The Impacts of Variable Renewable Production and Market Coupling on the Convergence of French and German Electricity Prices

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Non-technical summary

This paper estimates the impact of two separate factors on the spread between French and German electricity prices, the amount of production by variable renewables and "market coupling". As renewable electricity production is concentrated during a limited number of hours with favourable meteorological conditions and interconnection capacity between France and Germany is limited, increases in production of wind and solar PV in Germany lead to the congestion of interconnections and increasing price spreads between the two countries. Our estimates based on a sample of 24 hourly French and German day-ahead prices from November 2009 to June 2013 confirm that renewable electricity production in Germany has a strongly positive impact on price divergence. On the other hand, market coupling, the establishment of a combined order book on the basis of information of both markets, which was introduced in November 2010, can be shown to have mitigated the observed price divergence. Both results have policy relevant implications for welfare and the optimal provision of interconnection capacity.

France and Germany are the two most important electricity markets in continental Europe, disposing of the two largest European generation systems as well as the highest consumption. Their interaction has a decisive influence on electricity prices all over Europe. While French gains 75% of its electricity from nuclear power, Germany has in recent years invested heavily in wind and solar PV. Their respective capacity today exceeds 36 GW (wind) and 38 GW (solar PV). While in 2014 their share was only 9.9% (wind) and 6.3% (solar PV) of total German production, their impact on electricity prices is far more significant due to their low variable cost and, in particular, their time structure of production, which is clustered around high output hours when it strongly impacts interconnection flows.

European power market operators installed the market coupling mechanism in November 2010 in the Central Western Europe (CWE) electricity market, of which France and Germany are the two largest members. Market coupling aims at optimising welfare by ensuring that buyers and sellers exchange electricity at the best possible price taking into account the combined order books of all power exchanges involved as well as the available transfer capacities between different bidding zones. By doing so, interconnection capacity is allocated to those who value it most.

As predicted by theory, electricity prices in France and Germany converged substantially in 2010 and 2011 in the wake of market coupling with concomitant welfare benefits. These benefits were shared between both countries. However since 2012, electricity prices between France and Germany *diverged*, a process that accelerated during 2013. In 2009 and before market coupling, German and French prices converged only 1% of the time. After the introduction of market coupling, prices converged 67% of the time in 2011. However, this trend then reversed. While in 2012 the convergence rate was still 64%, it was only 41% for the first semester of 2013. This is due to the fact

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that the production of variable renewables (wind and solar PV) in Germany is clustered during certain hours, for instance peak solar production around noontime. Thus when the production of wind and solar PV is high, German exports tend to saturate interconnections thus causing price convergence to cease and French-German electricity prices to diverge. Market coupling has mitigated this effect but has been unable to reverse it. This has important welfare impacts as consumers no longer benefit from price convergence.

The econometric estimations of this article show that an increase in hourly wind production of 1 GW in Germany on average a divergence of French and German electricity prices of 0.48 Euros per MWh with market coupling and would cause a divergence of 0.57 Euros per MWh without market coupling. The effect is even starker for an increase of 1 GW in hourly solar PV production, where the effect with market coupling is 0.39 Euros per MWh and without 0.795 Euros per MWh. The mitigating impact of market coupling is stronger for solar PV on the price spread due to the fact that it exhibits an even stronger auto-correlation than wind and is concentrated during an even smaller number of hours. The vast majority of solar PV power is also produced by a large number of decentralised producers unable to arbitrage between the French and the German electricity markets on heir own. The benefits of centralised market coupling are consequently stronger.

Price divergence is, of course, also a function of available interconnection capacity. The theoretical common price in the absence of network constraints thus provides an important normative benchmark for assessing losses of consumer surplus and welfare. EPEX Spot and EEX provide this benchmark by publishing since October 2010 the European Electricity Index (ELIX). The ELIX is calculated on the basis of the actual aggregated bid and offer curves of France, Germany and Switzerland assuming unlimited interconnection capacity.

One can thus assess the order of magnitude of the annual economic welfare loss by working with the ELIX reference price. These welfare costs would then need to be put in relation with the costs of adding interconnection capacity up to the point where its marginal costs equals the marginal benefit of additional electricity trades. With unlimited capacity in the French-German electricity markets the daily average prices during 2012 would have been on average € 4.15 per MWh lower to reach the average level of the ELIX price of € 42.78 per MWh. Such a 9.1% decrease in prices would have implied an increase in French consumer surplus of € 2.29 billion. It would have led to a decrease in consumer surplus for German consumers of € 265 million. Even given the unavoidable approximations of such an exercise, the results allow two important conclusions. First, improving interconnections could lead to significant further increase in welfare even after market coupling. Second, while German consumers would experience higher prices than they otherwise would, their losses are considerably smaller than the gains of their neighbours.

Of course, the optimal level of physical interconnection capacity is not a fixed datum. It depends precisely on issues such as market coupling and variable renewable production. If market coupling has been able to improve the utilisation of existing infrastructure, increased production from variable renewables in Germany has by now more than compensated this effect and has driven the system to its limit. This has modified the fundamentals of electricity trade and requires a new look at European power market integration and infrastructure provision. At the policy level, poses the questions of what constitutes success in terms of market harmonization and what level of physical infrastructure provision is socially optimal at both the national and the European level.