Gigawatts of installed output



Sources: 50 Hertz; Amprion; Tennet; TransnetBW; network development plans 2014; Scenario frame for electricity network scenario planning 2015 – proposal of the transmission system operators, April 30, 2014.

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Transmission system operators expect lignite-fired power plants to stay online longer.

ropean Emissions Trading System (EU ETS) as well as including options for additional measures in the specific German context of energy transition. The key issue paper also clearly states that this is not about establishing mutually exclusive instruments or mechanisms, but about taking action in several areas simultaneously. The paper cites three possible courses of action: greater commitment outside the framework of the EU ETS,

a focus on an ambitious structural reform of the EU ETS, and flanking measures within the context of energy transition.

Table 1

Possible Instruments for Reducing Coal-Based Power Generation

	Effect	Possible advantages	Possible shortcomings	Proposed by
ETS reform	Price signal through the introduction of market stability reserve (MSR), 900 million backloading allowances directly in MSR, start of MSR in 2017 instead of 2021	EU-wide instrument; thus, no cross-border leakage effects	Structural reforms uncertain from today's perspective; the extent of the impact is unpredictable	German government (2014)
Min. CO ₂ price	CO ₂ certificates would become more expensive	Investment security for investors	Feasible prices probably too low to result in a switch from coal towards natural gas; implementation at national level problematic	Alliance 90/the Green Party (2014)
Minimum efficiency level	Closure of inefficient power plants	More efficient utilization of raw materials	Open cycle gas turbines (OCGT) would also be affected; complex and time-consuming test and measurement processes	Alliance 90/the Green Party (2009)
Flexibility requirements	Closure or singling out of inflexible power plants	Better integration of fluctuating renewable energy sources	Combined cycle gas turbines (CCGT) would also be affected; complex and time-consuming test and measurement processes	Öko-Institut/LBD/Raue (2012)
Coal phase-out law	Maximum Production or emissions allowances	Fixed coal phase-out plan & schedule	Auctioning difficult to predict	Greenpeace (2012), DIE LINKE (2014)
Emissions performance standard (specifically for new plants and retrofits)	Restrictions for new plants and retrofits (without CO ₂ capture)	Prevention of CO ₂ -intensive investments	Minor short-term reduction in emissions	IASS (2014)
Emissions performance standard (emissions cap for existing plants)	Reduce load factor for older coal-fired power plants that have been written off	Maintenance of generation capacities, e.g., by shifting into a strategic reserve	Negative impact on economic efficiency of power plants; effect on energy efficiency unclear	IASS (2014)

Source: Oei et al., "Braunkohle und die Energiewende".

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Different Instruments under Discussion

Possible flanking measures to reduce coal-based power generation include minimum energy efficiency levels or greater flexibility requirements, national minimum prices for CO₂ emissions allowances, capacity mechanisms, a residual emissions cap for coal-fired power plants, and emissions performance standards (see Table 1). In Germany, these could be implemented parallel to the desired reform of the EU ETS.

Reform of European Emissions Trading System

The EU ETS is one of the European Union's central instruments for combating climate change. In the medium term, however, emissions trading will not be sending out price signals that will foster the move away from lignite as a source of energy toward other, less CO₂-intensive energy sources; this is due to inherent structural deficits, low flexibility, high volatility, and a lack of political consensus at European level. Depending on the ef-

iciency level of the given power plant, this critical CO₂ price starts at around 40 euros per ton of carbon dioxide emitted; for hard coal, the corresponding figure is around 20 euros (see Figure 2).²¹

To address the huge surplus of emissions allowances that has accumulated, the European Union has passed an amendment according to which the auctioning of 900 million carbon emissions allowances for 2014-2016 will be postponed to 2019 and 2020 (backloading). The European Commission expects the overall surplus to fall initially; however, by the end of the third trading period in 2020, the surplus is expected to be even bigger than it is today.²² Nonetheless, the possible solutions to the surplus problem currently being discussed by the

²¹ See Oei et al. "Braunkohleausstieg - Gestaltungsoptionen im Rahmen der Energiewende" para. 5. Calculated on the basis of mean raw material prices between 2011 and 2013.

²² See K. Neuhoﬀ, and A. Schopp, "Europäischer Emissionshandel: Durch Backloading Zeit für Strukturreform gewinnen," Wochenbericht des DIW Berlin, no. 11 (2013).

European Commission will apply to the fourth trading period beginning in 2021 only. For this phase, the Commission proposes introducing what is known as a market stability reserve.²³ Emissions trading could be more effective, and would have a more immediate impact, if the German government were to come through on their recently announced objective to transfer the backloading certificates directly to the market stability reserve instead of opening them up to auction in 2019 and 2020. This would allow the reform of the EU ETS to begin to take effect as early as 2017²⁴ which would be very important for the credibility of the system and would bolster European climate policy, although it would have a limited impact on compliance with short-term national emissions targets for 2020. For this reason, additional national instruments are under discussion which could be introduced in parallel to emissions trading.

Minimum CO₂ Price

To strengthen emissions trading, a minimum price for CO₂ emissions could be set at European level.²⁵ National governments, however, could also set their own individual minimum prices to help meet climate targets. In 2013, for example, the UK introduced an additional tax on carbon dioxide emissions in the power sector known as the Carbon Price Floor (CPF).²⁶ Together, the tax and CO₂ price make up a “minimum price” for CO₂ emissions. For the 2013/14 financial period, the minimum price is 16 GB pounds (around 20 euro) for each ton of CO₂ emitted. Originally, this was to increase linearly to 30 GB pounds per ton by 2020/2021, but this figure was frozen at 18 GB pounds for the rest of the decade.²⁷ In Germany, the introduction of a minimum CO₂ price

²³ For a surplus of more than 833 million allowances, this mechanism would automatically transfer 100 million allowances to a reserve to ensure that emissions certificates are sufficiently scarce on the emissions trading market. If the number of permits in circulation dips below the surplus threshold of 400 million, allowances would be released from the reserve once again. See also W. Acworth, “Can the Market Stability Reserve Stabilise the EU ETS: Commentators Hedge Their Bets,” DIW-Roundup 23, 4 (2014).

²⁴ www.bmub.bund.de/P3383/.

²⁵ See J. Diekmann, “EU-Emissionshandel: Anpassungsbedarf des Caps als Reaktion auf externe Schocks und unerwartete Entwicklungen?,” Climate Change 17 (UBA, 2012).

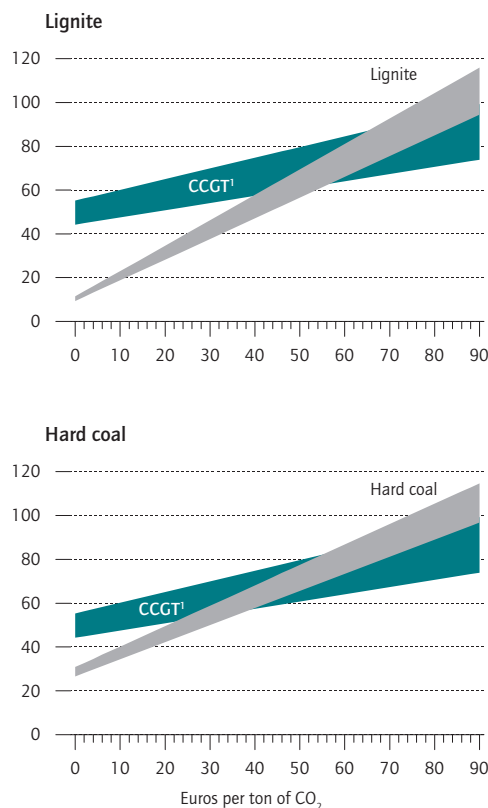
²⁶ HM Revenue & Customs, Carbon Price Floor (2013), www.hmrc.gov.uk/climate-change/levy/carbon-pf.htm, accessed on June 8, 2014.

²⁷ The grounds for this decision were the large gap between this and the CO₂ price in the ETS scheme, which would have a negative impact on the competitiveness of the UK's domestic industry. See Carbon price floor: reform and other technical amendments, www.gov.uk/government/uploads/system/uploads/attachment_data/file/293849/TIIN_6002_7047_carbon_price_floor_and_other_technical_amendments.pdf, accessed on April 29, 2014; Budget 2014 speech by UK Chancellor George Osborne, www.gov.uk/government/speeches/chancellor-george-osborne-budget-2014-speech, accessed on April 29, 2014.

Figure 2

Incremental Costs in Power Generation Incl. Different CO₂ Prices

In euros per megawatt hour



1 Combined-cycle gas and steam turbines.

Source: calculations by DIW Berlin.

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Gas-fired power plants overtake lignite power plants at a carbon price of around 40 euros per ton and above.

in the form of an additional tax on the purchase of CO₂ emissions allowances, as proposed in a bill by Bündnis 90/Die Grünen (Alliance 90/the Green Party), would be possible.²⁸ Under current energy tax laws in Germany, power plant operators are expressly exempt from the existing energy tax,²⁹ and plans are in place to remove this tax altogether. In all likelihood, however, a government-fixed minimum price on carbon emissions would

²⁸ A Climate Change Act bill recently proposed by the parliamentary group Bündnis 90/Die Grünen (Alliance 90/The Greens) calls for the introduction of a minimum price for CO₂ similar to that in the UK. According to the bill, the CO₂ price was to start at 15 euros/t in 2015 and increase by one euro per ton per annum until 2020. See German Bundestag (Entwurf eines Gesetzes zur Festlegung nationaler Klimaschutzziele und zur Förderung des Klimaschutzes (Klimaschutzgesetz), Bundestag printed paper 18/1612 (Berlin: June 3, 2014).

²⁹ Part 37, Section 2 of the German Energy Tax Act (EnergieStG).

Table 2

Technical Data for Gas- and Coal-Fired Power Plants

	Start-up time in hrs.	Min. load in %	Efficiency at rated power P_{rated} in percent	Efficiency at 50 % of P_{rated} in percent
Open-cycle gas turbine (OCGT)	< 0.1	20-50	30-35	27-32
Combined-cycle gas turbine /standard	0.75-1.0	30-50	58-59	54-57
Combined-cycle gas turbine /flexible	0.5	15-25	> 60	52-55
Hard coal /standard	2-3	40	42-45	40-42
Hard coal /flexible	1-2	20	45-47	42-44

Source: VDE (2012).

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In terms of adaptability to the given demand, modern coal-fired power plants are not much more latent than combined-cycle gas and steam power plants.

have very little impact on coal-based power generation unless switches prices to gas are being met.

Minimum Efficiency Levels and Greater Flexibility Requirements

Innovations in the energy sector have long since focused on increasing efficiency levels; the main motivation behind this, however, was competition and not regulatory measures. Further advances in this field are hindered by tight technical restrictions.³⁰ In Germany, a bill to introduce a minimum efficiency level put forward by the Green Party parliamentary group in the German Bundestag in 2009, for example, failed.³¹ The bill proposed an amendment to the Federal Immission Control Act (Bundesimmissionsschutzgesetz, BImSchG) which would require all newly built power plants to have a minimum efficiency level of 58 percent. Existing hard coal and lignite power plants would have to have a minimum efficiency factor of 38 and 36 percent, respectively. In 2020, these figures were to be increased to 40 and 38 percent. The existing legal hurdle for efficiency requirements³² was also to be removed. At 40-percent efficiency and above, the introduction of minimum efficiency levels for power plants, including existing plants, would affect

more than 10 GW of Germany's lignite capacity. However, if a general, non-technology-specific minimum efficiency level were to be introduced, this would affect not only coal-fired power plants but also open cycle gas turbines (OCGT) that have similar efficiency levels to coal-fired power plants (see Table 2). Owing to their flexibility, however, open-cycle gas turbines power plants are an essential part of an energy mix based on a high percentage of fluctuating renewable energy sources.

Given the steady increase in the share of renewables in our energy mix, the flexibility of conventional power plants becomes increasingly important. The key benchmarks for flexibility are the short-term ability to change production levels, minimum must-run generation, the start-up as well as ramping times, and the minimum run-time of a power plant. Irrespective of what fuel is used, steam power plants, in particular, face certain technical restrictions. The introduction of flexibility requirements would therefore apply not only to coal-fired plants but also to combined cycle gas power plants (CCGT plants).³³ Owing to the combined use of gas and steam, these gas-driven power plants can achieve higher efficiency levels; they are not as flexible, however, as open-cycle gas turbines that run without steam. Both the minimum generation (must-run) and the maximum start-up times of CCGT plants are similar to those of coal-fired power plants.

Provided they are not introduced as fuel-dependent or as combined power generation regulations, this means that in some cases minimum efficiency levels and flexibility requirements would affect either open cycle or combined cycle gas power plants in addition to coal-fired power plants. These instruments are therefore not primarily suitable for reducing coal-based power generation.

Coal Phase-Out through Residual Emissions Cap

A coal phase-out law based on allocated remaining production or emissions allowances, if introduced, could include a fixed time frame for phasing out coal-based power generation in Germany. A specific scenario for coal phase-out on the basis of fixed production allowances was described in a study conducted by Ecofys on behalf of Greenpeace in 2012.³⁴ An alternative means of combatting climate change would be to introduce a residual

³⁰ Coal pre-drying or retrofit measures would lead to insignificant increases in efficiency in the region of a few percent.

³¹ See German Bundestag, Neue Kohlekraftwerke verhindern – Genehmigungsrecht verschärfen, Bundestag printed paper 16/12916 (Berlin: May 7, 2009).

³² Part 5, Section 2 of the German Federal Immission Control Act (BImSchG), http://www.bmub.bund.de/fileadmin/bmu-import/files/english/pdf/application/pdf/bimschg_en_bf.pdf.

³³ See Association for Electric, Electronic & Information Technologies (VDE), Erneuerbare Energie braucht flexible Kraftwerke – Szenarien bis 2020 (Frankfurt am Main: 2012).

³⁴ Ecofys, Allokationsmethoden der Reststrommengen nach dem Entwurf des Kohleausstiegsgesetzes, study commissioned by Greenpeace (Nuremberg: May 24, 2012). See also the motion made by DIE LINKE parliamentary group, German Bundestag, Energiewende durch Kohleausstiegsgesetz absichern, printed paper 18/1673 (Berlin: June 5, 2014).

emissions cap for coal-fired power plants, where the total residual CO₂ emissions would be allocated to the individual power plants on the basis of “historical” emissions (free allocation) or by means of individual auctions. In addition to the allocation of emissions allowances by the state, this instrument could allow the transfer of residual CO₂ emissions from one power plant to another.³⁵

Supply Security and Capacity Mechanisms

The discussion surrounding capacity mechanisms³⁶ also has to include aspects that concern climate policy. Specifically, different scenarios affect the energy mix differently and, consequently, the CO₂-intensity of future power generation. Put in simple terms, the more the existing power plant fleet is being supported, the more CO₂ intensive it will be. Having one instrument for gas power plants alone (for example, the establishment of minimum flexibility requirements or emissions performance standards)³⁷ would help make these plants more profitable; this would not, however, in short-term result in an automatic adjustment of the ranking (merit order) of the power plants, nor would it bring about a reduction in CO₂ emissions in Germany. What this debate about capacity instruments does, however, is provide a platform for negotiations with the operators of coal-fired power plants. Future regulations on capacity mechanisms, for instance, could contain conditions for CO₂ reductions.³⁸ It would also be possible to transfer coal-fired power plants into a strategic reserve. This would help cut emissions while retaining capacity. In turn, investment incentives for gas power plants would increase, and power plant operators would be given compensation for complying with the given capacity requirements.

³⁵ Worth considering are the effects of transferring residual emissions from lignite plants which are directly linked to their nearby open-cast mines. A conceivable solution would be to impose requirements that the transfer of emissions permits would only be allowed if it prevented the reallocation of additional citizens.

³⁶ See K. Neuhoﬀ, J. Diekmann, C. Kemfert, W.-P. Schill, S. Schwenen, T. Traber, and C. von Hirschhausen, “Energiewende und Versorgungssicherheit: Deutschland braucht keinen Kapazitätsmarkt”, Wochenbericht des DIW Berlin, no. 48 (2013); see also W.-P. Schill and J. Diekmann, “Die Kontroverse um Kapazitätsmechanismen für den deutschen Strommarkt”, DIW Roundup, no. 5 (2014).

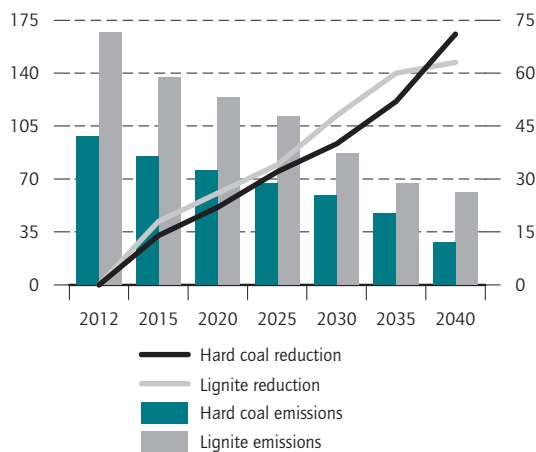
³⁷ See Öko-Institut, LBD, Raue, Fokussierte Kapazitätsmärkte. Ein neues Marktdesign für den Übergang zu einem neuen Energiesystem (Berlin: 2012).

³⁸ In the Netherlands, for example, agreements have been made with individual operators who, owing to the coal tax being abolished, have agreed to the closure of coal-fired power plants with a total capacity of 3 GW earlier than planned by 2017.

Figure 3

CO₂ Emissions Produced by Coal-Fired Power Plants in Germany if Emissions Caps Were Introduced

In millions of tons of CO₂ per year or in percent



Source: Ziehm et al., *Neue Braunkohlentagebaue*.

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Lignite-based power generation, in particular, would be curbed by emissions caps.

Emissions Performance Standard

In addition to the EU ETS, another means of tackling the emissions problem that has been increasingly discussed in recent years in many countries is the possible introduction of CO₂ limits in the form of an Emissions Performance Standard (EPS). Following in Canada and California's footsteps, the UK has already incorporated this into an amendment of its Energy Act which was passed in December 2013. This basically prevents the construction of new coal-fired power plants (that do not make use of carbon capture). In Canada, this standard has also been extended to existing power plants.

The introduction of an Emissions Performance Standard in Germany is permissible under European Law, Article 193 of the Treaty on the Functioning of the European Union (TFEU).³⁹ One obstacle, however, is the “barring clause” in the Federal Immission Control Act which would then have to be removed.

³⁹ See C. Ziehm, *Zur Zulässigkeit nationaler CO₂-Grenzwerte für dem Emissionshandel unterfallende neue Energieerzeugungsanlagen* (Berlin: 2013).

Table 3

Annual CO₂ Emissions in Coal-Based Power Generation in the Case of the Introduction of Emissions Performance Standards

	Hard coal	Lignite	Coal, (Total)	Hard Coal	Lignite	Coal (Total)
	In millions of metric tons of CO ₂ per year			Difference to 2012 in percent		
2012	98	167	265	0	0	0
2015	85	137	222	-14	-18	-16
2020	76	124	200	-22	-26	-24
2025	67	111	177	-32	-34	-33
2030	59	87	145	-40	-48	-45
2035	47	67	114	-52	-60	-57
2040	28	61	89	-71	-63	-66

Source: Ziehm et al. (2014), *Neue Braunkohlentagebaue*.

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CO₂ emissions from coal-fired power plants could be reduced by up to 66 percent by 2040.

The potential impact of an Emissions Performance Standard depends on what it entails specifically.⁴⁰ For new plants and retrofit measures, taking the UK as an example, a specific limit of 450 grams per kWh of electricity is feasible. This provision would ultimately put a stop to the construction of new coal-fired power plants. Existing plants that have been in operation for 30 years or more⁴¹ could be subject to an annual emissions cap. A regulation such as this is aimed at the oldest and least efficient power plants without jeopardizing existing plants' "grandfather" status. In this case, the performance standard involves limiting the maximum net annual emissions to 3,154 tons of CO₂ per megawatt⁴² and, depending on the given emissions factor and efficiency levels of the individual plants, is equivalent to a load factor of around 90 to 100 percent for gas and steam power plants, 40 to 50 percent for hard-coal-fired power plants, and around 30 to 40 percent for lignite power plants. Separate regulations would be applicable to combined heat and power (CHP) plants.

Hard-coal-fired power plants with a total output of around 10.5 gigawatts and lignite plants with around 9.5 giga-

watts would be affected by the regulation for existing plants in 2015. The annual power generation of these plants would thus fall by 45 terawatt hours. Other 1.5-gigawatt coal-fired power plants that are also more than 50 years old would be closed down, since retrofit measures would not be allowed, nor would the construction of new plants. The number of coal-fired power plants falling under this regulation would increase over time thus leading to a continuous reduction of overall CO₂ emissions (see Figure 3). This would take emissions levels down by around 24 percent (65 million tons of CO₂) by 2020, and by around 66 percent⁴³ (176 million tons) by 2040 compared with 2012 levels (see Table 3).⁴⁴ The emission of other pollutants would also be avoided in the process.

Conclusion

Coal-based generation continues to account for a large proportion of our energy supply and hence CO₂ emissions in Germany, making it all the more difficult for climate targets to be met and a sustainable energy transition to take place. The need for action on the energy and climate policy front is therefore a very pressing matter.

The European Emissions Trading System (EU ETS) is a central component of EU policy on combating climate change. At the moment, however, its steering capacity is rather limited, which is why the German government's proposal to reinforce emissions trading is very much welcomed. This would be an important signal as regards the credibility of the EU ETS and would help bolster European climate policy. This would, however, do very little in the way of helping to meet short-term national emissions targets for 2020. Continued large-scale coal-fired power generation would also pose a threat to medium- and long-term climate targets. This is where additional national instruments which would be employed alongside emissions trading come into play. The following conclusions can be drawn:

- A national minimum price for CO₂ allowances would presumably not be sufficient to effect a switch from coal to natural gas.
- Minimum efficiency levels for power plants and flexibility requirements do not aim directly to reduce CO₂

⁴⁰ For a possible solution, see C. Ziehm, C. Kemfert, P.-Y. Oei, and C. von Hirschhausen, "Entwurf und Erläuterung für ein Gesetz zur Festsetzung nationaler CO₂-Emissionsstandards für fossile Kraftwerke in Deutschland," DIW Politikberatung kompakt 82, 2014.

⁴¹ Following the considerations made with regard to the nuclear phase-out, the basis of the 30-year-limit is the write-off period for power plants once this period has expired plus a given profit realization period. In this way, the plant operators can trust that their legal positions are sufficiently protected – from Article 14 German Basic Law (GG) or Article 12 German Basic Law (GG).

⁴² Calculation basis: gas power plant emissions data (450 g CO₂/kWh), the total annual operating hours at 80-percent capacity: 450 g CO₂/kWh × 8760 h × 0.8 = 3154 t CO₂/MW.

⁴³ The reduction levels include the fact that new plants or retrofits would not be possible, resulting in an automatic closure of a large proportion of older coal-fired power plants over time.

⁴⁴ Ziehm, "Entwurf und Erläuterung." Based on the average CO₂ emissions factors from the BMUB (2013). Since modern power plants have lower emissions levels, they are allowed to be operational for more hours per annum; this does not, however, affect the maximum permissible CO₂ emissions for a power plant.

emissions and, depending on specifics, would also affect gas power plants.

- A coal phase-out law with fixed production or emissions allowances for coal-fired power plants could include a fixed time frame for phasing out coal-based power generation in Germany, but is presumably not politically viable.
- The introduction of national CO₂ emissions performance standard for new and existing fossil-fired power plants could be contemplated as a specific means of reducing coal-based power generation, taking into account plant age structure.

This discussion should not focus only on the direct impact that such measures will have on CO₂ emissions in Germany, but should also factor in other aspects such as the effectiveness of the measures with regard to emissions levels in the EU as a whole, cost effectiveness in terms of economic efficiency, and energy sector effects with regard to capacity, power generation output, and electricity prices. Furthermore, the interplay between a restrictive coal policy and the EU ETS and other climate policy measures at national and European level should be taken into account. Finally, the potential for emissions reductions in the transport, building and housing sectors, and industry must not be left out of account.

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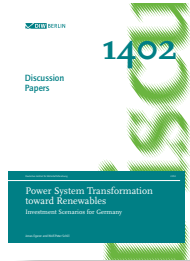
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JEL: Q48, Q52, L71, L94

Keywords: Energy transition, lignite, coal, policy instruments, ETS

Discussion Papers 1402/2014

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Power System Transformation toward Renewables: Investment Scenarios for Germany

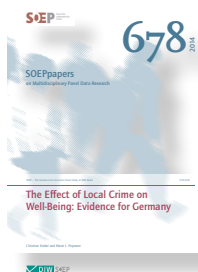
We analyze distinctive investment scenarios for the integration of fluctuating renewables in the German power system. Using a combined model for dispatch, transmission, and investment, three different investment options are considered, including gas-fired power plants, pumped hydro storage, and transmission lines. We find that geographically optimized power plant investments dominate in the reference scenarios for 2024 and 2034. In scenarios with decreased renewable curtailment, storage and transmission requirements significantly increase. In an alternative scenario with larger investments into storage, system costs are only slightly higher compared

to the reference; thus, considering potential system values of flexible pumped hydro storage facilities that are not included in the optimization, a moderate expansion of storage capacities appears to be a no-regret strategy from a system perspective. Additional transmission and storage investments may not only foster renewable integration, but also increase the utilization of emission-intensive plants. A comparison of results for 2024 and 2034 indicates that this is only a temporary effect. In the long run, infrastructure investments gain importance in the context of an ongoing energy transition from coal to renewables. Because of long lead times, planning and administrative procedures for large-scale projects should start early.

JEL-Classification: C61;H54;L94

Keywords: German energy transformation, integrated planning, renewable integration, transmission, storage
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SOEPpapers 678/2014
Christian Krekel, Marie L. Poprawe



The Effect of Local Crime on Well-Being: Evidence for Germany

This paper investigates the effect of local crime on well-being in Germany, using data from the German Socio-Economic Panel (SOEP) and a novel data set constructed from official police crime statistics, covering both counties and urban districts for the time period between 1994 and 2012. We find that local area crime has a significantly negative impact on life satisfaction, makes residents worry more frequently, and worry more about crime in Germany. In particular, a 1% increase in the crime frequency ratio results in a 0.043 standard deviation decrease in life satisfaction. This effect is driven almost exclusively by violent crimes, while property crimes and other crimes have no significant impact on well-being.

Keywords: Crime, well-being, Germany
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Discussion Papers 1405/2014

Helmut Herwartz, Konstantin A. Kholodilin



Uncertainty of Macroeconomic Forecasters and the Prediction of Stock Market Bubbles

We assess the contribution of macroeconomic uncertainty -- approximated by the dispersion of the real GDP survey forecasts -- to the ex post and ex ante prediction of stock price bubbles. For a panel of six OECD economies covering 24 years, two alternative binary chronologies of bubble periods are determined and subjected to panel logit regressions conditioning on macroeconomic indicators and expectation uncertainty. Measures of macroeconomic uncertainty improve the ex ante signalling of stock price booms and bubbles.

JEL-Classification: G01;G17;E27

Keywords: Stock market bubbles, out-of-sample forecasting, consensus forecasts, macroeconomic uncertainty, OECD countries

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