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October 2016

Decarbonising Interconnected Power Markets: Should Germany Join France in Implementing a CO_2 Price Floor?

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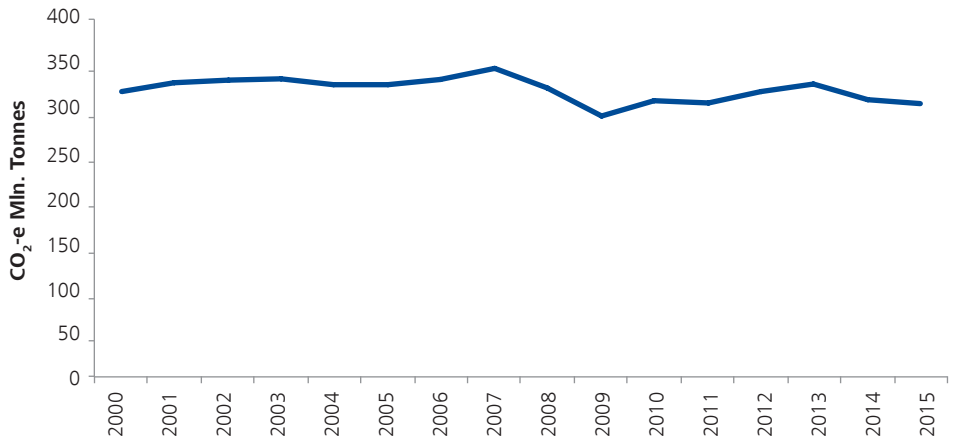
Introduction

Germany has been pursuing an agenda of "greening" and decarbonising its power sector under the auspices of a policy called the Energiewende.[2] On the supply side, the main policy instruments that the country has relied on to date are:[3]

- promotion of renewables via subsidies under the Renewable Energy Sources Act (the Erneuerbare-Energien-Gesetz, or EEG);[4] and
- incentives to substitute gas for coal provided by the European Union's cap-and-trade carbon trading scheme, the EU Emission Trading System (ETS).

Figure 1. **German Power Sector CO_2 Emissions**



Source: Umweltbundesamt (UBA) 2015 from 2000 to 2012, Agora Energiewende estimates from 2013 to 2015.

As illustrated by Figure 1, CO_2 emissions from the German power sector fell from 334 million tonnes (Mt) in 2005 (the start of the EU ETS) to 301Mt in 2009 (the height of the post-Lehman recession in Germany), but since then, CO_2 emissions have once again risen, reaching 313 Mt in 2015. Despite the Energiewende, there is no sign that CO_2 emissions from the German power sector are on a downwards trend.

In practice, Germany's decision to phase out nuclear energy in the wake of the Fukushima Daiichi accident in Japan, combined with low EU ETS CO_2 prices and a crash in global coal prices, have boosted production from coal and lignite plants relative to government expectations.[5] This recent trend is jeopardising Germany's chances of meeting its CO_2 emissions targets—which would include a 50% cut in power sector CO_2 emissions by 2030 against a base year of 2014, if the Federal Environment Ministry were to get its way[6]—and has prompted the government to think again about new measures.

Last year, the German government proposed a CO_2 top-up tax on old coal-fired plants, known as the CO_2 levy (or Klimaabgabe). Following discussions with the energy and mining industry, supported by modelling that indicated that the CO_2 levy would lead to mass closures of lignite plants, the German government ultimately backed down. Instead, it made a deal with industry to force a limited number of specific lignite plants off of the system, placing them in a so-called "climate reserve" (or Sicherheitsbereitschaft) that might be called upon in system stress situations (i.e., a form of capacity reserve).[7]

The proposed CO_2 levy in Germany and the subsequent decision to force selected plants into a "climate reserve" are indicative of wider "nationalist" trends in energy policymaking across Europe. For example, the UK government has already instigated its own CO_2 top-up tax in an attempt to bolster the weak incentives provided by the EU ETS.[8] In the Netherlands, the Energieakkoord arranged for various ageing Dutch coal plants to shut down in exchange for allowing new ones to open, as part of the country's pursuit of national CO_2 emissions reduction goals;[9] Dutch lawmakers have subsequently approved a non-binding motion urging the government to shut down all coal plants—even the new ones.[10] And many governments across Europe have enacted, or are considering enacting, their own *national* carbon budgets to drive *national* carbon reduction efforts.[11]

Now, the French government has announced that it plans to introduce a CO_2 price floor of its own in 2017, with the price initially set at €30/tCO_2.[12] The French government has also suggested that Germany join it in adopting a CO_2 price floor,[13] albeit Germany has thus far rejected this proposal in favour of pursuing EU ETS reform.[14]

In this paper, we review the implications of further fragmentation of energy and climate policy in Europe along national lines, with a focus on whether there would be any benefits should Germany join France in implementing a CO_2 price floor. To inform our review, we have modelled the effects of these measures using our Aurora European electricity market model.

French CO_2 Price Floor Proposal

The main mechanism for pricing carbon emissions in the EU power sector is via the EU ETS, which was introduced in 2005. Since 2013, the European power sector has needed to buy a large share of its required emissions allowances, either from governments or on the market, rather than receiving them for free.[15] The price of EU ETS allowances is approximately €4/tCO_2 today, which is widely viewed as being below the level needed to incentivise rapid decarbonisation.

In April 2016, the French Environment Ministry announced plans to introduce a domestic carbon price floor for all power generators, effective as of the beginning of 2017.[16] The intention to implement a unilateral carbon price floor in the French power sector follows French proposals earlier in the year to introduce a Europe-wide carbon price "corridor" for the EU ETS, which would include a minimum price trajectory as well as a "safety valve" to prevent prices from rising too high (effectively turning the EU ETS into something more akin to a tax).[17] At the time of the announcement in April, the ministry predicted that the price floor would have the effect of positioning gas-fired generation ahead of coal in the French merit order and would lead to a reduction of approximately 12 Mt of CO_2 per year in the French power sector, equivalent to almost half of the country's power-related emissions.

Subsequently, a panel of experts, commissioned by the French Ministry, has recommended that the price floor be limited solely to coal-fired generation, rather than remain technology-neutral. The panel suggested this restriction would deliver significant environmental benefits without compromising security of supply by risking the shutdown of gas-fired generators in France.[18] Ségolène Royal, the French Environment Minister, has now signalled she will accept this recommendation.[19]

France is expected to set the carbon price floor at a level of around €30/tCO_2 under the 2017 Finance Law. No further details on the likely trajectory or duration of the carbon price floor have been released to date.

Modelling

Using our Aurora European electricity market model (see Box 1 for more details), we have assessed the implications of two alternative CO_2 price floor scenarios as follows:

- *Unilateral French CO_2 price floor*: In this scenario, we assume the French government imposes a CO_2 price floor on *coal-fired generation* of €30/tonne starting in 2017, as per the recommendations of the panel of experts; and

- *Bilateral French-German CO_2 price floor*: In this scenario, we assume the French and German governments impose a *technology-neutral* CO_2 price floor of €30/tonne starting in 2017.

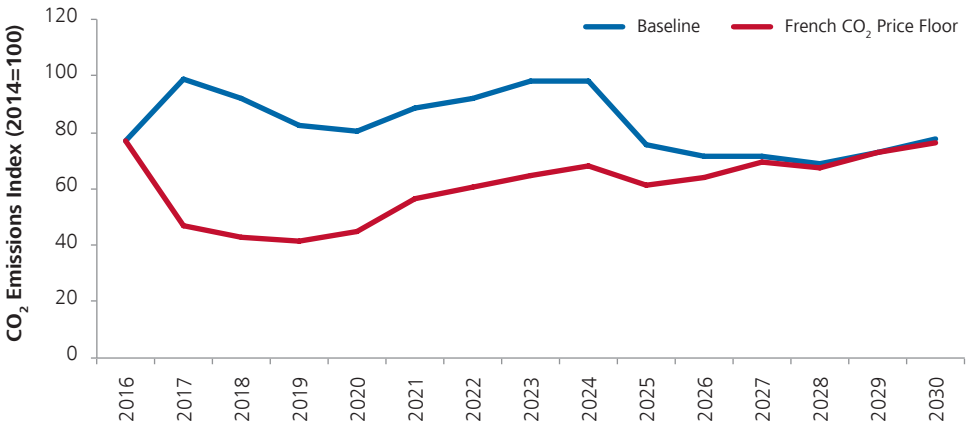
Together, these scenarios span a range of plausible CO_2 price floor scenarios for France and Germany, given France's proposal that Germany also adopt a CO_2 price floor and Germany's previous rejection of a coal-only CO_2 levy.

We report the impact of these scenarios as changes versus a baseline scenario in which the EU ETS continues to operate according to the current rules and our assumptions on other policy-driven factors, such as the growth of renewables and interconnections, are calibrated to official policy targets and plans (e.g., in terms of German renewables targets).

Unilateral French CO_2 Price Floor

Our modelling indicates that a unilateral CO_2 price floor in France would have a dramatic impact on CO_2 emissions from the French power sector, even when its scope is limited to coal-fired generation, as illustrated in Figure 2.

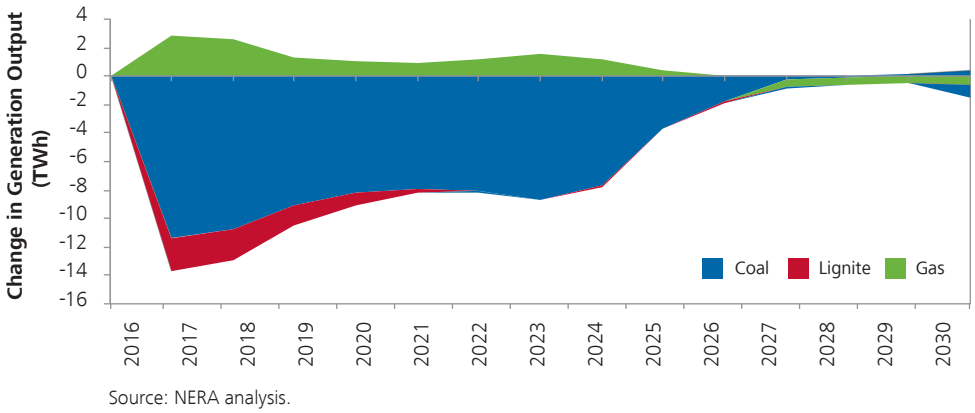
Figure 2. **French CO_2 Emissions With and Without a French CO_2 Price Floor**



Source: NERA analysis.

With a CO_2 price floor at €30/tCO_2, French power sector emissions would drop by over 50% in 2017 relative to our baseline emissions. As illustrated in Figure 3, the key driver of the reduction in CO_2 emissions in France is a reduction in production from coal plants in France that far outweighs any offsetting increase in production from French gas plants.[21]

Figure 3. **Impact of a French CO_2 Price Floor on French Power Generation**



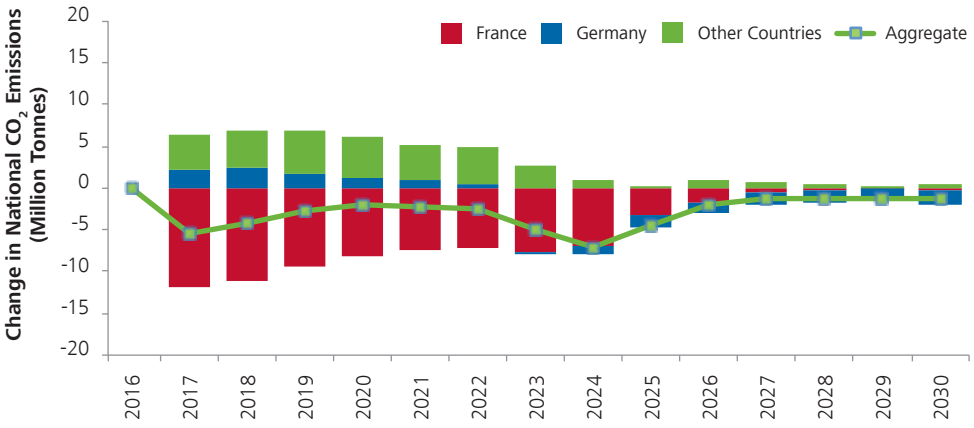
Source: NERA analysis.

Figures 2 and 3 also show that the impact of the CO_2 price floor diminishes over time, driven by our assumption that the EU ETS CO_2 price increases over the long term, rising to above €30/tCO_2 from 2029 onwards. Hence, according to our modelling, French power sector CO_2 emissions by 2030 will be approximately 20% lower than 2014 levels, regardless of whether a CO_2 price floor is put in place.

If the government commitment to a CO_2 price floor is perceived to be credible, its effect is twofold: (a) to provide extra certainty that long-term CO_2 reductions will be achieved in France (as it puts a floor under the floating EU ETS price), and (b) to reduce French CO_2 emissions in the intervening period between 2017 and 2029. According to our modelling, the total cumulative emissions reduction over this period is just over 50 Mt of CO_2 relative to our baseline scenario, which is roughly equivalent to a one-third reduction in French power sector emissions compared to what they would have been otherwise.

Due to the highly interconnected nature of the liberalised European electricity market, however, the impacts of a unilateral French CO_2 price floor will also be felt outside France—France alone has more than 15GW of available interconnection capacity, roughly equivalent to 15 large coal-fired power stations. A higher CO_2 price in France implies higher marginal costs of production for French coal-fired generation, thus making it less competitive compared to similar sources in neighbouring markets. As a result, French coal-fired generation is displaced in the merit order by coal (and gas) plants in neighbouring markets, leading to increased net imports to France. The net effect, according to our modelling, is that the reduction in CO_2 emissions in France will be offset to a very significant extent by increased CO_2 emissions in Germany and elsewhere in Europe, as illustrated in Figure 4. We estimate that "carbon leakage"—the substitution of carbon-emitting French production by carbon-emitting production elsewhere in Europe—will reduce the effectiveness of a French CO_2 price floor by almost half from 2016 to 2030 (i.e., approximately half of CO_2 emissions reductions in France will be offset by increased emissions elsewhere).[22]

Figure 4. **Impact of a French CO_2 Price Floor on European Power Sector Emissions**



Source: NERA analysis.

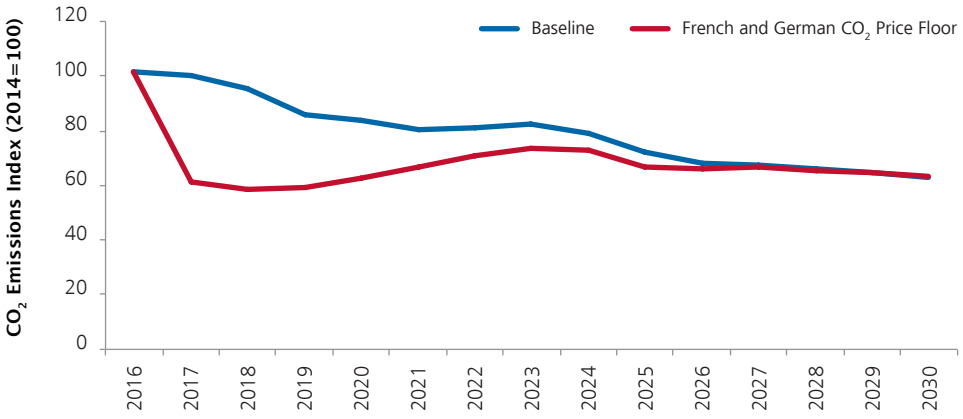
As illustrated in Figure 4, the aggregate reduction in European power sector emissions estimated by our model is in the range of 1 to 7 $MtCO_2$ per annum from 2016 to 2030, which equals 3 $MtCO_2$ per annum on average over this period or, put another way, 0.4% of the total annual average power sector emissions at a European level over the same period.[23] This is a negligible impact, and even this estimate overstates the impact of a French CO_2 price floor, as it does not factor in any impacts from the reduced demand for emissions on EU ETS CO_2 prices, which would lead to an additional increase in emissions elsewhere.[24]

Bilateral French-German CO_2 Price Floor

If Germany were to join France and introduce a CO_2 price floor, as has been suggested by the French government, it would create the potential for much bigger reductions in CO_2 emissions compared to a unilateral French measure, given the much higher carbon intensity of the German power sector, with its heavy reliance on lignite and coal plants. In theory, it would also reduce the scope for "carbon leakage".

Our modelling indicates that a technology-neutral French-German CO_2 price floor would have a major impact on CO_2 emissions from the German power sector, as illustrated in Figure 5. Relative to a 2014 base year and relative to baseline emissions, a CO_2 price floor would reduce German power sector emissions by approximately 40% in 2017. The impact of the CO_2 price floor again declines over time; according to our modelling, by 2030, German power sector CO_2 emissions will be approximately 35% lower than 2014 levels, regardless of whether a CO_2 price floor is put in place. Hence, although a French-German CO_2 price floor may provide extra certainty that long-term CO_2 reductions would be achieved in Germany and lead to lower German CO_2 emissions from 2016 to 2030, German emissions reductions would still fall short of the goal that the German Environment Ministry advocated earlier this year of reducing emissions by 50% by 2030 (measured against 2014 levels).

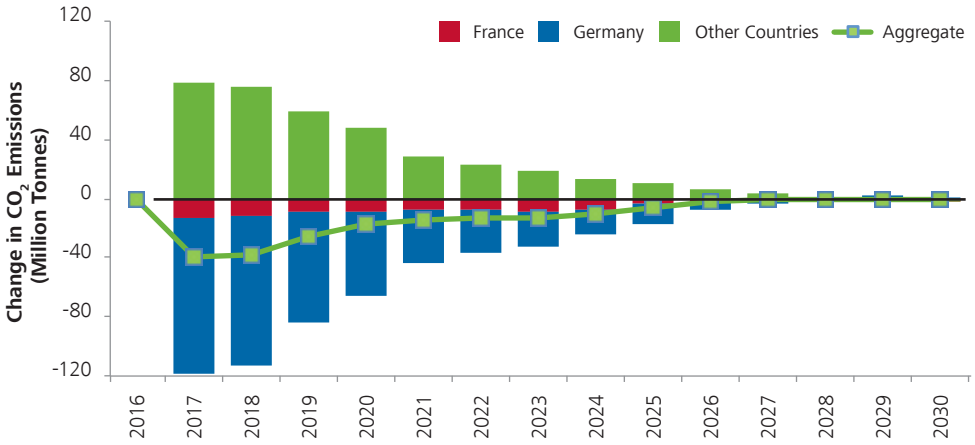
Figure 5. **German CO_2 Emissions With and Without a French-German CO_2 Price Floor**



Source: NERA analysis.

As with a unilateral French CO_2 price floor, our modelling indicates that there would again be extensive "carbon leakage" to neighbouring markets. Approximately two-thirds of CO_2 emissions reductions in Germany and France would be offset by increased emissions elsewhere. Hence, the aggregate effect of a bilateral French-German measure on CO_2 emissions from the European power sector is very limited, as illustrated in Figure 6. Over the period, 2017-2030, the average annual reduction in CO_2 emissions equals approximately 15 Mt per annum or 1.8% of the total annual average power sector emissions at a European level. And, as above, even this small impact overstates the true impact of a bilateral French-German CO_2 price floor, as it again does not factor in the effect of the reduction in aggregate CO_2 emissions on the EU ETS price.

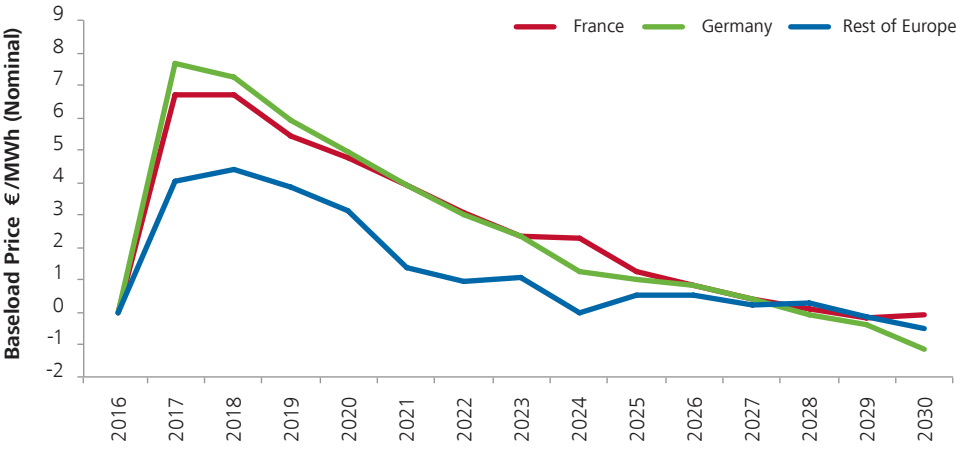
Figure 6. **Impact of a French-German CO_2 Price Floor on European Power Sector Emissions**



Source: NERA analysis.

On the other hand, the negative effects of a French-German CO_2 price floor on consumers in France, Germany, and neighbouring markets, due to increased electricity prices, would be significant, as illustrated in Figure 7. Our modelling indicates that French and German baseload wholesale prices would rise by between approximately €6/MWh and €8/MWh in 2017 as a result of the French-German CO_2 price floor. Compared to 2017 forward prices for baseload German contracts, which are currently trading at approximately €27/MWh,[25] this change represents an increase of approximately 20% to 30%. The level of price increases attenuates over time as EU ETS prices rise up to the level of the CO_2 price floor, but the overall detriment to consumers in France and Germany is clearly significant. Consumers in neighbouring markets would also suffer substantial price rises—of up to €4/MWh—as increased demand for generation in these markets would drive prices higher.[26]

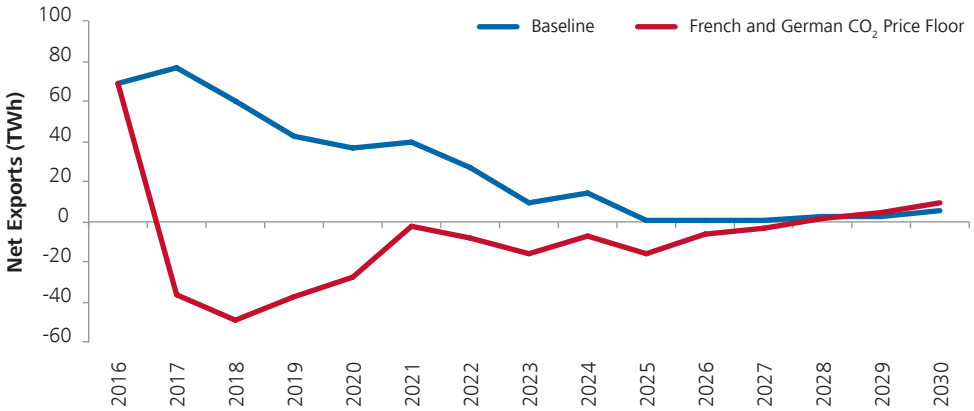
Figure 7. **Impact of French-German CO_2 Price Floor on Wholesale Prices**



Source: NERA analysis. Note: the "Rest of Europe" price is an arithmetic average of the prices in other European markets covered by our model.

There would also be major distortions to cross-border trade as a result of the introduction of a French-German CO_2 price floor, as illustrated in Figure 8.

Figure 8. **Impact of French-German CO_2 Price Floor on German Net Exports of Electricity**



Source: NERA analysis.

Conclusion

Unilateral or bilateral CO_2 price interventions may to some extent help national governments achieve their national CO_2 targets, but they are of little benefit in terms of CO_2 emission reductions at a European or global level. The highly interconnected nature of the liberalised European electricity market means that "carbon leakage"—due to a combination of direct supply-side substitution and lower prices for emissions allowances—would substantially offset the effects of such measures even in the short term.

The following example puts the impact of a French-German carbon price floor into context. As part of recent efforts to boost the EU ETS price, the European Commission has proposed tightening the annual reduction in the emissions cap from 1.74% to 2.2%.[27] This translates into a further tightening of the emissions cap by 10 $MtCO_2$ annually, from 38 $MtCO_2$/year to 48 $MtCO_2$/year. So the average annual reduction of 15 $MtCO_2$ resulting from a bilateral French-German CO_2 price floor in the power sector would completely eliminate any expected impact of the tighter cap on the carbon price over our modelling horizon.

This dynamic does not translate into good news for the environment. As a consequence of the lower emissions, emissions allowances that would otherwise have been used by the power sector in France and Germany would simply be added to the growing surplus of allowances, or be used by the power sector or industry elsewhere. Over the longer term, unless the increase in unused emissions allowances led policymakers to adopt tighter emissions caps, or to cancel unused allowances, there would be, in fact, no net impact on emissions at all because total emissions are limited only by the level of annual caps and by the associated number of available allowances.

Rather than helping the environment, the effects of a "nationalistic" French or French-German CO_2 price floor would be to raise the price of electricity for consumers and distort cross-border trade. In this area of energy regulation at least, what is needed is more Europe, not less: Germany should politely decline France's offer to join it in implementing a CO_2 price floor.

Box 1: **NERA's European Electricity Market Model**

Our Aurora European power market model is pan-European in scope and spans a modelling horizon out to 2040.[20]

The model uses a mixed integer programme (MIP) to optimise dispatch of the merit-order based on short-run marginal costs, and an iterative algorithm to project entry/exit decisions, based on an assessment of the costs and profitability of existing and future generation capacity. As prices reflect the system marginal cost, generators recover their fixed and investment costs in periods when the system marginal cost is above their own marginal production cost and in periods of scarcity (i.e., when market prices rise to reflect the value of scarcity). The modelling logic therefore simulates the behaviour of competitive electricity markets.

When dispatching installed generation capacity to meet demand, the model endogenously selects flows across interconnectors to minimise system costs, given the assumed marginal cost of supply across the different market zones and given the capacity constraints on interconnectors. Hence, the model implicitly simulates the market-coupling process envisaged by the EU Target Model.

In terms of the granularity of the model, the key features are as follows:

- each key European country is modelled as a market zone with explicit assumptions on the amount of interconnection capacity linking each zone;
- demand in each zone is represented through chronological hourly demand profiles covering every day of the year throughout the modelling horizon;
- thermal generation capacity in each zone is represented through unit/plant level capacity data and assumptions on technical characteristics (heat rates, outages, etc.);
- renewable capacity in each zone is represented through a mix of unit/plant level data for existing facilities and aggregate tranches of capacity differentiated by technology type for new build capacity (e.g., wind, photovoltaic (PV), hydro); and
- production from renewable capacity in each zone is represented through the use of hourly production profiles differentiated by technology type and geography (e.g., German onshore wind, Italian solar PV, Swiss hydro, etc.).

We have populated the model with data and assumptions drawn from reputable, publicly-available sources wherever possible, including the European Network of Transmission System Operators for Electricity (ENTSO-E), International Energy Agency (IEA), and Platts Powervision database.

Notes

[1] With thanks to NERA Analyst Konrad Borkowski and Consultant Harry Fearnehough for their assistance with modelling and research.

[2] The stated aim of the Energiewende is "to completely re-orient the German energy sector towards renewables and make the German economy one of the most environmentally friendly while keeping energy affordable". See German government website on the Energiewende, https://www.bundesregierung.de.

[3] Other policies include the promotion of efficient combined heat and power (CHP), energy efficiency investments, etc.

[4] "2014 Amendment of the Renewable Energy Sources Act", International Energy Agency, 30 July 2015, http://www.iea.org/policiesandmeasures/pams/germany/name-145053-en.php.

[5] "The German Energiewende and Its Climate Paradox", Agora Energiewende, April 2014, p. 7, https://www.agora-energiewende.de/fileadmin/downloads/publikationen/Analysen/Trends_im_deutschen_Stromsektor/Analysis_Energiewende_Paradox_web_EN.pdf; Christian Schwagerl, "A Clash of Green and Brown: Germany Struggles to End Coal", *Yale Environment 360*, 7 July 2015, http://e360.yale.edu/feature/a_clash_of_green_and_brown_coal_stays_strong_in_germany/2891.

[6] Markus Wacket, "Germany to Exit Coal Power 'Well Before 2050': Draft Document", *Reuters*, 3 May 2016, http://www.reuters.com/article/us-germany-environment-coal-idUSKCN0XU1R1. The 50% target is based on the German environmental ministry's original proposal for the so-called Climate Protection Plan. The latest publicly discussed version of the Plan no longer contains an explicit target following interventions by the Federal Ministry for Economic Affairs and Energy and the German Chancellor's Office.

[7] Sören Amelang, Kerstine Appunn, Sven Egenter, and Julian Wettengel, "Climate Levy – The Debate and Proposals for Cutting CO_2 Emissions", *Clean Energy Wire*, 27 May 2016, https://www.cleanenergywire.org/news/climate-levy-debate-and-proposals-cutting-co2-emissions.

[8] "Environmental Taxes, Reliefs and Schemes for Businesses", https://www.gov.uk/green-taxes-and-reliefs/climate-change-levy.

[9] The Dutch authorities simultaneously got rid of a coal tax, which can be thought of as a fuel-specific CO_2 tax.

[10] Arthur Nelson, "Dutch Parliament Votes to Close Down Country's Coal Industry", *The Guardian*, 23 September 2016. https://www.theguardian.com/environment/2016/sep/23/dutch-parliament-votes-to-close-down-countrys-coal-industry.

[11] For example: (1) UK: "The Fifth Carbon Budget – The Next Step Towards a Low-Carbon Economy", Committee on Climate Change, https://www.theccc.org.uk/publication/the-fifth-carbon-budget-the-next-step-towards-a-low-carbon-economy; (2) France: "Adoption of the National Low-Carbon Strategy for Climate", 27 November 2015, http://www.gouvernement.fr/en/adoption-of-the-national-low-carbon-strategy-for-climate.

[12] "France Sets Carbon Price Floor", 17 May 2016, *Reuters*, http://www.theguardian.com/environment/2016/may/17/france-sets-carbon-price-floor.

[13] "France Seeks German Support for Carbon Emissions Floor Price", 11 May 2016, *Bloomberg*, http://www.bloomberg.com/news/articles/2016-05-11/france-seeks-to-convince-germany-to-mirror-30-euro-carbon-price.

[14] "Offensive for Energy Efficiency / Germany Rejects French Proposal for Carbon Floor Price", 12 May 2016, *Clean Energy Wire*, https://www.cleanenergywire.org/news/offensive-energy-efficiency-germany-rejects-carbon-floor-price.

[15] Prior to 2013, power generators were allocated a proportion of their required allowances for free. Since 2013, eight Member States of the EU ETS have been allowed to allocate, for free, a share of the allowances required to cover power sector emissions.

[16] "Dossier de Clotûre de la Conférence Environnementale 2016," French Ministry of the Environment, Energy and the Sea, 26 April 2016, http://www.developpement-durable.gouv.fr/Dossier-de-cloture-de-la.html.

[17] For a discussion of the proposal, see "'We Can't Wait Any Longer': France Floats EU ETS Price Support Proposal", *Carbon Pulse*, 13 March 2016, http://carbon-pulse.com/16939, and for the "non paper", see http://carbon-pulse.com/wp-content/uploads/2016/03/France-non-paper-A-soft-price-collar-for-the-EU-ETS.docx. Note that the price corridor proposal relates to all sectors and countries covered by the EU ETS, whereas the French carbon price floor, if implemented, will only cover the French power sector, or potentially (see following paragraphs) just coal generation.

[18] Pascal Canfin, Alain Grandjean, and Gérard Mestrallet, *Rapport de la Mission: Propositions pour des prix du carbone alignés avec l'Accord de Paris*, July 2016.

[19] "Le Prix Plancher du CO2 en France Ne Concernera Que Les Centrales Électriques au Charbon", *Le Monde*, 7 November 2016, http://www.lemonde.fr/planete/article/2016/07/11/le-prix-plancher-du-co2-en-france-ne-concernera-que-les-centrales-electriques-au-charbon_4967948_3244.html.

[20] Aurora is a dedicated electricity market modelling software package marketed by EPIS Inc. of the US (http://epis.com/aurora_xmp). It is used by market practitioners and by industries around the world to simulate market development and price formation in electricity markets.

[21] Our model takes account of recent closures of coal plants in France and hence, assumes circa 3,000MW of coal capacity remains on the system in France at the beginning of the modelling horizon in January 2016. Our modelling indicates that the immediate response in 2017 to a CO_2 price floor would be a complete cessation of production from French coal plants. In practice, this effect may be diluted to the extent that French coal plants sit behind transmission constraints within the French system and are thus forced to run, or prevented from runnining,for grid stability reasons.

[22] Although EU ETS policy discussions have tended to focus on the problem of carbon leakage as it applies to industrial sectors only, it is widely recognised that it can also affect the power sector where there are differences in the carbon costs applied to similar power plants across political boundaries.

[23] This percentage is calculated relative to annual average emissions from the European power sector covered within our model.

[24] As we discuss further below, over the very long term, these policies would not be expected to have any impact on total emissions, unless they led policymakers to adopt tighter emissions caps or to cancel unused allowances.

[25] *Heren European Daily Electricity Markets*, 22 September 2016, ICIS.

[26] We calculate the "rest of Europe" price as the arithmetic average of market-clearing prices in all other European electricity markets, outside of France and Germany.

[27] COM (2015) 337 final, European Commission, 15 July 2015; and accompanying document: "Detailed Questions and Answers on the Proposal to Revise the EU Emissions Trading System", European Commission, 15 July 2015.

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