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 CO_2 emissions allowances in the European Emissions Trading System do not rise considerably in the foreseeable future, a market-driven transition from coal to less CO_2-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 CO_2 emissions allowances, capacity mechanisms, a residual emissions cap for coal-fired power plants, CO_2 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 CO_2 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 CO_2 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, "CO_2-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

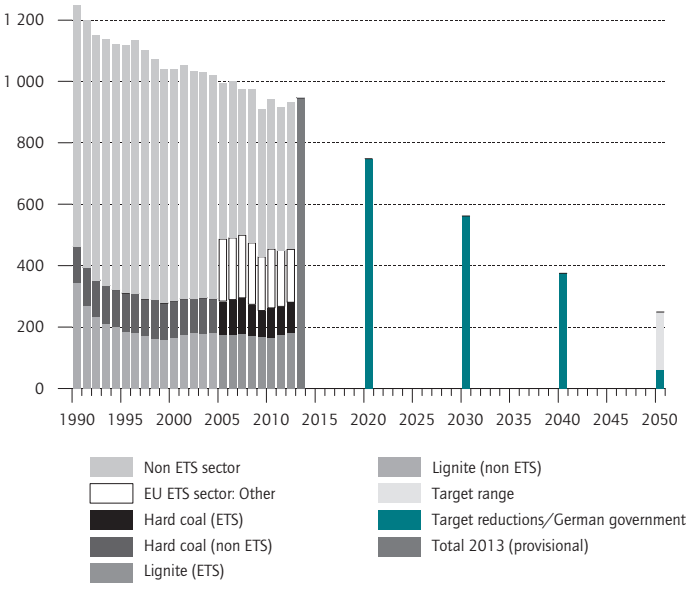
The need for action is pressing: in Germany, a look at greenhouse gas emissions since 1990 shows that CO_2 reductions in recent years were not achieved in the area of coal-based power generation, although this very area is in dire need of reductions in carbon dioxide emissions if climate targets are 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 CO_2, which is equivalent to 84 percent of the total CO_2 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 CO_2).[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 in 2013.[11] The resultant 170 million tons of CO_2 are responsible for half the total CO_2 emissions produced in the power sector.[12]

Figure 1

Greenhouse Gas Emissions in Germany
($MMTCO_2e$)



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

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The coal industry is not accountable for the CO_2 reductions achieved in recent years.

Against this background, Germany is running the risk of falling drastically short of its goal to cut CO_2 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 CO_2 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-ein-sammelbecken-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 CO_2/kWh; natural gas: 411 g CO_2/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 Schleenhein 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 CO_2 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 (MEEEK), 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.

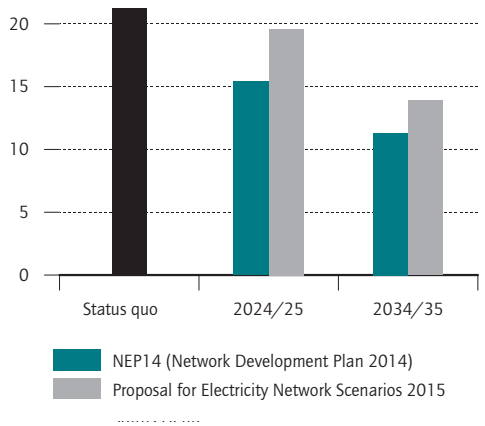
Scenario A contains the construction of two new lignite power plants: one in the Rhineland (Niederaußem) and one in central Germany (Profen). Furthermore, this new role that lignite has taken on in the network planning scenarios has led to an increase in lignite capacity for 2025 from 15.3 GW (as per 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 CO_2 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 CO_2 emissions and is not compatible with the pollution control laws of the state of North Rhine-Westphalia, either.[1]

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.

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

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

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".

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 CO_2 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 CO_2-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 efficiency level of the given power plant, this critical CO_2 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 2017[24] 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.

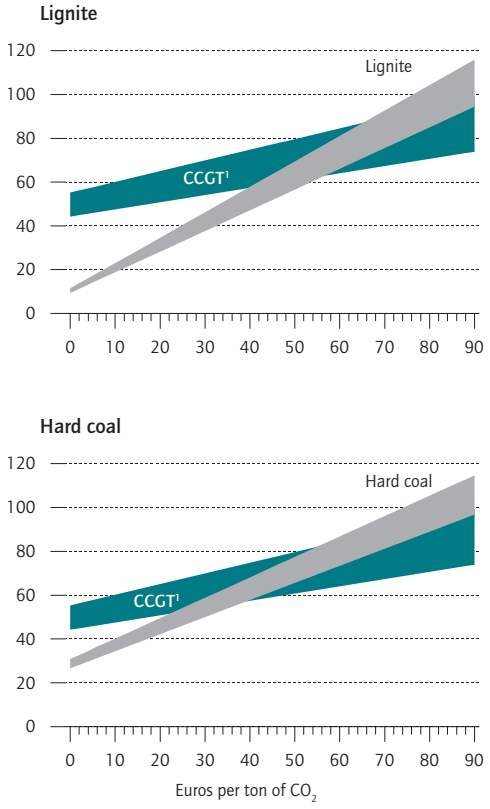
Minimum CO_2 Price

To strengthen emissions trading, a minimum price for CO_2 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 CO_2 price make up a "minimum price" for CO_2 emissions. For the 2013/14 financial period, the minimum price is 16 GB pounds (around 20 euro) for each ton of CO_2 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 CO_2 price in the form of an additional tax on the purchase of CO_2 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

Figure 2

Incremental Costs in Power Generation Incl. Different CO_2 Prices

In euros per megawatt hour



1 Combined-cycle gas and steam turbines.
Source: calculations by DIW Berlin.

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

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 unterwartete 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 CO_2 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 Osbourne, www.gov.uk/government/speeches/chancellor-george-osbornes-budget-2014-speech, accessed on April 29, 2014.

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 CO_2 similar to that in the UK. According to the bill, the CO_2 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).

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 (Bundesimmissionsschutzgetz, 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 requirements[32] 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 runtime 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 CO_2 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 CO_2 emissions from one power plant to another.[35]

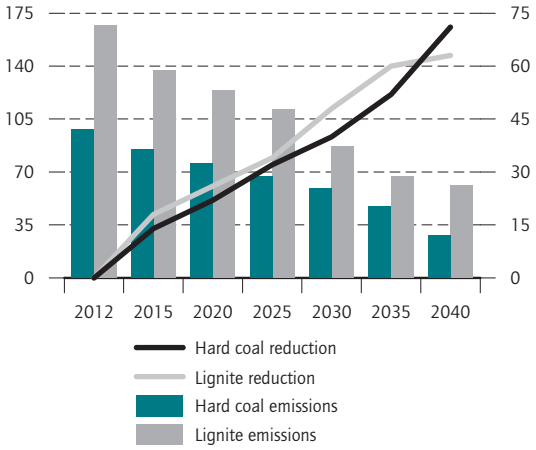
Supply Security and Capacity Mechanisms

The discussion surrounding capacity mechanisms[36] also has to include aspects that concern climate policy. Specifically, different scenarios affect the energy mix differently and, consequently, the CO_2-intensity of future power generation. Put in simple terms, the more the existing power plant fleet is being supported, the more CO_2 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 CO_2 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 CO_2 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.

Figure 3

CO_2 Emissions Produced by Coal-Fired Power Plants in Germany if Emissions Caps Were Introduced

In millions of tons of CO_2 per year or in percent



Source: Ziehm et al., Neue Braunkohlentagebaue .

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 CO_2 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.

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 transferral 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.

39 See C. Ziehm, Zur Zulässigkeit nationaler CO_2-Grenzwerte für dem Emissionshandel unterfallende neue Energieerzeugungsanlagen (Berlin: 2013).

Table 3

Annual CO_2 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.

CO_2 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 more[41] 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 CO_2 per megawatt[42] 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 gigawatts 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 CO_2 emissions (see Figure 3). This would take emissions levels down by around 24 percent (65 million tons of CO_2) by 2020, and by around 66 percent[43] (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 CO_2 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 CO_2 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 CO_2

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 CO_2-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 CO_2/kWh), the total annual operating hours at 80-percent capacity: 450 g CO_2/kWh × 8760 h × 0.8 = 3154 t CO_2/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 CO_2 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 CO_2 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 CO_2 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 CO_2 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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