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The Electricity Wholesale Sector:
Market Integration and Competition

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Contents

Tables

Figures

Executive summary

Concerns about non-integrated European electricity wholesale markets and market power of national players are often articulated. Most prominently, the Sector Inquiry by the European Commission raised such concerns with respect to the years 2002 to 2005. Against this background RWE has retained a project team composed of ESMT Competition Analysis (ESMT CA), led by Professor Lars-Hendrik Röller, and Professor Axel Ockenfels in order to investigate the state and development of European market integration. Alongside, RWE asked the project team to assess whether German wholesale price levels[1] appeared higher than functioning competitive markets would suggest. The study focuses on Germany and its neighbouring countries. The Commission's Sector Inquiry (SI) serves as a point of reference.

In conclusion we find ample evidence that markets have become more integrated since the Sector Inquiry. The German market design has been constantly improved and with respect to the Western neighbouring countries further substantial improvements (CWE Market Coupling) are envisaged for the year 2010. These improvements will finalise market integration from a design perspective so that physical interconnector capacity will become the sole potential bottleneck towards full or perfect market integration. Against this background, utilizing indicators that are less distorted by the remaining frictions of institutional design than day-ahead spot exchange market data, our price analyses suggest that Dutch, French and Austrian markets are to a large extent competitively interlinked with the German market.

We also find that price levels in Germany have i) tended to be lower than they were in Western neighbouring countries and ii) often been below the level that would incentivise investments into new generation capacity. This suggests that the scope for lower German electricity prices due to stronger market integration is small. At the same time, stronger market integration would in principle increase the scope for relaxed national antitrust scrutiny by increasing the

1 Throughout this report we are only concerned with electricity wholesale prices.

number of hours when foreign suppliers bound domestic price levels in addition to national competition. Against this background we advocate that policy and regulatory measures, e.g. regarding the (costly) extension of interconnector capacity, should be set in clear perspective to well defined economic goals and be evaluated accordingly.

Key points

Market integration

It is helpful to start with two observations. First, in the public and the political debate about the electricity sector, the concept of market integration is often applied rather loosely for it may refer to perfect integration, integration from an antitrust perspective or regulatory and market design purposes, to name only a few aspects. Second, often there seems to be an implicit presumption that perfect market integration of electricity wholesale markets was something desirable, *per se*. Our analyses offer a number of clarifications and qualifications.

At a given point in time and at a given location, electricity is a homogenous good. As such, electricity traded in a *perfectly* integrated market should have a single price. However, one observes that the German day-ahead spot exchange market price often diverges (positively or negatively) from other European exchange prices. This could be interpreted as European electricity markets cannot yet be considered perfectly integrated. However, looking only at spot exchange market price dispersion may yield an incomplete picture of market integration.

Electricity wholesale markets may not be perfectly integrated for two reasons. The first one is insufficient interconnection capacity between two neighbouring areas. Second, market design imperfections may hinder optimal usage of interconnection capacity. For example, European spot exchange markets trade electricity for the same specified hour on the next day but close at different points in time and employ different pricing rules. The electricity price can then differ because of the additional information (e.g. about wind conditions) between spot exchange market closing times and the different auction rules.

This observation is important because the market design has been constantly improved and further substantial improvements are envisaged for the year 2010. Most notably, the German spot exchange market will be coupled with the markets in the Netherlands, Belgium, Luxemburg and France (CWE Market Coupling). This will remove imperfections due to market design and imperfect use of interconnectors. The following analyses assess (prospective) market integration by means of price indicators that are less sensitive to design imperfections than dispersions of day-ahead spot exchange market data.

First, one may adhere to day-ahead spot exchange market data but consider co-movements rather than price dispersions. To that end we find that price correlations between the Netherlands and Germany have increased substantially from 0.57 in 2004 to 0.91 in 2009. Price correlations with respect to France and Austria have remained at high levels, around 0.83 to 0.91, that already stood out during the SI. Furthermore we find that German day-ahead spot exchange market prices are co-integrated with Dutch, French and Austrian prices within the period 2005 to 2008. This further substantiates a long-term competitive relationship between Germany and important neighbouring trading partners.

Second, we use hourly prices (auction results) for interconnection capacity between Germany and its neighbouring countries as a measure for market participants' hourly valuation of location price spreads between Germany and neighbouring countries. Following a downward trend, in the year 2009 price-location spreads between Germany and the Netherlands, France and Austria exceeded 5% in only 12%, 29% and 0% of trading hours, respectively. We also assess price dispersions by means of year-ahead future products. Here we find a positive recent development in that, for example, Dutch and French futures diverge from German futures by more than 5% in only 1.3% and 11% of all instances (Austrian data is not available).

In conclusion, our price analyses suggest that in terms of the underlying economic fundamentals, markets are substantially stronger interlinked than persisting day-ahead spot exchange market price dispersions would suggest. Accordingly, a more differentiated view appears advisable, particularly in light of the market coupling of the German, Dutch, Belgian and French region in 2010.

The price indicators discussed above inform about trends and may also benchmark price dispersions against the counterfactual of a perfectly integrated market. However, whether or not markets appear sufficiently integrated from an *antitrust perspective* is a matter of degree. Specifically, an affirmative answer to the question whether foreign suppliers could discipline a concerted action of *all* German suppliers to increase their prices by a small amount of 5 to 10% would likely imply that a merger of German suppliers could be cleared without an in-depth investigation. Of course, this test is arguably strong if there is no large merger at stake in Germany. Also, this test is rather difficult to implement for electricity wholesale markets and requires a lot of assumptions and simplifications. To the best of our knowledge, this study provides the first attempt in that direction. If we focus on interconnection capacity as the main barrier to market integration, employ hourly prices (auction results) for interconnection capacity and RWE cost estimates, we find that the relevant geographic market would be broader than Germany in 29 to 50% of all trading hours. That is, none of the suggestions that the German electricity market can be assessed in complete isolation or regarded as always fully integrated can be supported. We emphasize that, by construction, the test does not allow any conclusions regarding whether there is market power in the German electricity market. The same result would hold if there were 1.000 suppliers in the German market. In fact, the observed incomplete market integration in our analyses partly becomes visible through the fact that German electricity prices often tend to be *lower* than the prices of neighbouring countries.

Indeed, absent a merger the *regulatory and market design perspective* would ask whether German prices would likely decrease if we had more interconnection capacity. To that end we consider that, whenever German prices exceeded those of a foreign country, more interconnection capacity would eliminate price dispersions, the new common price being the midst of the two pre-existing price levels.[2] We find, for example, that more (i.e. unlimited) interconnection capacity to the Netherlands would have decreased German prices as suggested by interconnection prices in only 1.5% of all hours in 2008, whereby in these hours German prices would have decreased by an average of 0.1%. As regards the French border, we find that German prices might have decreased in 33% of all hours; but still German prices would have decreased by an average of 2.1% only. By virtue of zero congestion more interconnection capacity to Austria would not at all affect German price levels. That said, more interconnection capacity may also increase prices in Germany whenever the pre-existing German price level is lower than the foreign one. For example we obtain that, on balance, German prices would tend to increase due to higher interconnection capacity to the Netherlands, France and Austria whilst for Eastern and Northern European countries the reverse is true. These findings cast some doubt on whether perfect market integration and (costly) interconnection capacity should be a means to its own end under all circumstances. The macroeconomic benefit of only slightly converging prices should be set into perspective against the investment costs for new cross-border interconnection capacity. Furthermore, the increase of cross-border interconnection capacity would not *per se* increase commercial cross-border flows due to technical constraints (ring flows, safety margins, bottlenecks in the underlying national grid topology, priority of renewable energy). Finally, new cross-border capacity should be assessed against other possible remedies (e.g. higher generation capacity).

Of course, the latter analysis presumes competitive price levels in Germany and its neighbouring countries; otherwise additional interconnection capacity could put additional downward pressure on both the German and its neighbouring countries' prices. Our presumption of competitive price levels is consistent with our final analysis of generator profitability at the plant level (see below).

Investment incentives and market power

Next to the degree of market integration, the Sector Inquiry addresses potential market power of national suppliers. In particular, the SI raises concerns of high price-cost margins and strategic capacity withdrawals.

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[2] This supposes symmetric merit order curves in both countries. See Section 0.

In the long run, generation capacity will shrink if, first, old plants reach the end of their lifetime and, second, there are not sufficient new investments to replace the old plants. Clearly, generators shut down old plants over time. The question to be answered is whether German price levels are sufficiently high in order to economically justify investments into new plants. A market that does not reach such levels is not sustainable.

Electricity suppliers assess the profitability of new plants on the basis of future input costs and both operational and capital costs, spread over supposed generation quantities. These average total future costs are then compared to future electricity prices. It has been observed that, in the years after the liberalization, because of excess capacities, prices were below the level that would induce investments. We concentrate on prices starting at 2005 and find that the average total margin of a new hard coal fired plant (high capex and low variable cost) has been negative from 2005 to 2009 (with the exception of 2007). The average total margin of a new gas-fired plant (low capex and high variable cost) has been negative between 2005 and 2007 and positive in 2008 and 2009.

Negative margins may contribute to the explanation why closed plants have not been substituted by new ones. Indeed, this appears fully consistent with functioning and competitive electricity markets. As long as capacity additions do not earn their capital costs, net capacity tends to shrink. Rather, supply must become sufficiently tight so that scarcity rents also re-cover capital costs of capacity additions. According to our analysis, this happened only for low capex gas-fired plants and only in the more recent years 2008 and 2009.

Below we summarise our findings in more detail. First we address the state of play with respect to market integration. Second, we address price levels relative to the full costs of new generation capacity (including observations on market power).

Market integration

As regards the degree of market integration, the Sector Inquiry summarised its main conclusions as follows:

> *The Sector Inquiry leads to the preliminary findings that the lack of electricity market integration mainly results from:*
>
> - *insufficient interconnecting infrastructure between national electricity systems,*
> - *insufficient incentives to improve cross border infrastructure,*
> - *inefficient allocation of existing capacities, and*

- *incompatible market design (e.g. differences between balancing regimes, nomination procedures, differences in opening hours of power exchanges) between TSOs and/or spot market operators (521).*

The concern raised by the Sector Inquiry regards a number of points and the combination thereof. In our view there have been, since the Sector Inquiry was undertaken, substantial improvements in some areas, while substantial further improvements will become effective in the near future. The evidence reviewed in this report confirms this. It points towards stronger market integration than found in the Sector Inquiry and, in particular, substantial existing competitive relationships between Germany and its neighbouring countries. However, with some important facilitating factors still on the waiting list, the data also reveals that wholesale markets cannot yet be considered perfectly integrated in all circumstances.

That said, we do not advocate that perfectly integrated markets in all circumstances should be the overriding policy goal *per se*. For example, our results indicate that in some cases further integration of Germany and some of its neighbouring countries may have only little positive effects for German consumers. This suggests a more qualified and effects-based approach towards stronger market integration, at least with respect to the underlying policy goals in question. Furthermore, our results do not imply *per se* that German electricity suppliers have market power. Whilst not being the main focus of this report, we notice that German supply is comparably fragmented (see SI) and that the persisting price levels have rarely appeared sufficient to allow entry in the past.

Relevant indicators

At a given point in time and at a given location, electricity is a homogenous good. As such, electricity traded in a perfectly integrated market should have a homogenous price. In our view, price homogeneity is the ultimate indicator of whether two regions form a perfectly integrated market. However, as we argue below, regions do not need to be perfectly integrated in order to constitute a common market from an antitrust perspective. For example, with the German spot exchange market closing later than the French one, regional trading facilities have not yet been fully aligned. As a consequence, the electricity traded is not homogenous but differentiated by the additional information on e.g. wind or unplanned outages that parties receive in between the closing times. Of course, prices may then not be equal.

Market coupling and the synchronisation of the closing times of exchanges (or, indeed, mergers of exchanges) will make prices homogeneous as it is already the case in the Nord Pool. In such an environment, price homogeneity is the ultimate indicator for testing if two regions form a perfectly integrated market.

If price homogeneity of day-ahead prices at the exchanges is not the perfect indicator as long as institutional differences prevail, what other evidence can be considered to assess market integration?

First, some obstacles notwithstanding, international electricity suppliers may still exert sufficient competitive constraints on each other so as to form an integrated market from an antitrust perspective. For example, suppliers to a spot exchange platform with a slightly earlier closure time (e.g. France) are aware that customers can also use the platform which closes later (e.g. Germany); likewise customers would not rely on the German spot exchange market if prices were structurally higher than on the French market. Such competitive interaction should be reflected in price co-movements of day-ahead prices at exchanges, e.g. price correlations.

If day-ahead spot exchange market prices might diverge due to some remaining imperfections in the market design, one would expect that price data not subject to market design imperfections were more closely aligned. In contrast to spot exchange trade, day-ahead interconnection capacity trade happens simultaneously so that trading in different countries exhibits the same information. For example, OTC price spreads can be shown to coincide with the averaged hourly results of the daily cross-border auction for interconnection capacity.[3] This suggests that hourly prices for interconnection capacity measure market participants' hourly valuation of location price spreads between Germany and neighbouring countries. We therefore use hourly prices for interconnection capacity in order to approximate price spreads that are caused by economic fundamentals rather than market design imperfections.

Another source to investigate the degree of price homogeneity between Germany and its neighbouring countries are future contracts. Such contracts should not be affected by institutional problems described above. That is, if we observe spot exchange market price spreads primarily as a consequence of the above described (temporary) imperfections in market design, we should observe substantially smaller future spreads.

Due to the volatility in supply and demand, optimal electricity networks will exhibit congestion at some points in the network at some time. With respect to analysing market integration, one interesting question is whether electricity suppliers in foreign interconnected countries imposed a strong enough constraint on suppliers active on the German market (German suppliers) so that, at a given point in time, a small but significant, non-transitory increase in prices (SSNIP) by a hypothetical concerted action of all German suppliers would be unprofitable. This question may in fact be asked from two angles.

[3] Non-public information provided by RWE.

The first is, whether foreign suppliers would constrain German suppliers from increasing their prices above the existing level, e.g. as a consequence of a merger in Germany. Indeed, this would be the correct question if a potential merger of German suppliers had to be assessed.

From a second angle, one might wonder whether the existing degree of market integration appears insufficient in order to induce low (enough) prices in e.g. Germany. This question appears relevant if no merger of German suppliers is at stake. In other words, would stronger (and costly) market integration be likely to reduce prices in Germany below the current level? By the same token one might ask whether stronger market integration might also increase price levels in Germany.

Finally, the development of European electricity markets has been and still is dynamic in nature. Many efforts towards stronger market integration have been made in the past. Yet, some important measures such as market coupling will only become effective in the near future. The investigation should hence not take a static stand but also hint at developments and likely outcomes in the near future. Again, even if prices are not yet exactly equal to date, structural indicators may hint towards convergence in the near future.

Price correlations and price convergence

Day-ahead spot exchange market prices

Day-ahead spot exchange market data is a natural starting point for the investigation. The data suggests that there are indeed still many instances in which German day-ahead spot exchange market prices diverge from day-ahead spot exchange market prices of its neighbouring countries. In the year 2008, for example, the German day-ahead spot exchange market price diverged from the Dutch, French and Austrian price by more than 5% in 67%, 68% and 63% of all trading hours, respectively. The comparison with other countries looks similar.

At face value this seems inconsistent with integrated electricity markets. However, as we argued above, differences in day-ahead spot exchange market prices may not (only) reflect missing competitive interaction but simply products that are differentiated by time and institutional design. As explained above, i) European suppliers might still exert competitive constraints on each other and ii) (some) crucial institutional changes are envisaged in the near future. We therefore investigate whether additional data supports a hypothesis of competitive interaction and hence is likely to support stronger price convergence once markets are coupled (in 2010).

First we look at day-ahead spot exchange market price correlations. This measure has also been used in the SI and picks up some of the competitive interaction between suppliers of different countries, price differences notwithstanding. With respect to Germany’s most important trading partners to the West and South:

The Netherlands: correlations have gone up from 0.57 (2004) and 0.67 (2005) during the SI to 0.85 and 0.91 in 2008 and 2009, respectively.

France: high correlations during the SI at 0.91 (2004) and 0.85 (2005) have remained stable at levels of 0.88 and 0.83 in 2008 and 2009, respectively.

Austria: high correlations during the SI at 0.93 (2004) and 0.88 (2005) have remained stable at levels of 0.93 and 0.91 in 2008 and 2009, respectively.

The data hence points towards substantially increased market integration with respect to the Netherlands. As regards France and Austria, the correlations remain high at a level that already stood out during the SI.[4] To that end the data is consistent with strong competitive linkages between Germany and its main trading partners.

Price correlations are also high to the Czech Republic (0.91 and 0.89 in 2008 and 2009, respectively). As regards Switzerland, Denmark, Nord Pool, Poland and Sweden price correlations are also consistent with competitive linkages, albeit at a somewhat lower level between 0.50 and 0.85. With the exception of Poland, lower price correlations in these countries can be explained by strong seasonality effects and weather-related availability fluctuations of hydro-electric power supply. Here, steps towards market coupling and efforts to increase interconnector capacity can be expected to lead to higher market integration.

Whilst we cannot observe day-ahead spot exchange market price homogeneity, correlations do point towards market integration, in particular with respect to important trading partners in terms of trading volume such as the Netherlands, France and Austria. Below we move on to further substantiate this hypothesis.

However, co-movements are often caused by common factors, such as input prices. Price correlations might then be high due to co-movements of these input prices rather than competitive relationships between neighbouring countries, a phenomenon called ‘spurious correlation’.

We therefore extend our analysis of the day-ahead exchange price movements further. In particular, we study the relationship in day-ahead exchange prices between Germany and its neighbours using econometric techniques. To this end we use co-integration technique which, like a simple regression, measures the degree of the relationship. However, this econometric approach mitigates a number of technical shortcomings of a simple regression technique.

We focused our analysis on the day-ahead exchange prices between Germany and its main trading partners: the Netherlands, France and Austria. We find the following:

[4] In contrast, correlations Spain-France, France-Italy and France-Netherlands were 0.66 to 0.71, 0.63 to 0.58 and 0.07 to 0.16, respectively (see SI, p. 335). However, we notice that for the pair France—Netherlands our own calculations would yield a correlation coefficient of 0.57 (rather than 0.07) for the year 2004.

German prices were statistically significantly related with the Dutch, Austrian and French prices during both periods 2003–2004 and 2007–2008. Hence, the correlations reported earlier were not spurious.

Our results also indicate that the systematic price relationships between Germany and its neighbouring countries became stronger between periods 2003–2004 and 2007–2008, whereby the German-Dutch price relationship increased most substantially.

Results of this analysis are broadly consistent with the simple day-ahead spot exchange-market correlation results we discussed above. Both analyses show that the French and Austrian prices have been strongly correlated with the German prices since 2005 whereas the Dutch prices have recently become more correlated with the German prices. The analysis also supports the hypothesis of a structurally relevant competitive interaction between Germany and important neighbouring countries like the Netherlands, France and Austria. Furthermore, comparing the two snapshots 2003–2004 and 2007–2008, the results suggest that the institutional improvements described in Section 2 have actually translated into stronger competitive linkages between Germany and its most important trading partners. As the markets are announced to become more synchronized and indeed coupled in the near future, these competitive linkages are likely to become stronger.

Convergence of price spreads as suggested by interconnection prices

We argued above that day-ahead spot exchange market prices may diverge due to some remaining imperfections in the market design rather than due to (structurally) missing competitive links. If this was true one would expect that price data which was not subject to market design imperfections was more closely aligned.

In contrast to day-ahead spot exchange trade, day-ahead OTC trade happens simultaneously so that trading in different countries exhibits the same information. Indeed, we understand that the OTC price spread between two countries corresponds to the hourly prices (auction results) for interconnection capacity towards the direction of the high-price country. While OTC price spreads are not publically available, auction results for cross-border interconnection capacity are.

We can hence relate cross-border interconnection prices, as a measure of market participants' hourly valuation of location price spreads, to German day-ahead spot exchange market prices, as a measure of the German price level. The coefficient approximates the percentage divergence between Germany's and a neighbouring country's prices due to economic fundamentals rather than due to market design imperfections. With respect to the most important western and southern trading partners we find the following:

The Netherlands: price spreads as suggested by interconnection auction results have exceeded 5% in 46% of all hours in 2006 but in only 12% of all hours in 2009.

France: price spreads as suggested by interconnection auction results have exceeded 5% in 45% of all hours in 2006 but in only 29% of all hours in 2009.

As a benchmark, consider Austria where there was no known incidence of congestion in the years after the liberalization of the electricity market. Here, price spreads as suggested by interconnection auction results have exceeded 5% in virtually no hours between 2006 and 2009.[5]

The price spreads as suggested by interconnection auction results, having been 'cleaned' from (some) distortions due to design imperfections, suggest much stronger price convergence than day-ahead spot exchange market data would do. Indeed, the above 2009 figures would be consistent with integrated markets in the great majority of all hours.

The data also indicates strong price convergence with the Czech Republic, where the share of hours with differences larger than 5% decreased from 47% in 2006 to 8% in 2008. However, in 2009 this figure increased again to about 32%. Price spreads as suggested by interconnection prices between Germany and Poland as well as to Denmark West remain above 5% in a substantial share of 62 to 68% of all hours. The share of hours with above 5% spreads between German and Swiss prices has, however, increased in the period between 2006 and 2009.

Convergence of future prices

Another source to investigate the degree of price homogeneity between Germany and its neighbouring countries are future contracts. Year-ahead futures are less sensitive to short-term and extraordinary influences; in particular to those, which spot exchange markets absorb at different points in time. A comparison of futures hence reflects the structural and persisting differences of supply and demand conditions, rather than the short-term distortions involved in day-ahead spot exchange market prices:

> *Whereas forward prices are or should be primarily influenced by supply-demand fundamentals that are expected to prevail in the future, spot prices are determined by the out-turn of these fundamentals. (SI 374)*

We do not advocate that homogeneity in futures alone were a sufficient indicator for truly integrated electricity markets. But they do inform about the expected systematic asymmetries or the absence thereof, that cannot be equalised through cross-border trade. For example, if market participants expect that interconnection capacity is insufficient so as to equalise short-term day-ahead spot exchange market prices, futures will differ if it is believed that the short-

[5] We do not have interconnector price data on Austria and presume that the prices differences have always been equal to zero.

term price level in Germany is systematically higher than in the neighbouring country; by the same token, equal levels of futures indicate that parties do not anticipate systematic differences.

Data on futures is available for Germany and its neighbouring countries the Netherlands, France, Czech Republic and the Nord Pool area. We find the following:

In 2009 Dutch, French and Czech baseload futures diverge from German futures by more than 5% in less than 1.3%, 11% and 13% of all instances, respectively. In comparison, futures from the Nord Pool area diverge from German futures by more than 5% in 100% of all instances.

In 2009 Dutch, French and Czech peakload futures do not diverge from German futures by more than 5% in all instances. In comparison, futures from the Nord Pool area diverge from German futures by more than 5% in 100% of all instances.

The most recent available data hence points towards small price differences in Germany, the Netherlands, France and the Czech Republic. In more than 85% of all instances (days), price differences are small enough to be consistent with integrated markets. The differences with regard to Nordic prices are due to lower Nordic prices, being based on hydro opportunity costs. However, even with respect to the Nord Pool area, we observe high future price correlations to Germany.

Small price differences in futures appear as a recent phenomenon, though. Notwithstanding a missing clear trend of future price convergence, the 2009 findings are encouraging.

Testing the competitive constraints through foreign suppliers

Price correlations and convergence provide indirect evidence on whether regions (or products) belong to the same or different markets. In particular, this kind of evidence may serve as a screening device. However, correlations and price differences alone may often be inconclusive of whether suppliers in two regions (or of two products) exert *sufficient* competitive constraints on each other so as to include them in the same common market.

This question may in fact be asked from two angles. The first is, whether foreign suppliers would constrain German suppliers from increasing their prices above the existing level, e.g. as a consequence of a merger of all suppliers active in Germany. Indeed, this would be the correct question if a potential merger of German suppliers had to be assessed and corresponds to the classical SSNIP test question.

From a second angle, one might wonder whether the existing degree of market integration appears insufficient in order to induce low (enough) prices in e.g. Germany. This question appears relevant if no merger of national suppliers is at stake. In other words, would stronger (and costly) market integration likely reduce prices in Germany below the current level?

We believe that it is important to raise the question in these distinct ways because the public debate sometimes appears centred around the first and sometimes the second angle, rarely though with an explicit reference to either one. However, such a qualification appears crucial in order to derive useful policy implications: e.g. is more interconnector capacity required to lower the prices now, or only to remedy potential competitive concerns arising from a larger concentration in e.g. Germany?

We conduct the elements of a classical SSNIP test under the hypothesis of a perfect market design and focus on interconnection capacity as a potential bottleneck. This has three reasons. First, as is explained in more detail elsewhere, this presumption resolves a number of severe measurement issues. Second, insufficient interconnection capacity is often considered as a prime constraint to market integration. The methodology addresses this claim. Third, market design has improved much more rapidly in the past and will further improve in the near future. The analysis accounts for these dynamics and focuses on constraints that may persist beyond the next couple of years. Finally, it should be noted that all analyses are based on price spreads as suggested by interconnection prices (see above) rather than day-ahead spot exchange market data for reasons explained above. The analyses regard the most recent complete year of the dataset, 2008.

To answer the first question, we compare the (hourly) German price level to the (hourly) price level of the interconnected neighbouring country. If German prices are lower at the outset but higher after the 5 to 10% price increase, we suppose two consequences. First, German suppliers will not be able to supply electricity to the neighbouring country anymore and incur a volume loss in that country. Second, suppliers from the neighbouring country will supply electricity to Germany and German suppliers incur an additional volume loss in Germany. To that end we suppose that German suppliers loose volume according to the export and import interconnection capacity (NTC), respectively. Repeating these steps for each interconnected country,[6] we calculate the potential actual quantity loss that German suppliers would incur due to a 5 to 10% price increase. Finally, we examine whether the actual potential volume loss exceeds the critical volume loss that renders the price increase in question unprofitable. If so, foreign suppliers would prevent German suppliers to increase their prices and, to that end, markets should be delineated broader than national (from a German perspective). In our preferred model specification we find the following:

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[6] We acknowledge that NTC capacity cannot be simply be added. Indeed, to the extent that we add up large amounts of NTC, we may overstate the possible inflow to Germany and serves as a rough estimate only.

In 2008, a 10% price increase by all German suppliers would have been unprofitable in 29% of all hours.

In 2008, a 5% price increase by all German suppliers would have been unprofitable in 50% of all hours.

These results suggest that Germany is already sufficiently interconnected so that foreign suppliers would restrain German suppliers from a 5% increase in prices in about half of all hours. A higher price increase of 10% would still be unprofitable in about one third of all hours. However, these numbers were derived through an *ex-post* analysis; that is under full certainty about the market outcome without a price increase. To the extent that market participants cannot predict the market outcome (without a price increase) under full certainty, they have to act upon expectations and, correspondingly, expected profitability of price increases. Indeed the expected profitability of price increases will be lower than suggested above: under uncertainty, some expectedly profitable price increases will turn out unprofitable, *ex-post*. Against this background, a general claim that regions appear insufficiently interconnected must be qualified: often, electricity wholesale markets are broader than national from an antitrust perspective. However, interconnection capacities are insufficient in order to discipline a concerted action of all German suppliers (as a hypothetical monopolist or a merged entity) in all circumstances. A potential merger in Germany should not be cleared by virtue of broader than national markets but must be assessed in a competitive effects analysis.

This finding should neither be equated with the existence of market power in Germany (the same result would be obtained if there were 1.000 equally sized suppliers in Germany), nor with larger interconnection capacity to automatically decrease electricity wholesale prices in Germany. In fact, low prices may actually be the result of a lack of market integration. In order to illustrate this, assume that the German price levels are always more than 5% below the price levels of the neighbouring countries. Then, a 5% increase of domestic prices of a hypothetical monopoly would not yet attract electricity from foreign suppliers and, thus, would always be profitable. In such a situation a fully integrated market with complete price convergence would likely yield higher prices.

The latter observation is addressed by our second analysis where we determine the hypothetical maximal price reduction in Germany, if interconnector capacities were unlimited. In particular, we suppose that whenever the German price had exceeded the price of a neighbouring country as suggested by interconnection prices, unlimited import capacity would drive the German price down by 50% of the price divergence.[7] We then calculate the likely potential price decrease that unlimited interconnection capacity could possibly achieve.

[7] This assumes that demand and supply functions in Germany and the neighbouring country are linear and have the same slope. For example, if demand curves in Germany and the neighbouring country were linear and had the same slope, then the German price would decrease by more than 50% if the German supply curve had a larger slope than the neighbour's supply curve (and vice versa). Sometimes Germany's supply curve will have a larger slope and sometimes it will have a lower slope than the neighbouring country. Also the total capacities are important, as slopes become basically infinite at the capacity limit. Without any precise knowledge about the underlying supply curves it appears reasonable that, on average, supply curves have similar slopes.

With respect to the important South-Western trading countries we find the following:

The Netherlands: in 2008, unlimited interconnection capacity might have decreased competitive German prices in only 1.5% of all hours; in these hours competitive German prices might have decreased by an average of 0.1%.

France: in 2008, unlimited interconnection capacity might have decreased competitive German prices in 33% of all hours; in these hours competitive German prices might have decreased by an average of 2.1%.

Austria: in 2008, by virtue of no zero congestion, additional interconnector capacity would have no effect on prices in Germany.

As regards interconnection to Switzerland and the Czech Republic, the maximum potential price drop in Germany would amount to 0.1% and 2.4%, respectively. Larger interconnector capacities to Poland and Denmark West might have a stronger effect though, decreasing German prices by up to 12% and 6.6%, respectively.

The above results presume that larger (unlimited) interconnection capacity would decrease prices in Germany subject to production cost efficiencies. That is, the analysis supposes no (additional) price decreases due to competitive effects. This presumption is in line with the findings reported below according to which German price levels already tend to appear too low in order to accommodate entry. That is, price levels in Germany appear to not exceed long-term competitive prices.

The results qualify general requests for more interconnection capacity. More capacity to the Netherlands, Switzerland and Austria would hardly decrease prices in Germany. Gains arising from more capacity to France and the Czech Republic should be assessed on a careful cost-benefit analysis. In conclusion we find that more interconnection capacity might often not decrease prices in Germany.

The analysis above refers to the extent of potential price decreases in Germany due to unlimited interconnector capacity. As such it focused on hours where prices in Germany exceeded prices in foreign countries. By the same token and as a point of reference, one might also consider the potential maximum price *increase* in Germany due to unlimited interconnector capacity.

To that end we determine all hours in which the price in Germany was lower than in a foreign country and approximate the potential price increase in Germany as 50% of the price divergence to the foreign country. The findings are as follows:

The Netherlands: in 2008, unlimited interconnection capacity might have increased competitive German prices in 98% of all hours; in these hours competitive German prices might have increased by 5.0% on average.

France: in 2008, unlimited interconnection capacity might have increased competitive German prices in 64% of all hours; in these hours competitive German prices might have increased by 5.6% on average.

Austria: in 2008, by virtue of zero congestion, additional interconnector capacity would have no effect on prices in Germany.

As regards interconnection to Switzerland, Denmark West and Poland the potential price increase in Germany might amount to 11%, 7.2% and 4.2%, respectively. As regards the Czech Republic, potential price increases in Germany are negligible.

These findings cast some doubt on whether perfect market integration and (costly) interconnection capacity should be a means to its own end under all circumstances. Again, a more differentiated view appears advisable. Benefits have to be assessed against investment costs taking into account other possible bottlenecks (e.g. grid typology) and remedies (e.g. higher generation capacity). The macroeconomic benefit of only slightly converging prices should be set into perspective against the investment costs for new cross-border interconnection capacity. Furthermore, the increase of cross-border interconnection capacity would not *per se* increase commercial cross-border flows due to technical constraints (ring flows, safety margins, bottlenecks in the underlying national grid topology, priority of renewable energy). Finally, new cross-border capacity should be assessed against other possible remedies (e.g. higher generation capacity).

Investment incentives and market power

Next to the degree of market integration, the Sector Inquiry addresses potential market power of national suppliers. In particular, the SI raises concerns of high price-cost margins and strategic withdrawal of capacity. In the context of capacity withdrawals, the SI addresses German suppliers:

> *It is interesting to note that the total generation capacity of the four main German generators decreased between 2000 and early 2005 by 2149MW (addition of 960MW of capacity, and retirement of 3109MW of capacity). The retirement of a plant may be explained by the age of the plant and the need for an operator to replace its old plants. In that respect it is to be noted that in the preceding years some new plants were switched on by these operators, although net additions in the preceding years were still of a lesser scale than these retirements. In any event, this decrease of total capacity is likely to have had an adverse effect on the balance of supply and demand. Furthermore, out of all the plants which have been retired, most of the capacity retired (2679MW) had low variable costs. (445)*

In the given context, the above statement might be understood as if German suppliers reduced available and cheap capacity, so as to increase price levels and profits. As we explain below, a closer investigation suggests a reversed causation: price levels have not been high enough so as to justify substantial investments in new plants, once old plants approach the end of their lifetime.

We understand that electricity suppliers assess the profitability of new plants on the basis of future input prices, operational costs and capital costs, spread over supposed generation quantities. Total average future costs are then compared to future electricity prices. Regarding future prices, the available data only goes back until the year 2005. We find:

Based on futures, the average total margin of a new Hard Coal plant (high capex and low variable cost) has been negative from 2005 to 2009 (with the exception of 2007).

Based on futures, the average total margin of a new CCGT plant (low capex and high variable cost) has been negative between 2005 and 2007; and positive in 2008 and 2009.

Negative margins may hence explain why closed plants have not been substituted by new ones. Indeed, this appears fully consistent with functioning and competitive electricity markets. As long as capacity additions do not earn their capital costs, net capacity tends to shrink. Rather, supply must become sufficiently tight so that scarcity rents also re-cover capital costs of capacity additions. According to our analysis, this happened only for low capex gas-fired plants and only in more recent years in 2008 and 2009.

1. Market integration: An introductory note on relevant indicators

At a given point in time and at a given location, electricity is a homogenous good. As such, electricity traded in a perfectly integrated market should have a homogenous price. In our view, price homogeneity is the ultimate indicator of whether two regions form a perfectly integrated market. However, as we argue below, regions do not need to be perfectly integrated in order to constitute a common market from an antitrust perspective. For example, with the German spot exchange market closing later than the French one, regional trading facilities have not yet been fully aligned. As a consequence, the electricity traded is not homogenous but differentiated by the additional information on e.g. wind or unplanned outages that parties receive in between the closing times. Of course, prices may then not be equal.

Market coupling and the synchronisation of the closing times of exchanges (or, indeed, mergers of exchanges) will make prices homogeneous as it is already the case in the Nord Pool. In such an environment, price homogeneity is the ultimate indicator for testing if two regions form a perfectly integrated market.

If price homogeneity of day-ahead prices at the exchanges is not the perfect indicator as long as institutional differences prevail, what other evidence can be considered to assess market integration?

First, some obstacles notwithstanding, international electricity suppliers may still exert sufficient competitive constraints on each other so as to form an integrated market from an antitrust perspective. For example, suppliers to a spot exchange platform with a slightly earlier closure time (e.g. France) are aware that customers can also use the platform which closes later (e.g. Germany); likewise customers would not rely on the German spot exchange market if prices were structurally higher than on the French market. Such competitive interaction should be reflected in price co-movements of day-ahead prices at exchanges, e.g. price correlations.

If day-ahead spot exchange market prices might diverge due to some remaining imperfections in the market design, one would expect that price data not subject to market design imperfections were more closely aligned. In contrast to day-ahead exchange spot trade, day-ahead OTC trade happens simultaneously so that trading in different countries exhibits the same information. For example, based on a limited dataset provided by RWE, OTC baseload price spreads can be shown to coincide with the averaged hourly results of the daily cross-border auction for interconnection capacity. This suggests that hourly prices for interconnection capacity measure market participants' hourly valuation of location price spreads between Germany and neighbouring countries. We therefore use hourly prices for interconnection capacity in order to approximate price spreads that are caused by economic fundamentals rather than market design imperfections.

Another source to investigate the degree of price homogeneity between Germany and its neighbouring countries are future contracts. Such contracts should not be affected by institutional problems described above. That is, if we observe day-ahead spot exchange market price spreads primarily as a consequence of the above described (temporary) imperfections in market design, we should observe substantially smaller future spreads.

Due to the volatility in supply and demand, optimal electricity grids will exhibit congestion at some points in the network at some time. With respect to analysing market integration, one interesting question is whether electricity suppliers in foreign interconnected countries imposed a strong enough constraint on suppliers active on the German market (German suppliers) so that, at a given point in time, a small but significant, non-transitory increase in prices (SSNIP) by a hypothetical concerted action of all German suppliers would be unprofitable. This question may in fact be asked from two angles.

The first is, whether foreign suppliers would constrain German suppliers from increasing their prices above the existing level, e.g. as a consequence of a merger in Germany. Indeed, this would be the correct question if a potential merger of German suppliers had to be assessed.

From a second angle, one might wonder whether the existing degree of market integration appears insufficient in order to induce low (enough) prices in e.g. Germany. This question appears relevant if no merger of German suppliers is at stake. In other words, would stronger (and costly) market integration be likely to reduce prices in Germany below the current level? By the same token one might ask whether stronger market integration might also increase price levels in Germany.

Finally, the development of European electricity markets has been and still is dynamic in nature. Many efforts towards stronger market integration have been made in the past. Yet, some important measures such as market coupling will only become effective in the near future. The investigation should hence not take a static stand but also hint at developments and likely outcomes in the near future. Again, even if prices are not yet exactly equal to date, structural indicators may hint towards convergence in the near future.

2. Improved institutional design

This section reviews the changes to the institutional design of cross-border electricity trading within Europe. The final report of the European Commission's inquiry into the energy sector raises the concern that rules and mechanisms for cross-border electricity transmission within Europe are poorly designed. In addition to insufficient cross-border transmission capacity, these institutional problems lead, it is argued, to a lack of market integration between Member States.

However, since the Sector Inquiry several important institutional changes have taken place that should facilitate market integration and thereby address some of the concerns listed in the report. This section provides an overview of recent institutional changes that concern the German electricity market.

The main conclusions are as follows:

A major change for European electricity markets is the creation of seven regional electricity markets by the Electricity Regional Initiatives. Germany is part of four such regional markets. Important changes have already taken place within these regional markets and those changes should lead to closer integration.

There has also been an increased cooperation between different power exchanges and TSOs. Again, closer cooperation should facilitate integration of national electricity markets.

With respect to the Western neighbouring countries, CWE Market Coupling is envisaged for the year 2010. These improvements will finalise market integration from a design perspective so that physical interconnector capacity will become the sole potential bottleneck towards full or perfect market integration.

The remainder of this section is structured in two sub-sections. The first section reviews the changes to cross-border transmission auctions at the German border brought about in the context of regional electricity markets. The following section provides an overview of cooperation between European electricity exchanges.

Cross-border transmission auctions at the German borders

The chapter on market integration of the final report of the energy Sector Inquiry concludes that cross-border electricity transmission does not exert significant competitive pressure on incumbent operators. Reasons for the lack of market integration (beside the insufficient level of cross-border capacities) were seen in the poor institutional design of the market for cross-border transmission. The inquiry argued that the design of congestion management is inefficient due to:

Congestion management: Inefficient congestion management methods, even if there were explicit auctions at the border.

Market administration: Important differences in rules that manage the electricity market administratively within and between control areas.

Capacity reservation: Long-term cross-border transmission capacity reservation under discriminatory conditions.

These conclusions were based on the market conditions which had mainly been established before 2005. Since this time significant changes in the institutional design of the market have taken place.

The first great leap towards the integration of Europe’s national energy markets was the launch of the Electricity Regional Initiatives (ERIs) through the European Regulators' Group for Electricity and Gas (ERGEG) in February 2006. The Regional Initiatives established seven regional electricity markets (REM) as an interim stage towards a single EU energy market:

Baltic REM (Estonia, Latvia and Lithuania)

Central-East REM (Austria, the Czech Republic, Germany, Hungary, Poland, Slovakia and Slovenia)

Central-South REM (Austria, France, Germany, Greece and Slovenia)

Central-West REM (Belgium, France, Germany, Luxemburg and the Netherlands)

Northern REM (Nord Pool [Denmark, Finland, Norway, Sweden], Germany and Poland)

South-West REM (Iberian peninsula [Portugal and Spain] and France)

France, Ireland and UK REM

The aim of the ERIs is to integrate the regional markets of the member countries of each REM into a single regional electricity market. The focus of the REMs is to improve cross-border congestion management as well as to increase transparency.

The REMs are geographically organized in a way of several overlapping areas between them, e.g. Germany is a member country of four REM's. Hence, if each REM reaches its final aim to establish coordinated implicit cross-border auctions, a single EU energy market will arise automatically.

The ERIs are organized in a way that regulators, market operators and key stakeholders work together in a way to improve European market integration, e.g. by the evaluation of the auction rules of the cross-border capacity allocation and its improvement on a yearly base.

Due to the unique geographical position of the German electricity market, the improvements of the institutional designs in the Central-West, Central-South, Central-East and Northern REM will be important for the emergence of a single EU energy market. Thus, this section concentrates on institutional changes of the cross-border transmission – additionally to the yearly changes in the auction rules at the borders – in these regional markets only.

The Central-West Region

The Central-West regional market includes the German borders with the Netherlands and with France. The main improvement on market design has taken place in 2008 when the TSOs of this region created the CASC-CWE (Capacity Allocation Service Company for the Central Western European Electricity Market). Since 28 November 2008, this joint company implements and organizes the annual and monthly auctions of transmission capacity on the common borders between the member countries as an integrated auctioning agency on one standardized platform using common rules at all borders. During 2009 it is planned to arrange the daily auctions by CASC-CWE as well. However, there were some smaller steps toward market integration on the German-French and the German-Dutch borders in the years after 2005 until the culmination of CASC-CWE. Auction rules for long term auctions are harmonized.

Germany/France

The Sector Inquiry reports that the congestion at the German – French border increases from 0% in December 2004 to an amount of nearly 100% in the following six months. The congestion was managed by a pro-rata rationing until 5 April 2005. This rationing rule was detached by the German TSOs Amprion (formerly: RWE Transportnetz Strom GmbH) and EnBW Transportnetz AG and changed into a single-sided explicit auction for transfer capacity from Germany to France. In January 2006, the cooperation with the French TSO RTE (Réseau de Transport d' Electricité) resulted in the extension of the congestion management to coordinated auctions, which allow market based capacity auctions from France to Germany as well. The capacities are offered in yearly, monthly and daily explicit auctions. Moreover, since January 2007, a secondary market exists where the reselling of capacities in following auctions is available, i.e. capacities from a yearly auction can be resold in the following monthly or day-ahead auction and monthly capacities in the following day-ahead auction. Additionally, intra-day capacity trade is provided by a web-based service. Intraday-capacities were made available from May 2007 onwards.

Germany/Netherlands

The auctioning of net transfer capacity between the German and the Dutch net has the longest history in capacity auctions of all German borders. In autumn 2000 the independent auction office TSO Auction BV was set up. The coordinated explicit auctions at this border are quite similar to the auctions at the German-French border. Starting in November 2001, the auctions are processed electronically. The capacities are offered in yearly, monthly and daily explicit auctions and since 10 December 2008 even intra-day capacities are provided on their website. However, in contrast to the French border, where the two German TSOs involved (RWE and EnBW) have agreed to common auctions for the transmission capacity, individual auctions between the Dutch TSO TennT and the Amprion and between TennT and E.on Netz (now: Transpower Stromübertragungs GmbH) exist to date.

Central-South Region

The German market has borders with three countries in this region: Austria, France and Switzerland. The management of cross-border transmissions at the German-French border is organized within the Central-West REM (see above) and at the German-Austrian border within the Central-East REM (see below).

Germany/Switzerland

The Energy Sector Inquiry does not explicitly disclose a significant congestion between the German and the Swiss grid. In March 2005, there were temporary congestions at this border which were managed by a pro-rata rationing by the EnBW Transportnetze AG. Since January 2006, the TSO's EnBW Transportnetze AG, Amprion, VKW-Netz AG and swissgrid (former ETRANS) run coordinated explicit auctions together to manage the congestions. The auctions are coordinated by the EnBW Transportnetze AG and offer monthly, day-ahead (since January 2006) and intra-day capacity auctions (since November 2007), as well as yearly auctions (since November 2007). To improve the efficiency of the intra-day auctions by increasing the number of the intra-day electricity traders and to decrease the time lack between booking the cross-border capacities and the use of the line to 60 minutes (or even 15 minutes) in advance, the allocation of the capacities were changed from telephone trading to the web service www.intraday-capacity.com. Additionally, since August 2007, traders have the possibility to resell capacities in the following auctions via a secondary market.

Central-East Region

In the Central-East Region, Germany is connected with Austria, the Czech Republic and Poland. Between Germany and Austria congestions have never appeared. Thus, explicit auctions were only established at the borders to the Czech Republic and Poland in commonly coordinated auctions since 2005 only. The operators of the electricity transmission systems of the relevant parts of the German net (Transpower Stromübertragungs GmbH and Vattenfall Europe Transmission GmbH), the Czech Republic (CEPS SA) and Poland (PSE-Operator SA) organize the coordinated auctions on the borders. The auctions were organized by the common electronic auction office (http://www.e-trace.biz/) in yearly, monthly and daily auctions operated by CEPS SA. In July 2008, the TSOs of this REM established a common regional capacity-allocation office (CAO Central Allocation Office GmbH) for the whole Central-East Region, located in Freising near Munich, Germany. The office will allocate yearly, monthly and daily rights for cross-border electricity transmission in the Central-East Region. Finally, the company will replace the activities of http://www.e-trace.biz at the German borders.

Germany/Czech Republic and Poland

Starting in 2003, the Transpower Stromübertragungs GmbH has been running cross-border capacity auctions to CEPS SA. Since January 2004, the Vattenfall Europe Transmission GmbH and CEPS SA also provide common monthly and yearly coordinated cross-border capacity auctions over the common border. The Polish operator (PSE SA) joined the project in April 2004. In 2005, all relevant operators (Vattenfall, Transpower and CEPS) established common rules on a common web platform (http://www.e-trace.biz) for cross-border capacity auctions. However, at the border between Germany and the Czech Republic individual auctions between Vattenfall and the Czech operator CEPS and between Transpower and CEPS coexisted. The efficiency of the capacity auctions was increased in 2006 through the extension of auctions offered on a daily basis and additionally in September 2007 (April 2008 respectively) when Vattenfall (and Transpower) established bilateral intra-day auctioning as well.

Germany/Austria

The German-Austrian border is the only one of the German Control Area and in Europe where no congestion has been observed in the years after the liberalization of the electricity market. The demand for interconnector capacity never exceeded the available transmission capacity. As a consequence, it was possible for the European Energy Exchange (EEX) to offer the fulfilment of energy contracts within Austria's by far largest control area from 1 April 2005. Thus, the German Energy Market and the Austrian Energy Market nearly merged to a one-price area and thus achieved the long term aim of the EU Commission for all European electricity markets.

Northern Region

The Northern regional market includes the borders of Germany and Denmark as well as Germany and Sweden. Denmark and Sweden both are integrated in the Nord Pool market, where market coupling between the Member States is implemented already. The current main aim of the Northern REM is to integrate the German market to the Nord Pool market.

Germany/Denmark

The congestion management at the German-Danish border is separated into two interconnectors: the cross-border transmission between Jutland (Denmark West) and Germany (Transpower Stromübertragungs GmbH) and between Zealand (Denmark East) and Germany (Vattenfall). In the interconnection from the net of Transpower and Denmark, yearly, monthly and daily explicit auctions are being applied since 2000. Since this time a secondary market exists as well, where capacity acquired in the yearly auction can be resold by its owners. In the interconnection of the Vattenfall area and Denmark, monthly and daily explicit auctions exist since 2002. On 5 October 2005, the Nordic power exchange Nord Pool Spot opened a day-ahead implicit price quotation into the Germany/Austrian market (Elspot). The new bidding area was named KONTEK (controlled by Vattenfall). On 25 September 2006, Nord Pool Spot extended its intra-day market to KONTEK as well (Elbas). On 10 January 2007, the auction was expanded to the whole German/Austrian market, thus allowing implicit intra-day trading of power between the German market and the Nord Pool area. To achieve a market coupling of Nord Pool and the German/Austrian market, the TSOs Vattenfall Europe Transmission, Transpower and Energinet.dk as well as the Power Exchanges Nord Pool Spot and the European Energy Exchange have founded a joint project: the European Market Coupling Company GmbH (EMCC) was founded in August 2008. EMCC is accredited at Nord Pool Spot and EEX and is entitled by the transmission capacity owners (the TSOs) to allocate the cross-border capacities between Germany and Denmark. Both markets were coupled for the first time on 29 September 2008, while only the daily auctions at the link between Denmark West and Germany where replaced, the explicit monthly and annual auctions remain. However, due to difficulties EMCC has decided to suspend the market coupling in October 2008. To this end, the daily explicit auctions on the interconnector between Denmark West and Germany (Transpower) were reactivated on 9 October 2008 and the implicit auction between Germany and Eastern Denmark on 14 October 2008 as well. However, the EMCC announced to relaunch the market coupling project during the second quarter of 2009.

Germany/Sweden

The allocation of interconnection capacities between Germany and Sweden differs significantly from the other borders. The interconnector is owned by Baltic Cable AB, neither owner nor affiliated to a TSO. The company offers transmission short term since 1994 on a day-by-day basis at fix prices (see http://www.balticcable.com/tariffsindex.html).

Summary

The analysis of the recent developments of the cross-border capacity allocation at the German borders has shown that the German market area was already well integrated to its neighbour markets at the time of the Energy Sector Inquiry in 2005 (see Figure 1).

Figure 1: Cross-border capacity allocation at German borders in 2005

German border to:	coord. explicit actions	secondary market	common allocation office	intra-day market	market coupling
FR	no	no	no	no	no
NL	yes	yes	yes	no	no
CH	no congestion problems				
CZ / PL	yes	yes	yes	no	no
AT	no congestion problems				
DK_E	yes	yes	yes	no	no
DK_W	yes	yes	yes	no	no
SE	proprietary allocation				

Source: ESMT CA

However, several changes have taken place to improve the efficiency of the cross-border transmission and the transparency of its allocation. Since 2006, we find the following changes:

Improvements in auction rules: The auction rules have been revised every year to achieve common efficient rules for the capacity allocation.

Improved transparency: The allocation is organised on common action offices, organized on web platforms which has increased the transparency of the allocation.

Increased product variety: The capacities can be bought on different terms (yearly, monthly, daily, intra-day).

Improved liquidity: Acquired capacity can be resold on secondary markets.

These changes are effective at all German borders.

The fundament for the enhancements was the implementation of the Electricity Regional Initiatives (ERIs) and the resulting establishment of the Regional Electricity Markets (REM's). These Initiatives allow for a continuous improvement of the congestion management at the borders and they make it possible that the enhancements are accompanied and controlled by all stakeholders (the TSO's, the market participants and the regulators). The main aim, the coupling of the markets, however, is not implemented yet, but the changes in the institutional design since 2006 are the basis for this final aim.

The following Table 1 summarizes the main changes in the institutional design at the German borders.

Table 1: Overview of changes in institutional design at German borders

2005	**April**	• first explicit day-ahead auction at French border
	June	• first quarterly auction at French border
		• first monthly auction at French border
	December	• first yearly auction at French border (for 2006)
2006	**January**	• coordinated auctions at the German-French border
		• daily auctions at the borders to the Czech Republic and Poland
		• monthly, day-ahead and intra-day auctions at the border to Switzerland
	February	• launch of the Regional Market Initiatives
	September	• implicit intra-day auctions at KONTEK (Danish border)
2007	**January**	• secondary market at the French border
	May	• first intra-day auction at French border
	August	• secondary market at the Swiss border

	September	• intra-day auctions between Vattenfall's control area and the Czech Republic and Poland
	November	• yearly auctions at the Swiss border • improvement of the intra-day auctions at the Swiss border
2008	**April**	• intra-day auctions between the Transpower control area and the Czech Republic
	July	• formation of a common regional capacity-allocation office in the Central-East REM (CAO: Central Allocation Office GmbH)
	August	• formation of a common regional capacity-allocation office for the transmission between Germany and Denmark (EMCC: European Market Coupling Company GmbH)
	September	• first market coupling between the German/Austrian Market and the Danish control areas
	November	• first joint monthly and yearly auctions at the regional capacity-allocation office in the Central-West REM (CASC-CWE: Capacity Allocation Service Company for the Central Western European Electricity Market)
	December	• intra-day auctions at the German border to the Netherlands
2010	**March**	• Start of the ATC-based market coupling in the CWE region
	End	• Start of flow-based market coupling in the CWE region

Source: ESMT CA, RWE

Due to these changes, complete explicit capacity allocation auctions, including secondary capacity markets, are established at all German borders (see Figure 2 below). Finally, the formation of the common regional capacity-allocation offices in the different REMs in 2008 and the availability of web-based intra-day capacity trading are the basis for the final step to the integration of the German/Austrian electricity market with the neighbour markets: the coupling of markets in the CWE region.

The CWE Market Coupling will align trading conditions in Germany with those in the Netherlands, Belgium, Luxemburg and France. In particular, market coupling leads to a single trading platform for day-ahead capacities which are allocated in relation to spot market exchanges. Part of this are also aligned spot market trading conditions, notably simultaneity and unique price levels as long as there are no interconnection capacity constraints. As we argue below, this will reduce day-ahead spot exchange market price differences between Germany and the coupled countries substantially.

Figure 2: Cross-border capacity allocation at German borders in 2009

Border to:	coord. explicit actions	secondary market	common allocation office	intra-day market	market coupling
FR	yes	yes	yes	yes	no
NL	yes	yes		yes	no
CH	yes	yes	yes	yes	no
CZ / PL	yes	yes	yes	yes	no
AT	nearly integrated market				
DK_E	yes	yes	yes	yes	yes
DK_W	yes	yes		yes	
SE	proprietary allocation				

Source: ESMT CA

However, even if market coupling is not implemented yet, every single improvement in the institutional design should result in a more efficient allocation of the cross-border capacities compared to the situation described in the Energy Sector Inquiry, based on data by the end of 2005. Compared to the situation in 2005, the increase in the efficiency and the transparency of the cross-border capacity allocation should result in increasing trading activities at all interconnectors in general. Additionally, due to all improvements described above, the increasing trading activity should result in an increasing efficiency of cross-border capacity trading by means of capacity allocation, that follow the conditions at the power exchanges of the neighbour markets.

Cooperation and coordination of the EEX with the power exchanges of its neighbouring markets

To achieve an integration of the European electricity market, it is not sufficient that the cross-border capacity allocation is used in an efficient way. The sufficient and efficient use of cross-border capacities are necessary conditions only. However, market coupling requires the cooperation and coordination of the power exchanges as well.

Since 2005 the EEX was very successful in integrating other markets to its platform. The main achievement was the integration of the largest Austrian control area, which results in a nearly single German/Austrian electricity market. Also, the opening of the Swiss spot market SWISSIX in December 2006 on the EEX platform has increased the transparency and efficiency of energy trading between Germany and Switzerland. A further success is the cooperation between the EEX and the Nord Pool with the aim of establishing a stable market coupling of the German/Austrian control area and the northern market (see Section 2.1 above).

Another great leap was the establishment of the European Power Exchange EPEX Spot SE in September 2008. EEX and Powernext each hold 50 percent of the joint company. EPEX Spot provides since January 2009 the market data for Spot Market auctions for the market areas Germany/Austria, France, Switzerland, for the continuous day-ahead trading for France and for intra-day trading in Germany and France. As of July 2009, the common market rules and the common market model of the EPEX Spot became effectual for Germany/Austria, France and Switzerland. From this day on, the EEX and Powernext will concentrate their market activities in only one common European power exchange.

3.
Price indicators

Introduction

The Sector Inquiry (SI) identifies significant differences in electricity prices across EU countries and preliminarily finds a "lack of electricity market integration."[8] Indeed, electricity is an undifferentiated product and as such there should not be any price differences across perfectly integrated markets. However, even if some price differences exist and the markets are not perfectly integrated, they may still be sufficiently integrated from an antitrust or regulatory and market design perspective, provided the price differences are small enough. In the next section, we will examine if the German electricity market is sufficiently integrated with other European electricity markets from a competitive and antitrust perspective.

In this section, we will more closely examine the price differences between the German and other EU electricity markets identified by the SI. We will also identify some institutional market features that lead to some of the apparent price differences and are likely to be removed in the near future. For example, one of the differences between the German and French spot exchange markets is the hour of operation. In particular, the German spot exchange market closes later than the French one. Hence, German day-ahead spot exchange market prices incorporate additional price discovery due to additional fundamental information in the extra period of operation. Thus, as markets across the EU are synchronised in terms of timing and other institutional features (by coupling or mergers of exchanges, for example) some of the apparent price differentials are likely to disappear – as suggested by the experience of Nord Pool.

8 See SI 519-521.

Even though the day-ahead spot exchange market prices across the EU partly reflect differences in institutional market features and the price differential is not a perfect indicator of market integration, we can examine the co-movement in these prices to assess market integration. If the markets are integrated except for the discrepancy in timing, then suppliers may still exert severe competitive constraints on each other. For example, suppliers to a market with a slightly earlier closure time (e.g. France) know that customers can also use the market which closes later (e.g. Germany); likewise customers would not rely on the German spot exchange market if prices were structurally higher than in France. Such competitive interaction should be reflected in co-movements of day-ahead prices at exchanges, e.g. price correlations. Thus, we also examine the correlation in day-ahead spot exchange market prices.

However, co-movements are often caused by common factors such as input prices. Price correlations might then be high due to co-movements of these input prices rather than competitive relationships between neighbouring countries, a phenomenon called ‘spurious correlation’. We therefore extend our analysis of the day-ahead price movements further. In particular, we study the relationship in day-ahead prices between Germany and its neighbours using econometric techniques. To this end we use the co-integration technique which, like a simple regression, measures the degree of the relationship. However, this econometric approach mitigates a number of technical shortcomings of a simple regression technique.

Again, if some of the day-ahead spot exchange market price differences are due to differences in market design features, then one would expect that other prices that are not as strongly affected by such differences would be more closely aligned. One such price would be an over-the-counter (OTC) price which is based on trades that occur simultaneously across markets and hence reflect the same price discovery and fundamental information. Hourly OTC products do not exist. However, hourly prices for interconnection capacity measure market participants’ hourly valuation of location price differences between Germany and neighbouring countries. We therefore use hourly prices for interconnection capacity to approximate price differences that are caused by economic fundamentals rather than market feature differences.

Another electricity price not affected by the market feature difference is the price of future contracts. In particular, year-ahead future contracts are traded daily but regard electricity supply for a year ahead. With such a long time span ahead, additional price discovery worth a few hours becomes irrelevant and price differences are akin to expected fundamental differences (e.g. missing interconnector capacity) rather than additional price discovery. Thus, we examine the future contract price differences between Germany and its neighbouring countries. If spot exchange market price differences in part reflect differences in market features, then we should observe substantially smaller future contract price differences.

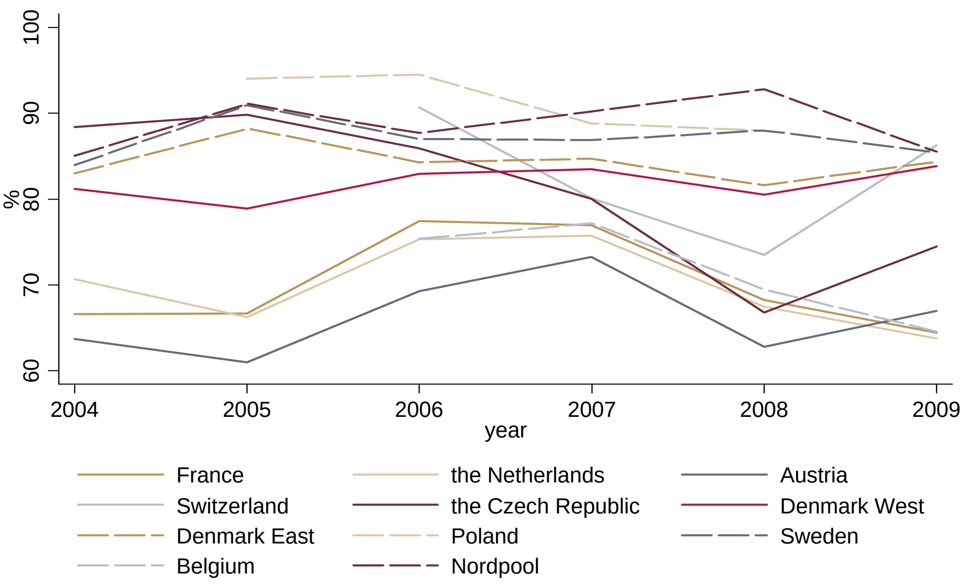
The rest of this section is organized as follows. First, we examine day-ahead spot exchange prices in Germany and neighbouring countries and their evolution over the last several years. Then we analyze co-movements of day-ahead spot exchange prices by means of simple correlation coefficients and co-integration analysis. Second, we consider prices for day-ahead interconnection capacity and, third, future prices.

Day-ahead spot exchange market prices

Convergence

We begin our examination by looking at day-ahead spot exchange market prices. We obtained data on hourly day-ahead prices directly from the power exchanges of Germany and of the neighbouring countries (EEX, Powernext, APX, EXAA etc.). Day-ahead spot exchange market prices point toward price differences between Germany and its neighbouring countries.[9] For each of Germany's neighbouring countries we calculated the number of hours in which its price and the German price differed by more than 5% as a share of total number of hours in each year. Figure 3 presents these shares from 2004 to 2009.[10]

Figure 3: Share of hours at which day-ahead spot exchange market price spread is more than 5% of the German day-ahead spot exchange market price



Source: Powernext, APX Group, Energy Exchange Austria, European Energy Exchange, OTE, Power Exchange Central Europe, Polish Power Exchange, Belpex, Nord Pool.

[9] Figure 12 in the Appendix shows annual average price differences in absolute terms.

[10] Dates for the year 2009 cover the period until May 2009.

As Figure 3 shows, there is a significant share of hours in which the day-ahead prices in Germany and its neighbouring countries differed by more than 5%. For example in 2008, the German day-ahead price differed from the Dutch, French and Austrian day-ahead price by more than 5% in 67%, 68% and 63% of the hours, respectively. Price differences with other countries are also larger than 5% in a significant share of hours. Figure 3 also suggests that Germany's neighbouring countries can be separated into two groups. The first group consists of the members of the Nord Pool, Sweden and Poland, whose price differences are more than 5% in more hours. The second group includes all other neighbouring countries with the Czech Republic moved from the first group to the second in 2008. Figure 3 does not show a clear decreasing trend in the share of hours and consequently day-ahead price convergence with all countries. Yet, with respect to France, Belgium and the Netherlands such a trend can be observed from 2006 onwards. We also analyzed the share of hours in which the day-ahead price differences were more than 10%. Figure 11 in the Appendix presents the results of that analysis.

Price correlation

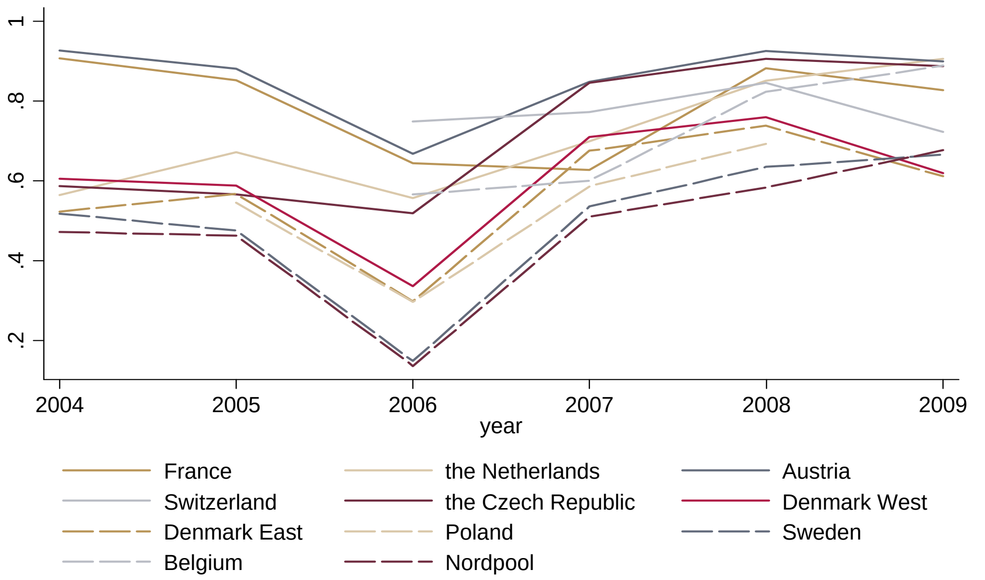
Simply examining the differences in day-ahead prices seems to suggest that the German electricity market is not well integrated with neighbouring countries. However, as discussed above, differences in the day-ahead prices in part reflect the difference in hours of trade operation. The period under investigation also coincides with an extensive increase of wind energy in Germany, from an installed capacity of 16629 MW in 2004 up to 24263 MW in 2009.[11] We understand that this trend alone induced substantial electricity flows from North to South which, in turn, reduced idle interconnection capacity. Moreover, as discussed above, i) European suppliers might still exert competitive constraints on each other and ii) (some) crucial institutional changes are envisaged in the near future, removing the difference in hours of market operation for some European spot market exchanges. We therefore analyse the day-ahead prices further to examine the competitive dynamics between the electricity markets in Germany and its neighbouring countries.

Specifically, we analyze the correlation in day-ahead prices between Germany and its neighbouring countries. This measure was also analyzed in the SI and picks up some of the competitive interaction between suppliers of different countries, price differences notwithstanding. Correlation between any two prices measures how closely the two prices tend to move together. Correlation takes a value between -1 and 1 with values closer to 1, suggesting higher propensity for the prices to move in the same direction.

Figure 4 shows correlations between day-ahead prices of Germany and its neighbours. Correlation coefficients are estimated for each year from 2004 to 2009 and for each of Germany's trading partners.

[11] Source: ISET.

Figure 4: Pairwise correlation of day-ahead spot exchange market prices in Germany and other countries



Source: Powernext, APX Group, Energy Exchange Austria, European Energy Exchange, OTE, Power Exchange Central Europe, Polish Power Exchange, Belpex, Nord Pool.

As illustrated in Figure 4, correlation between day-ahead prices in Germany and its most important trading partners to the West and South shows that:

The Netherlands: correlations have gone up from 0.57 (2004) and 0.67 (2005) during the SI to 0.85 and 0.91 in 2008 and 2009, respectively.

France: high correlations during the SI at 0.91 (2004) and 0.85 (2005) have remained stable at levels of 0.88 and 0.83 in 2008 and 2009, respectively.

Austria: high correlations during the SI at 0.93 (2004) and 0.88 (2005) have remained stable at levels of 0.93 and 0.91 in 2008 and 2009, respectively.

Hence, the day-ahead price correlation points towards substantially increased market integration between Germany and the Netherlands. As for France and Austria, the correlations remain at a high level as noted by the SI.[12] Thus, the correlation analysis suggests strong competitive linkages between Germany and its main trading partners.

Day-ahead price correlations are also high between Germany and the Czech Republic (0.91 and 0.89 in 2008 and 2009, respectively). Similarly, for Switzerland, Denmark, Nord Pool, Poland, Belgium and Sweden the price correlations are positive and consistent with competitive linkages, albeit at a somewhat lower level (between 0.58 and 0.85). Somewhat lower price

[12] In contrast, correlations Spain-France, France-Italy and France-Netherlands were 0.66 to 0.71, 0.63 to 0.58 and 0.07 to 0.16, respectively (see SI, p. 335). However, we notice that for the pair France–Netherlands our own calculations would yield a correlation coefficient of 0.57 for the year 2004.

correlations for these countries, with the exception of Poland, can be explained by strong seasonality effects and weather-related availability fluctuations of hydro-electric power supply.

Moreover, shows that since 2006[13] there has been a clear trend of increasing day–ahead price correlations between Germany and all of its neighbouring countries.[14] These high and increasing day-ahead price correlations suggest significant and increasing market integration – in particular with respect to Germany and its most important trading partners such as the Netherlands, France and Austria. Additional steps towards market coupling and efforts to increase interconnector capacity can be expected to lead to further market integration.

Co-integration analysis

We began this section by observing the differences in day-ahead prices between Germany and its neighbouring countries that suggested lack of market integration. Upon closer examination we found that day-ahead prices moved closely together. However, co-movements are often caused by common factors, such as input prices. Price correlations might then be high due to co-movements of these input prices rather than competitive relationships between neighbouring countries, a phenomenon called ‘spurious correlation’.

In this sub-section we therefore extend our analysis of the day-ahead price movements further. In particular, we study the relationship in day-ahead prices between Germany and its neighbours using econometric techniques. To this end we use the co-integration technique which, like a simple regression, measures the degree of the relationship. However, this econometric approach mitigates a number of technical shortcomings of a simple regression technique.

We focused our analysis on the day-ahead prices between Germany and its main trading partners: the Netherlands, France and Austria. We find the following:

German prices were statistically significantly related with the Dutch, Austrian and French prices during both periods 2003–2004 and 2007–2008. Hence, the correlations reported earlier were not spurious.

Our results also indicate that the systematic price relationships between Germany and its neighbouring countries became stronger between the periods 2003–2004 and 2007–2008, whereby the German-Dutch price relationship increased most substantially.

Results of this analysis are broadly consistent with the simple spot exchange market correlation results we discussed above. Both analyses show that the French and Austrian prices have been strongly correlated with the German prices since 2005 whereas the Dutch prices have recently become more correlated with the German prices. The analysis also supports the hypothesis of a structural

[13] Indeed, the year 2006 appears as an outlier in Figure 4. We understand that the year 2006 was extraordinary, among other, due to an extremely hot summer.

[14] It should be taken into account that for 2009, only data for the first four months of the year were used in the analysis.

competitive interaction between Germany and the important neighbouring countries the Netherlands, France and Austria. Furthermore, comparing the two snapshots 2003–2004 and 2007–2008, the results suggest that the institutional improvements described in Section 2 have actually translated into stronger competitive linkages between Germany and its most important trading partners. As the markets are announced to become more synchronized in the near future, these competitive linkages are likely to become stronger.

Price relationship modelling
Our analysis here is designed to estimate the long-term or structural relationship between Germany's and neighbouring countries' prices after controlling for the short-term disturbances caused by, for example, different information about wind at closing times. We assume that the relationship between the day-ahead price of Germany and its neighbour is captured by the following model:

$$p^G = \alpha + \beta p^N + \mu t + \varepsilon$$

In the model above, p^G stands for the price in Germany, p^N is the price in a neighbouring country, t represents a time trend with a coefficient μ and ε is a random disturbance. This last term, ε, reflects non-systematic and unpredictable short-term price disturbances. Average ε is assumed to equal zero, as it captures short-term disturbances but does not affect long-term price differences. Coefficients α and β capture the long-term relationship and systematic price differences which are determined by factors such as the transmission capacity, conduct of market players, market participants' cost structure, etc.

Thus, the model separates the systematic long-term price differences (captured by α and β) from the short-term disturbances (captured by ε). In order to estimate the model presented above and in particular to estimate the values of α and β, we use the co-integration technique as opposed to the more common simple ordinary least square (OLS) method. There are three steps involved in our analysis. First, we check for the stationarity of the price series. This test determines whether the co-integration technique is needed or whether the OLS technique is adequate. Second, we perform a trace test to check if the prices are co-integrated. Third, we estimate the model using the co-integration technique. This third and final step produces the estimates of α and β coefficients that represent the long-term relationship between coefficients as discussed above. Next, we describe these three steps in detail and present results.

Stationarity tests of prices
Estimating models involving time-series price data with the OLS technique usually leads to an issue known as the spurious correlation. Spurious correlation refers to

the issue of identifying a strong relationship between two unrelated price series even when such a relationship does not exist. Usually spurious correlation is caused by some other common factors, which drive prices in Germany and in a neighbouring country but do not present any competitive linkage between the two prices. Economic variables such as the prices of gas, hard coal and CO_2 allowances which are formed on global markets and are roughly the same for all European countries are such common factors that significantly influence electricity prices in different markets. As a result, prices in two totally independent markets could co-move and follow the same trend, which actually reflects input price dynamics rather than any competitive linkages.

From a technical standpoint, the OLS technique is likely to result in a spurious correlation when the price series are not stationary. Stationary price series display a mean-reverting property which is required to use the OLS technique. Instead, a non-stationary price series usually displays changing trends. Usually these changing trends are driven by some other common factors and not reflective of competitive linkages as discussed above.

Thus, the first step involved in estimating a long-term relationship between price series is to determine if the price series are stationary. If the price series are stationary then the OLS technique is adequate to estimate the model presented above.[15] Otherwise, a co-integration technique is needed which is able to distinguish between a spurious correlation and a direct relationship between prices indicative of competitive linkage.

We used the KPSS test to determine whether the day-ahead prices were stationary. We found that the price series for all countries were stationary for the years 2003 and 2004 and non-stationary for the years 2007 and 2008. Table 9 in the Appendix shows the results of the KPSS test.[16] Thus, for the years 2003 and 2004, OLS or FGLS is an adequate estimation tool. However, for the year 2007 and 2008 we needed to test for and employ the co-integration technique.

Trace tests for co-integrated prices

Once the price series are determined not to be stationary, we need to test if they are co-integrated. In other words, we determine if the prices are related above and beyond the relationship driven by changing trends as discussed above. In order to determine whether the prices are co-integrated for the years 2007 and 2008, we used the Johansen's trace test procedure. This test establishes whether there is a direct linear relationship between price series that are reflective of competitive linkage and are not driven merely by common factors.

We found that the price series between each pair of countries were co-integrated for the years 2007 and 2008. Table 10 in the Appendix shows the number of lags used for the trace test, trace statistics and critical values for the 5% significance

[15] With stationary price series, we can use either OLS or feasible generalized least square (FGLS) technique. FGLS is a more robust technique that controls for other technical issues such as heteroscedasticity and autocorrelation.

[16] KPSS test statistics are presented for both the level and first differences of the price series.

level. Trace tests and the model itself are estimated simultaneously and are dependent upon the model specification which is discussed next.

Estimated model and results

Finally, we estimated the model described above using the co-integration technique for the years 2007 and 2008. We used the estimation procedure based on a maximum likelihood method developed by Johansen.[17] As mentioned above, both the trace test and the co-integration coefficient estimation require model specification. Specifically, dummy variables, number of lags and a trend specification should be selected. Below we discuss each element of the model specification in detail.

Electricity price series have a well-known seasonal, daily pattern.[18] For example, winter prices are systematically higher than summer prices, and prices on weekdays are higher than prices on the weekends. We take these patterns into account in our model by introducing dummy variables for each month of the year and each day of the week. These dummy variables indicate the persistent differences in prices across seasons and days.

Electricity prices are also correlated over time. In other words, prices in one period are influenced by the prices in prior periods; this effect is usually called the lagged effects. We use the Hannan-Quinn Information Criterion (HQIC) to determine the number of lags in the data. When the number of lags determined by the HQIC does not facilitate a co-integration identification, we assume that there are seven lags in all price series. As long as we operate with daily prices, this assumption simply means that today’s price depends on a price appeared one week ago on the same day of the week.

Finally, one needs to decide on trend specification. Specifically, we assume that a linear time trend with some coefficient influences the price relationship, in other words, ceteris paribus, differences in prices decrease or increase over time. Moreover, we allow for a linear time trend in the price series themselves.

Hourly day-ahead price data was obtained from the power exchanges in each country. Large numbers of hourly observations tend to increase the power of the statistical tests, including the trace test. The increased power creates a bias towards the conclusion that the price series are co-integrated. Thus to be conservative, we aggregated the hourly prices to generate daily prices.[19] Our models are estimated using this daily price data.

We estimated the model described above between prices for Germany and each of its important trading partners: France, the Netherlands and Austria. We

[17] See Johansen, S. (1991), “Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models”, Econometrica 59, 1551–1580 and Johansen, S. (1995), “Likelihood-Based Inference in Cointegrated Vector Auto-Regressive Models”, Oxford University Press.

[18] They also have an hourly pattern. Due to the daily aggregation this is, however, irrelevant in the present context.

[19] See Juselius, M. and R. Stenbacka (2008), “The Relevant Market for Production and Wholesale in Electricity in the Nordic Countries: An Econometric Study”, Discussion Paper 222, Helsinki Center of Economic Research.

estimated a separate model for the periods 2003–2004 and 2007–2008. Thus, our model estimates the price relationship between each pair of countries and over time as well. As discussed above, the prices for the period 2003 to 2004 were stationary, hence for this period we estimated the model using the FGLS technique. Since the prices for the period 2007–2008 were not stationary, we used the Johansen's cointegration method to estimate the model for this period.

Table 2 shows the results for our price relationship models. The first column of Table 2 shows the estimated values of the coefficients for each country pair and for the period 2003–2004. The second column of the table presents estimated values for the period 2007–2008. All values are significantly different from zero.[20]

Table 2: Estimates of the price relationship coefficients

	2003-2004	2007-2008
France and Germany		
β	0.4	0.7
μ	-0.0002	0.0225
α	17	5
the Netherlands and Germany		
β	0.2	0.9
μ	0.0035	0.0063
α	19	-1.3
Austria and Germany		
β	0.7	0.9
μ	0.0007	0.0110
α	8.6	1.9

Source: ESMT CA analysis.

The results presented in Table 2 for the relationship between prices in Germany and France during 2007 and 2008 can be translated into the following expression:

$$p^G = 5.02 + 0.7 p^N + 0.0225t + \varepsilon$$

[20] Standard errors of the coefficients can be found in the Appendix Table 11.

In the same manner one can interpret coefficients for the other country pairs and other time periods. The comparison of the coefficient values for the two time periods indicates that the German market is becoming more integrated with those of the neighbouring countries. Values of 0 and 1 for the coefficients α and β, respectively, indicate structurally integrated markets. By this we mean e.g. two exchanges but without participation constraints (no interconnection bottlenecks) and time constraints (equal trading times). In reality values of the coefficients always differ from 0 and 1, respectively. However, the closer α and β are to 0 and 1 respectively, the more integrated the markets are. As Table 2 shows, for all country pairs the coefficients are closer to the integrated values in 2007–2008 than they are in 2003–2004. For example, coefficient β between Germany-France went from 0.4 in 2003–2004 to 0.7 in 2007–2008, and coefficient α from 17 to 5. Thus, the price relationship models indicate that the German electricity market is getting more integrated with the neighbouring country markets.

Convergence of price spreads as suggested by interconnection prices

As discussed above, the day-ahead spot exchange market prices may diverge due to differences in market features rather than due to the lack of market integration. Thus, next we examine prices that do not have this disconnect.

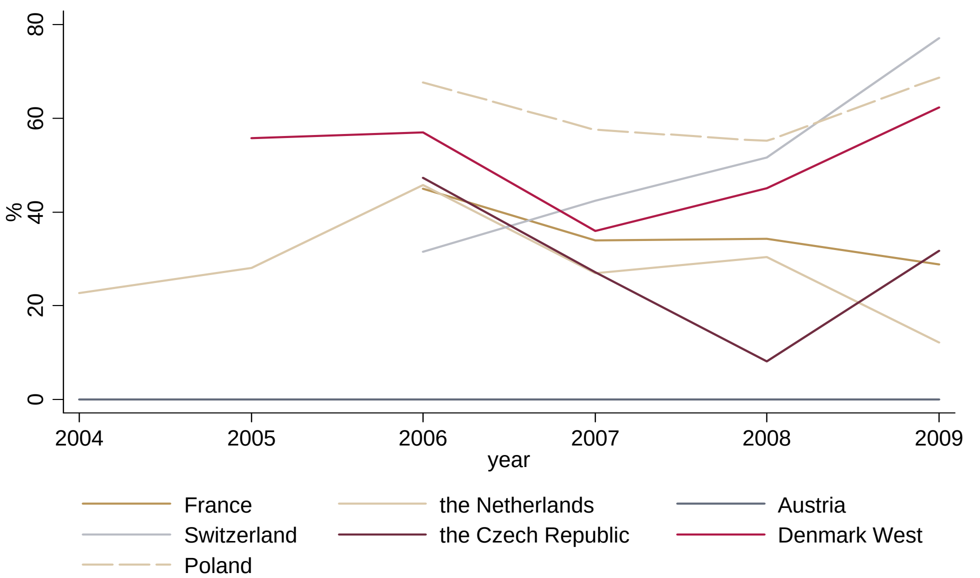
In contrast to the day-ahead spot exchange trade, day-ahead OTC trade happens simultaneously so that trading in different countries exhibits the same information. Indeed, we understand that the OTC price spread between two countries corresponds to prices (day-ahead auction results) for interconnection capacity towards the direction of the high-price country at the time of the auction. While OTC price spreads are not publically available, auction results for cross-border interconnection capacity are.

We can hence relate cross-border interconnection prices, as a measure of market participants' hourly valuation of location price spreads, to German day-ahead spot exchange market prices, as a measure of the German price level. The ratio approximates the percentage difference between Germany and a neighbouring country's price due to economic fundamentals rather than due to market design imperfections.

Data on the hourly interconnector prices are published by TSOs. If transmission on a border was served by more than one pair of TSO (e.g. Netherlands-Germany with Tenne-Transpower and Tenne-Amprion), prices charged for transmission services were averaged across the pairs, whereby booked capacities served as weights. The analysis is based on the interconnection price towards the high price country; corresponding negligible interconnection prices in the opposite direction were ignored.[21]

We calculated the share of hours with the interconnector price spread greater than 5% of the German price.[22] The share is calculated for all years from 2004 to 2009 and shown in Figure 5 for the following trading partners: France, the Netherlands, Austria, Poland, Denmark, Switzerland and the Czech Republic.

Figure 5: Share of hours at which interconnection prices exceeded 5% of the German day-ahead spot exchange market price



Source: The data are provided by respective TSOs, European Energy Exchange

As shown in Figure 5, with respect to the most important Western and Southern trading partners we find the following:

The Netherlands: price spreads as suggested by interconnection prices have exceeded 5% in 46% of all hours in 2006 but in only 12% of all hours in 2009.

France: price spreads as suggested by interconnection prices have exceeded 5% in 45% of all hours in 2006 but in only 29% of all hours in 2009.

As a benchmark, consider Austria where there was no known incidence of congestion in the years after the liberalization of the electricity market. Here,

[21] Price differences in the opposite direction (i.e. from the high cost country to the low cost country) reflect the time value of the underlying location spread option of trading electricity from the expected high price country to the low price country. For a zero or very small price, traders secure such capacity as generator outages or other events may change expected price levels between the trading time and flow nominations. But these capacities and the associated auction results do not reflect traders' expectations about the fundamental market conditions, as the intrinsic value is zero.

[22] Figure 13 in the Appendix presents average absolute interconnection price spreads for each year.

price spreads as suggested by interconnection prices have not exceeded 5% in virtually any hour between 2006 and 2009.[23]

Thus, the interconnection prices suggest much stronger convergence between the German price level and those of France, Austria and the Netherlands than the day-ahead spot exchange market prices. Indeed, the 2009 figures would be consistent with integrated markets in the great majority of all hours. We also analyzed the share of hours in which the interconnector price differences were more than 10%.

Figure 14 in the Appendix presents the results of that analysis.

The data also indicates strong price convergence with the Czech Republic, where the share of hours with differences larger then 5% decreased from 47% in 2006 to 8% in 2008. However, in 2009 this figure increased up to about 32% again. Price spreads as suggested by interconnection prices between Germany and Poland and Denmark West remain above 5% in a substantial share of hours – 62% to 68%. The share of hours with spreads more than 5% between German and Swiss prices has, however, increased in the period between 2006 and 2009 from 32% to 77%.

Convergence of future prices

Future contract prices provide another indication of market integration between Germany and its neighbouring countries. Year-ahead futures are less sensitive to short term influences; in particular to those that spot exchange markets absorb at different points in time. A comparison of futures hence reflects the structural and persistent differences of supply and demand conditions, rather than the short-term distortions involved in day-ahead spot exchange market prices:

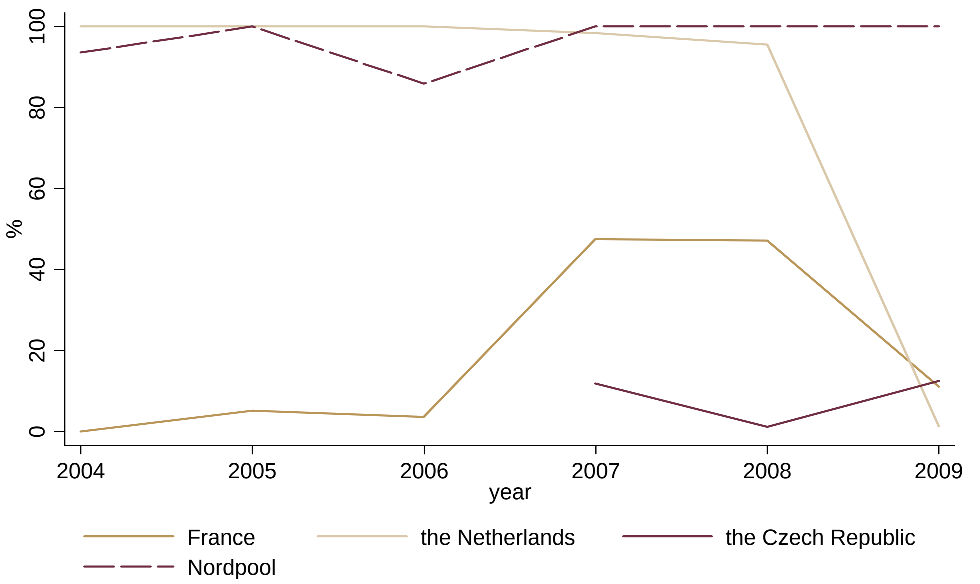
> *“Whereas forward prices are or should be primarily influenced by supply-demand fundamentals that are expected to prevail in the future, spot prices are determined by the out-turn of these fundamentals” (SI 374).*

We do not advocate that the future contract prices alone are sufficient indicators for truly integrated electricity markets. But they do inform about the expected systematic asymmetries, or the absence thereof, that cannot be equalised through cross-border trade. For example, if market participants expect that the interconnection capacity is insufficient so as to equalise short-term spot exchange market prices and, thus, the price level in Germany is systematically higher than in the neighbouring country, then the future prices will also reflect this difference. Similarly, a lack of future price differences indicates that the market does not anticipate systematic differences.

[23] We do not have an interconnector price data on Austria and presume that the price differences have always been equal to zero.

Data on daily future prices is available for Germany and its neighbouring countries the Netherlands, France, the Czech Republic and the Nord Pool area from the future exchanges. Results of the analysis are presented in Figure 6 for baseload future prices and in Figure 7 for peakload prices. Both figures show the share of hours which spread between the German future price and that of a trading partner exceeding 5% of the German future price.

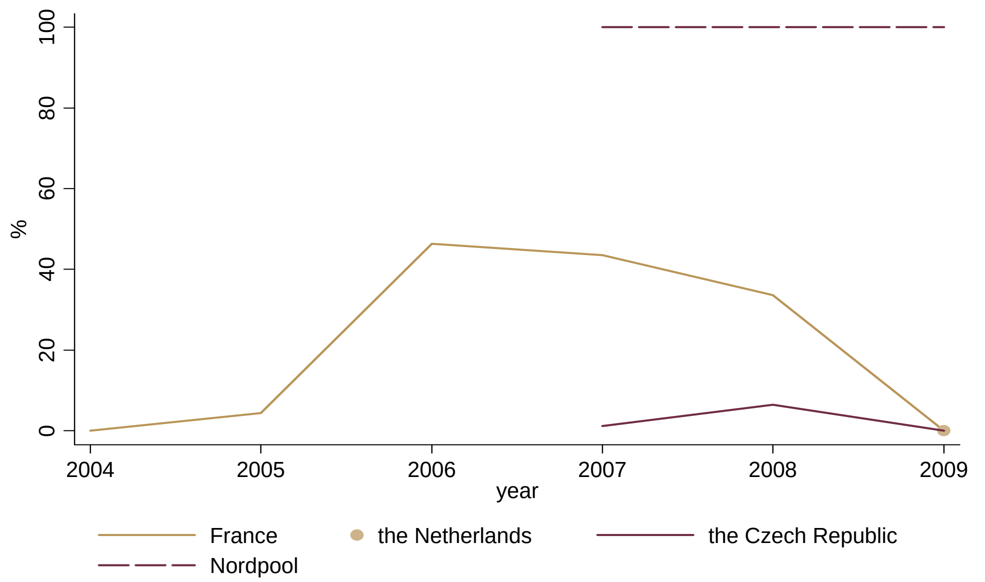
Figure 6: Share of hours at which year-ahead future baseload price spreads exceed 5% of the German future price



Source: Powernext, APX Group, European Energy Exchange, OTE, Power Exchange Central Europe, Nord Pool.

As Figure 6 shows, in 2009 the baseload future price difference between Germany and the Netherlands, France and the Czech Republic was more than 5% in less than 1.3%, 11% and 13% of all hours, respectively. We understand that strong price convergence of German and Dutch prices has been fostered through a new direct electricity connection between the Netherlands and the Nord Pool area (NordNed-Cable) and lower gas prices in 2009. In contrast, the baseload future price difference between Germany and the Nord Pool area was more than 5% in 100% of the hours.

Figure 7: Share of hours at which year-ahead future peakload price spreads exceed 5% of the German future price



Source: Powernext, APX Group, European Energy Exchange, OTE, Power Exchange Central Europe, Nord Pool.

As Figure 7 shows, in 2009 the peakload future price difference between Germany and the Netherlands, France and the Czech Republic was not more than 5% in any hour. In contrast, the peakload future price difference between Germany and the Nord Pool area was more than 5% in 100% of the hours.

The most recent available data hence points towards small price differences in Germany, the Netherlands, France and the Czech Republic. In more than 85% of all instances (days), price differences are small enough to be consistent with integrated markets. The differences with regard to Nordic prices are fundamentally explainable by the generally lower Nordic prices driven by hydro resources. However, even with respect to the Nord Pool area, we observe high future price correlations to Germany (see Figure 17 and Figure 18 in the Appendix).

Small price differences in 2009 futures have not emerged after a consistent period of price convergence among the countries in question, though. However, the 2009 findings are encouraging.

Figure 15 and Figure 16 in the Appendix present results of the 10% threshold analysis of the baseload and peakload future prices, respectively. Based on this threshold, price homogeneity (in the case of France and the Czech Republic) and a clear trend of convergence (with respect to the Netherlands) become even more apparent.

4. Competitive constraints through foreign suppliers

Introduction and summary

Price correlations and convergence provide indirect evidence on whether regions (or products) belong to the same or different markets. In particular, this kind of evidence may serve as a screening device. However, correlations and price differences alone may often be inconclusive of whether suppliers in two regions (or of two products) exert *sufficient* competitive constraints on each other so as to consider them as parts of an integrated market.

This question may in fact be asked from two angles. The first is, whether markets are sufficiently integrated so as to enable foreign suppliers to constrain German suppliers from increasing their prices above the existing level, e.g. as a consequence of a merger in Germany. Indeed, this would be the correct question if a potential merger of German suppliers had to be assessed and relates to the SSNIP test question commonly applied in competition policy.[24] Below we suggest a partial SSNIP test[25] to answer this question. The German Monopolies Commission has recently called for the application of this methodology in order to delineate geographic electricity wholesale markets:[26]

24 See, for example, the Commission Notice on the definition of relevant markets for the purposes of Community competition law. Official Journal C 372, 09/12/1997, p. 5 – 13.

25 SSNIP stands for Small but Significant Non-transitory Increase in Prices.

26 Monopolkommission, „Strom und Gas 2009: Energiemärkte im Spannungsfeld von Politik und Wettbewerb, Sondergutachten gemäß § 62 Abs. 1 EnWG“, p. 44.

> *Insbesondere drängt die Monopolkommission hierbei auf die Anwendung des hypothetischen Monopolistentests beispielsweise in seiner Gestalt als SSNIP-Test. (74)*

However, the above test for market integration is arguably conservative, difficult to implement, requires a lot of assumptions and simplifications and is potentially misleading when no merger is at stake.

From a second angle one might therefore wonder whether the existing degree of market integration appears insufficient in order to induce low (enough) prices in Germany, given the current competitive conditions. Put differently, the question is whether larger interconnector capacity would likely decrease electricity wholesale prices in Germany. This question appears to be more relevant from a regulatory and market design perspective aiming at reduced prices (in Germany).

We believe that it is important to raise the question in these distinct ways because the public debate sometimes appears centred around the first and sometimes the second one; rarely though with an explicit reference to either one. However, such a qualification appears crucial in order to derive useful policy implications: e.g. is more interconnector capacity required to lower prices now, or only to remedy potential competitive concerns arising from a larger concentration in Germany?

This section addresses the aforementioned questions. As for the first question of whether foreign suppliers can prevent price increases by 5 to 10% in Germany, our preferred model specification provides the following insights:

In 2008, a 5% price increase by all German suppliers would have been unprofitable in 50% of all hours.

In 2008, a 10% price increase by all German suppliers would have been unprofitable in 29% of all hours.

These results suggest that Germany is already sufficiently interconnected so that foreign suppliers would restrain German suppliers from a 5% increase in prices in about half of all hours. Against this background, a general claim that the regions appear insufficiently interconnected must be qualified: often, the electricity wholesale markets are broader than national from an antitrust perspective. However, interconnector capacity is insufficient in order to discipline a concerted action of all German suppliers (as a hypothetical monopolist or a merged entity) in all circumstances.

The second part of this section regards the question of whether a hypothetical larger interconnector capacity in 2008 would have likely led to a decrease or increase in electricity wholesale prices in Germany. The idea is that more interconnection capacity would, at maximum, dissipate any prevailing hourly price difference between Germany and a neighbouring country whilst the price in the high price area decreases and the price in the low price area increases. Of course, this analysis presumes competitive price levels in Germany and its neighbouring countries; otherwise additional interconnection capacity could put additional downward pressure on both German and its neighbouring countries' prices. Our presumption of competitive price levels is consistent with our final analysis of generator profitability at the plant level. We first discuss the relevance of hours where prices may have decreased in this scenario. We then analyse the relevance of hours where prices may have increased and move to a combined assessment.

With respect to the important South-Western trading countries we find the following regarding hours where prices might have decreased:

The Netherlands: in 2008, unlimited interconnector capacity might have decreased competitive German prices in 1.5% of all hours; in these hours competitive German prices might have decreased by an average of 0.1%.

France: in 2008, unlimited interconnection capacity might have decreased competitive German prices in 33% of all hours; in these hours competitive German prices might have decreased by an average of 2.1%.

Austria: in 2008, by virtue of zero congestion, additional interconnector capacity would have no effect on prices in Germany.

As regards interconnection to Switzerland and the Czech Republic, the maximum potential price drop in Germany at hours with excessive German prices would amount to 0.1% and 2.4%, respectively. Larger interconnector capacities to Poland and Denmark West might have a stronger effect though, decreasing German prices by up to 12% and 6.6%, respectively.

The results qualify general requests for more interconnector capacity. More capacity to the Netherlands, Switzerland and Austria would hardly decrease prices in Germany. Gains arising from more capacity to France and the Czech Republic should be assessed with a careful cost-benefit analysis. In conclusion we find that more interconnector capacity might often not decrease prices in Germany.

The analysis above refers to the extent of potential price decreases in Germany due to unlimited interconnector capacity. By the same token and as a point of reference, one might also consider the potential maximum price *increase* in Germany due to unlimited interconnector capacity. The findings are as follows:

The Netherlands: in 2008, unlimited interconnector capacity might have increased competitive German prices in 98% of all hours; in these hours competitive German prices might have increased by 5% on average.

France: in 2008, unlimited interconnector capacity might have increased competitive German prices in 64% of all hours; in these hours competitive German prices might have increased by 5.6% on average.

Austria: in 2008, by virtue of zero congestion, additional interconnector capacity would have no effect on prices in Germany.

As regards interconnection to Switzerland, Denmark West and Poland the potential price increase in Germany might amount to 11%, 7.2% and 4.2%, respectively. As regards the Czech Republic, potential price increases in Germany are negligible.

Finally, one may estimate the average overall German price change due to unlimited interconnector capacities. The results of the analysis are as follows:

The biggest average price drops would be induced by unlimited interconnector capacities to Sweden (13%), Poland (12%) and Denmark East (7.9%).

Unconstrained interconnector capacities to Switzerland, Belgium, the Netherlands and France might cause an average price increase by 6.7%, 3.6%, 3.2% and 2.2%, respectively.

The remainder of the section describes both the methodology and the results of these tests in more detail.

On foreign suppliers' ability to constrain German suppliers from price increases

Methodological remarks

We perform the analysis under the hypothesis of a perfect market design and focus on interconnector capacity as the single potential bottleneck to market integration. This has three reasons. First, this presumption resolves a number of severe measurement issues, related to market design imperfections. Second, insufficient interconnector capacity is often considered as a prime constraint to market integration. The methodology addresses this claim. Third, market design has improved much more rapidly in the past and will further improve in the near future. The analysis accounts for these dynamics and focuses on constraints that may persist beyond the next couple of years. The analysis regards the most recent year of the dataset, 2008.

We address the question of whether foreign suppliers would constrain German suppliers from increasing their prices in the vein of a SSNIP or, more precisely, critical loss analysis. This analysis determines the critical volume loss that is required in order to render a 5 to 10% price increase unprofitable. The critical volume loss can then be compared to the likely actual volume loss. If the actual volume loss exceeds the critical loss, the price increase would be unprofitable (and vice versa). This would mean that foreign suppliers restrain German suppliers from a 5 to 10% price increase (and vice versa). Below, the methodology of the actual loss and critical loss calculation is described in detail.

Actual loss

The actual loss estimation caused by a hypothetical 5 to 10% price increase of all German suppliers is constructed as follows:

If the German price is lower before and higher after the price increase, we assume that German suppliers lose volumes amounting to the sum of current exports to the neighbouring country (because foreign customers would prefer buying from foreign suppliers after the price increase) and the anticipated imports from the same neighbouring country (because German customers would prefer buying from foreign suppliers after the price increase). Because we suppose a perfect market design, we measure current exports by interconnection export capacity and anticipated imports by import capacity (both import and export as NTC values).[27]

If the German price equals the price of the neighbouring country, we consider no current electricity flows[28] and assume that German suppliers loose volumes amounting to the anticipated imports from the neighbouring country. Imports are again measured by the NTC import capacity.

If the German price is either higher before the price increase or still lower after the price increase, we assume that German suppliers do not incur any volume losses due to their price increase. If the German price is higher before the price increase, German suppliers will likely not export any volumes to the neighbouring country; instead the neighbouring country will likely supply to Germany. Hence, German suppliers cannot lose any volume due to a 5 to 10% price increase. If the German price is still lower after the price increase, then German suppliers would still export after the price increase. Again, there would be no volume losses.

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[27] The data on import and export capacities are available from the "European Transmission System Operators" ETSO at www.etso-net.org. The data is only obtainable in the form of semi-annual averages, differentiated as "summer" and "winter" capacity. The definition of "summer" and "winter" by months was not given. Therefore, import and export capacities for the months April through September are assumed to be "summer" capacities, and for the months October through December and January through March are considered as "winter" capacities.

[28] Equal prices might just be the result of cross-border electricity flows when interconnection capacity is not a constraint. This means, on such occasions we consider no flows when, actually, either export or import capacity is (to some extent) utilized. As a consequence we will overstate the actual loss (and are not conservative), if prices are equal because Germany imports and German prices would be higher otherwise. We will understate the actual loss (and are conservative), if prices are equal because Germany exports and the foreign price would be higher otherwise. We understand that, on average, Germany was a net exporter of electricity in the year 2008. To that end, on average, we tend to be conservative.

Following this procedure, we calculate German suppliers' actual volume loss with respect to each neighbouring country for each hour in 2008.[29] Actual volume losses with respect to each neighbouring country are then summed up to an hourly total actual volume loss.

A few comments on measurement issues are in place. For reasons explained above, we suppose a perfect market design and focus on interconnection capacity as the major barrier to market integration. Further, as explained above, the currently available hourly day-ahead spot exchange market data is still subject to a number of market design issues. Apparent differences between German and foreign prices are not always caused by insufficient interconnection capacity but different closing times of European exchanges. In order to 'clean' price differences from the latter mentioned design based disturbances, we employ again price differences as suggested by interconnection prices.[30]

For each hour there are two types of interconnector prices: those which are charged for electricity transmission from Germany to a neighbouring country (export), and those charged for the transmission in the opposite direction (import).[31] We suppose that in each hour there is only one relevant (non-zero) interconnector price, indicating i) the direction of the electricity flow[32] and ii) the absolute price difference between Germany and the neighbouring country. In particular:

If the interconnection price in direction to a foreign country *(export) exceeds* the interconnection price towards Germany (import), we suppose that the price in the foreign country exceeds the German price by the interconnection export price and German export.

If the interconnection price in direction to Germany *(import) exceeds* the interconnection price towards the foreign country (export), we suppose that the German price exceeds the price of the foreign country German import.

If both interconnection *prices are very small* (less than 1% of the corresponding German hourly day-ahead spot exchange market price), we suppose that prices are equal (but for the option value due to market design imperfections) and we consider that neither Germany, nor the neighbouring country exports

29 We acknowledge that import or export interconnector capacities cannot be simply summed up across the countries. Indeed, to the extent that we add up large amounts of the interconnector capacities, we may overstate the actual loss.

30 The data on German wholesale spot market prices are available from European Energy Exchange at www.eex.com/de.

31 Transmission services on a border are provided by a pair or pairs of companies. Each pair includes one interconnector operator from each side of the border. For example, on the German-Dutch border operate two pairs: RWE – TenneT and E.ON - TenneT. Each pair charges own prices and has separate capacity bookings. For borders on which operate more than one pair of interconnectors, country pair wise price levels were calculated as an average of pairs' prices weighted with corresponding pairs' booked amounts of interconnection capacity.

32 Although there are hours at which interconnector prices for transmission services in both directions are non-zero, we consider that only the higher one is economically relevant under a hypothesis of a perfect market design. The lower price, which is often close to zero, merely reflects the practically (low) option value of electricity flows in the opposite direction. Under a perfect market design with synchronized biddings and flow nominations, no such option value would exist. Moreover, if interconnector prices for transmission services in both directions are small enough (smaller than 1% of the German spot market price), then both prices are considered to be equal to zero.

or imports. We performed the same analysis but without the small price equalisation, described above. Results of the analysis are presented in the Appendix (Figure 19 and Figure 20).

The above described procedure determines the relevant hourly absolute price differences between Germany and a neighbouring country. A final comment regards the pre-existing price levels in Germany: we employ the hourly German day-ahead spot exchange market price data (in absence of any measure of cleaned price levels, notwithstanding the caveats pointed out above).

Critical loss

As explained above, the likely absolute volume loss has to be compared with the critical volume loss that renders the 5 to 10% price increase unprofitable (Appendix A3.1 contains the critical loss formula). To that end we determine the volume loss that equates profits before and after the price increase. The main (and only) assumption for this computation regards suppliers' profit margins on the units lost due to the 5 to 10% price increase.

As for the price part of the profit margin, we use the hourly German day-ahead spot exchange market price (in absence of any measure of cleaned price levels, notwithstanding the caveats pointed out above). As for the cost part of the profit margin we employ annual average variable costs of a new hard coal plant, 50.42 €/MWh, in the year 2008. This cost estimate excludes operational and capital costs that are fixed in the short term and was derived from a RWE cost-model. We check the sensitivity of our results to the cost assumption and perform the same analysis but under the assumption of 20% higher and 20% lower costs. Results of the sensitivity check are presented in the Appendix (Figure 21, Figure 22, Figure 23 and Figure 24).

This means we derive an hourly figure for suppliers' short term profit margins (i.e. excluding operational and capital costs). In particular, this figure captures higher and lower margins due to higher and lower price levels, respectively. This is useful, because the exercise accounts for suppliers having lower (higher) incentives to increase prices, given higher (lower) price levels and margins, respectively. However, as a drawback, our hourly margin figure does not account for varying marginal costs because i) we do not have information on the German merit order curve and ii) we do not have hourly data on firms' opportunity costs.[33]

In periods of low demand and low price levels, the variable cost used (of a new hard coal plant) may i) overstate the true variable costs, ii) understate the true margin and iii) overstate the profitability of a price increase. For example, in a number of 2617 hours in 2008, in which variable costs of a new hard coal plant exceeded the day-ahead spot exchange market price levels, we obtain negative

[33] We understand that suppliers dispatch their plants based on an hourly assessment of their opportunity costs. For example, input costs for hard coal might have been secured through futures a year before. However, as for dispatch decisions suppliers consider the opportunity costs of hard coal; that is the possible resale price at the moment of dispatch.

margins, implying profitable price increases. In such situations, our analysis tends to be conservative because suppliers were likely to employ cheaper production quantities. By the same token, the construction of the test readily implies that price increases would be unprofitable in 2617 hours; in other words the upper bound for non-profitable price increases (i.e. broader than national market) lies at about 70% of all hours.

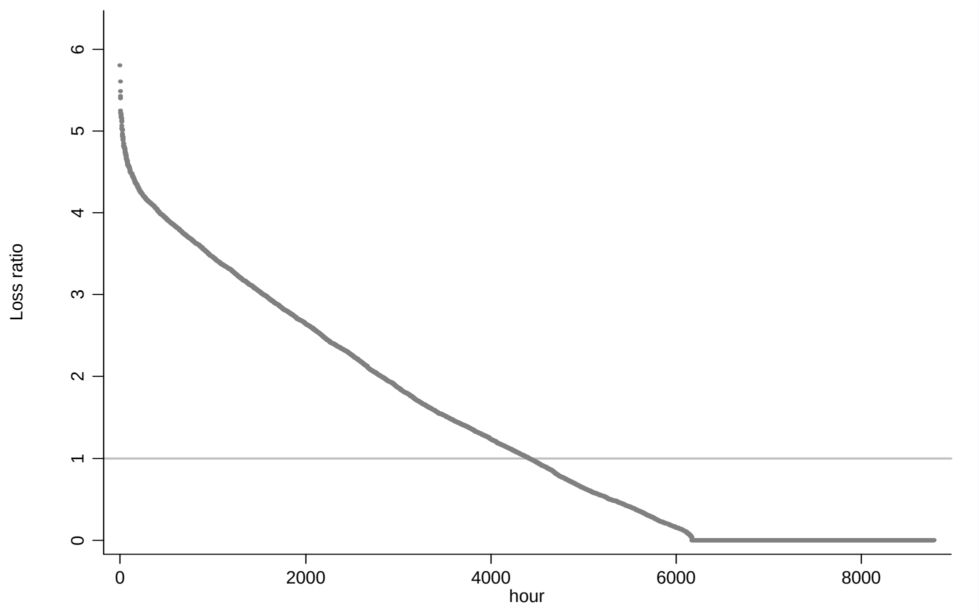
In periods of high demand and high prices, the variable costs used may i) understate the true variable costs, ii) overstate the true margin and iii) understate the profitability of a price increase. By the same token, our analysis tends to be not conservative in such situations.

Results of the analysis

Below, we first report the results of our analysis with respect to a hypothetical 5% price increase by all German suppliers, and then with regard to a 10% price increase.

Figure 8 displays the hourly ratio of the likely actual loss and the critical loss, due to a 5% price increase of all German suppliers.

Figure 8: Actual loss / critical loss of a 5% price increase by all German suppliers on an hourly basis in 2008

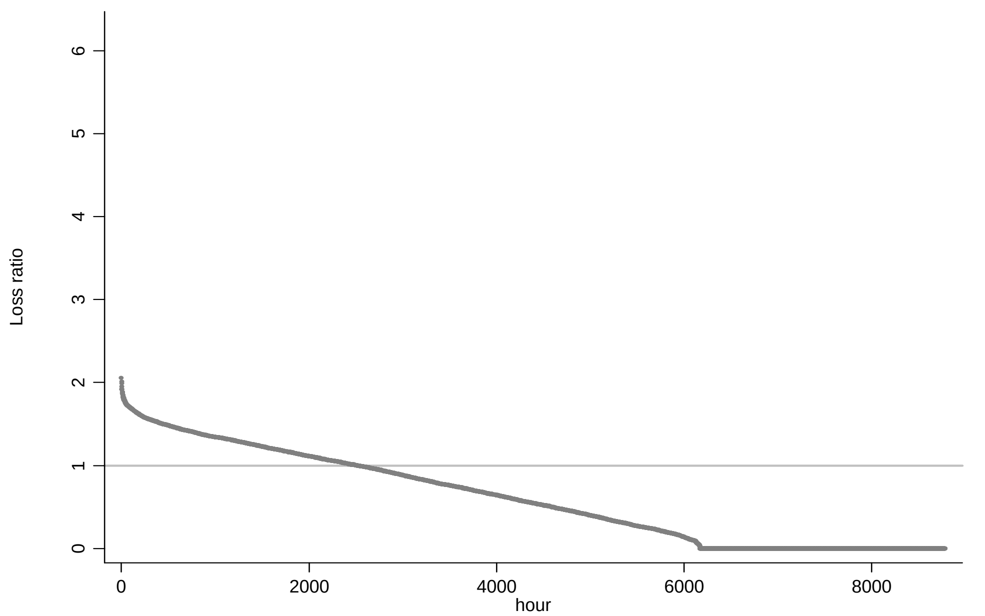


Source: European Energy Exchange, Nord Pool, European Climate Exchange, API2, TSOs, Union for the Coordination of Transmission of Electricity, European Network of Transmission System Operators for Electricity.

Figure 8 displays the ratio between actual and critical loss of a 5% price increase by all German suppliers for all hours[34] in 2008. If the ratio exceeds one, the actual loss would have exceeded the critical loss and, hence, a price increase would have been unprofitable. Conversely, if the ratio is smaller than one, the critical loss would have exceeded the actual loss and the price increase would have been profitable. As can be seen from the figure, the actual loss would have exceeded the potential loss in 4411 hours or 50% of all hours.

Figure 9 below repeats the same analysis but for a 10% price increase.

Figure 9: Actual loss / critical loss of a 10% price increase by all German suppliers on an hourly basis in 2008



Source: European Energy Exchange, Nord Pool, European Climate Exchange, API2, TSOs, Union for the Coordination of Transmission of Electricity, European Network of Transmission System Operators for Electricity.

Figure 9 displays the ratio between actual and critical loss of a 10% price increase by all German suppliers for all hours[35] in 2008. Again, if the ratio exceeds one, the actual loss would have exceeded the critical loss and, hence, a price increase would have been unprofitable. Conversely, if the ratio is smaller than one, the critical loss would have exceeded the actual loss and the price increase would have been profitable. As can be seen from the figure, the actual loss would have exceeded the potential loss in 2514 hours or 29% of all hours.

[34] Subject to data availability.

[35] Subject to data availability.

We believe that these findings cast some doubt on general claims according to which Germany was not sufficiently interconnected with its neighbouring countries: frequently, the electricity wholesale markets are broader than the national ones from an antitrust perspective. However, there remain a substantial number of hours in which interconnector capacities are insufficient in order to discipline a hypothetical concerted price increase of all German suppliers. To that end, for example, a hypothetical merger in Germany could not be cleared by virtue of sufficient competitive pressure through foreign suppliers alone.

That said, the findings should neither be equated with existence of market power in Germany (the same result would be obtained if there were 1.000 equally sized suppliers in Germany), nor with larger interconnector capacities to automatically decrease electricity wholesale prices in Germany. This question is addressed by our second analysis where we determine the hypothetical maximal price reduction in Germany, if interconnector capacities were unlimited.

On the possible impact of more interconnection capacity on price levels in Germany

The previous section revealed that the German electricity wholesale market seemed sufficiently integrated, so that foreign suppliers alone could restrain a German hypothetical monopolist from increasing its prices by 5 to 10% above the current level in a substantial share of hours. Yet, the analysis also revealed hours in which foreign suppliers could not do so. As pointed out above, the latter result implies by no means existing market power of German suppliers. Rather, the above analysis addressed whether foreign suppliers could countervail potential market power that could result from a merger in Germany.

However, if no merger of large German suppliers is at stake, the above assessment of market integration becomes less relevant. Absence any merger in Germany, a more relevant question is whether more interconnection capacity would likely reduce prices below current ones. Therefore, in the second part of the analysis, we determine the hypothetical maximal price reduction in Germany if interconnector capacities were unlimited.

We suppose that whenever the German price exceeds the price of a neighbouring country, again as suggested by interconnector prices estimated in the first part of the analysis, unlimited import capacity would at maximum reduce German prices by half of the pre-existing price difference. This assumes that demand and supply functions in Germany and the neighbouring country are linear and have the same slope. For example, if demand curves in Germany and the neighbouring country were linear and had the same slope, then the German price would decrease by more than 50% if the German supply curve had a larger slope than the neighbour's supply curve (and vice versa). Sometimes Germany's supply curve will have a larger slope and sometimes it will have a lower slope than the neighbouring country. Also, the total capacities are important, as slopes become infinite at the capacity limit. Without any precise knowledge about the underlying supply curves it appears reasonable that, on average, supply curves have similar slopes.

Table 3 shows the distribution of maximum potential price reductions in Germany due to unlimited interconnection capacity to varying neighbouring countries. The last column of the table presents the weighted average price reduction for all hours in which there is one.

Table 3: Hypothetical maximum price reduction in Germany if interconnection capacity to neighbouring countries were unlimited, 2008

Country	% of hrs with no price decrease	% of hrs with a price decrease 0 - 5%	% of hrs with a price decrease 5 - 10 %	% of hrs with a price decrease 10 - 20%	% of hrs with a price decrease > 20%	Weighted average German price decrease
The Netherlands	98%	1.5%	0%	0%	0%	0.1%
Switzerland	96%	4%	0%	0%	0%	0.1%
France	67%	30 %	1.2%	1%	0.8%	2.1%
Czech Republic	41%	56%	1.6%	1.1%	0.8%	2.4%
Austria*	100%	0%	0%	0%	0%	0%
	51 %	32%	12%	4.3%	1.3%	4.8%
Belgium**	64%	23 %	6.7%	3.3%	2.5%	5.5%
Denmark West	18 %	52%	12%	14%	3.8%	6.6%
Denmark East**	31%	20%	16%	21%	12 %	12%
Poland	30%	23%	13%	23%	12%	12%
Sweden**	23 %	14%	15%	27%	21%	15%

* The first row presents results of the analysis based on price differences suggested by interconnector prices which were always equal for Germany – Austria. The second row shows results based on spot market prices.

** Day-ahead spot exchange market prices were used in lieu non-available interconnector prices.

Source: European Energy Exchange, Nord Pool, TSOs, European Network of Transmission System Operators for Electricity.

The table reveals the following insights:

The Netherlands: in 2008, unlimited interconnector capacity might have decreased competitive German prices in only 1.5% of all hours; in these hours competitive German prices might have decreased by an average of 0.1%.

France: in 2008, unlimited interconnector capacity might have decreased competitive German prices in 33% of all hours; in these hours competitive German prices might have decreased by an average of 2.1%.

Austria: in 2008, by virtue of no zero congestion, additional interconnector capacity would have no effect on prices in Germany.

As regards interconnection to Switzerland and the Czech Republic, the maximum potential price drop in Germany would amount to 0.1% and 2.4%, respectively. Larger interconnector capacities to Poland and Denmark West might have a stronger effect, though, decreasing German prices by up to 12% and 6.6%, respectively.

In our opinion the results qualify general requests for more interconnection capacity. More capacity to the Netherlands, Switzerland and to Austria would hardly decrease prices in Germany. Gains arising from more capacity to France, the Czech Republic, Poland and Denmark West should be assessed on a careful cost-benefit analysis. In conclusion we find that more interconnection capacity might often not decrease prices in Germany.

Thus far we have focused on occasions in which German prices might have decreased due to unlimited interconnector capacity. However, by the same logic, there are just as well occasions in which the German price level is lower than the price level in the neighbouring country and where more (unlimited) interconnection capacity would put upward pressure on German prices. We calculate potential price increases in Germany, applying the same (mirrored) methodology as above.

Table 4 contains the results for potential price increases that might result from unlimited interconnection capacity to neighbouring countries.[36]

[36] There are a few hours with very high potential price increases in some countries. Such extreme values appear due to extremely small German prices, e.g. less than €1.00, and moderate absolute potential price increases. The outliers would distort the distribution of the potential price increase and the average price increase statistics reported in the Table 4. Hence, we dropped all observations in which the price level in one country was lower than €1.00 and, at the same time, the percentage price difference exceeded 1000%.

Table 4: Hypothetical maximum price increase in Germany if interconnection capacity to the neighbouring countries were unlimited, 2008

Country	% of hrs with no price increase	% of hrs with price increase 0 – 5%	% of hrs with price increase 5 - 10 %	% of hrs with price increase 10 - 20%	% of hrs with price increase > 20%	Weighted average German price increase
The Netherlands	2 %	79%	10%	5.5%	2.9%	5%
Switzerland	5.2%	51%	12%	16%	16 %	11%
France	36 %	45%	9.3%	6.3%	3.5%	5.6%
Czech Republic	78%	22%	0%	0%	0%	0.19%
Austria*	100%	0%	0%	0%	0%	0%
	49 %	30%	11%	5.8%	3.7%	9.7%
Belgium**	36 %	28%	15%	12%	9.7%	14%
Denmark West	86%	11%	1.2%	0.56%	1.0%	7.2%
Denmark East**	67%	14%	6.4%	4.5%	5.5%	22%
Poland	96 %	3.1%	0.33%	0.23%	0.26%	4.2%
Sweden**	77%	9.1%	4.8%	3.8%	5.3%	32%

* The first row presents results of the analysis based on price differences suggested by interconnector prices which were always equal for Germany – Austria. The second row shows results based on spot market prices.

** Day-ahead spot exchange market prices were used in lieu non-available interconnector prices.

Source: European Energy Exchange, Nord Pool, TSOs, the European Network of Transmission System for electricity.

Figure 4 above suggests the following:

The Netherlands: in 2008, unlimited interconnection capacity might have increased competitive German prices in 98% of all hours; in these hours competitive German prices might have increased by 5% on average.

France: in 2008, unlimited interconnection capacity might have increased competitive German prices in 64% of all hours; in these hours competitive German prices might have increased by 5.6% on average.

Austria: in 2008, by virtue of no zero congestion, additional interconnector capacity would have no effect on prices in Germany.

As regards interconnection to Switzerland, Denmark West and Poland the potential price increase in Germany might amount to 11%, 7.2% and 4.2%, respectively. As regards the Czech Republic, potential price increases in Germany are negligible.

Above we have first presented potential price decreases in Germany, provided that the German price exceeded the price in a neighbouring country. Second, we demonstrated potential price increases in Germany, provided that the German price was lower than the price in the neighbouring country. In a final step we will now consolidate both effects to determine the probable net effect of more (unlimited) interconnection capacity to and from Germany, respectively.

To that end Table 5 presents probable net changes of German average prices with respect to each neighbouring country. In a first step we calculated weighted average prices in Germany and the neighbouring country. Comparison of these average prices then led to the average price differences presented in the table below. One may also interpret the figures as maximum revenue changes of all German electricity suppliers due to unlimited interconnector capacity towards a neighbouring country. Indeed one must bear in mind, of course, that the exercise assesses an upper bound of the extent to which interconnection capacity might change average price levels. Other constraints, notably limited generation capacity (e.g. in Belgium), might substantially reduce the relative price changes. By the same token, country-wise price changes should not be aggregated.

Table 5: Hypothetical net price changes in Germany if interconnection capacity to the neighbouring countries were unlimited, 2008

	The Netherlands	Switzerland	France	Czech Republic	Austria	Belgium	Denmark West	Denmark East	Poland	Sweden
Price change	3.2%	6.7%	2.2%	-0.5%	0.4%	3.6%	-6.1%	-7.9%	-12%	-13%

Source: European Energy Exchange, Nord Pool, TSOs, the European Network of Transmission System for electricity.

As follows from the table, the biggest net price drops would be induced by unlimited interconnector capacities to Sweden (-13%), Poland (-12%) and Denmark East (-7.9%). According to the results of the analysis, unconstrained interconnector capacities to Switzerland, Belgium, the Netherlands and France might trigger net price increases by 6.7%, 3.6%, 3.2% and 2.2%, respectively.

These findings cast some doubt on whether perfect market integration and (costly) interconnection capacity should be a means to its own end under all circumstances. Again, a more differentiated view appears advisable. Benefits have to be assessed against investment costs taking into account other possible bottlenecks (e.g. grid typology) and remedies (e.g. higher generation capacity).[37]

[37] We understand that from a technical point of view it is more rational to increase generation capacity in countries with high prices to avoid huge power flows which are accompanied by an increase of grid losses. Furthermore high trading volumes decrease the capability of the grid to accommodate renewable energy which usually has to be transported from the generation

The macroeconomic benefit of only slightly converging prices should be set into perspective against the investment costs for new cross-border interconnection capacity. Furthermore, the increase of cross-border interconnection capacity would not *per se* increase commercial cross-border flows due to technical constraints (ring flows, safety margins, bottlenecks in the underlying national grid topology, priority of renewable energy). Finally, new cross-border capacity should be assessed against other possible remedies (e.g. higher generation capacity).

location to the load centre. This aspect will be more serious for ongoing installations of offshore wind generation.

5. Investment incentives and market power

Introduction and summary

The Sector Inquiry ("SI") observes that there was a decrease of 2149 MW in total generation capacity in the German electricity market between 2000 and 2005.[38] In particular, the SI notes that this capacity reduction was the result of the retirement of old generation capacity and the lack of new generation capacity installations. This observation is suggestive of a strategic withdrawal of generation capacity and exercise of market power. Left unexamined in the SI is the economics of new capacity installation. Our study indicates that the lack of new generation capacity is consistent with the lack of economic incentives.

Capacity withdrawals and output restrictions could potentially be consistent with the exercise of market power if new capacity is not being installed despite high prices and margins. However, the margins need to be sufficient to cover not only the variable cost of operation but also the capital cost of installation of new plants. We find that the electricity prices have not reached a level that would incentivise the installation of new capacity in the long run. In more recent years, the electricity prices and margins have increased but as regards hard coal plants margins are still not at a level that would induce new capacity installation in the long run.

We examined the revenue and total cost associated with two types of new generation plants – a new combined cycle gas turbine (CCGT) plant and a new

[38] SI (445).

hard coal plant. For both these types of new plants, the total average cost was higher than the average revenue based on the future year-ahead prices for calendar years 2005 and 2006.[39] Margins increased starting in 2007 as electricity prices rose, however the overall margins were still negative for new coal plants in calendar years 2008 and 2009. In summary we find that:

The average margin of a new hard coal plant (high capex and low variable cost) has been negative from 2005 to 2009 (with the exception of 2007).

The average margin of a new CCGT plant (low capex and high variable cost) has been negative between 2005 and 2007 and positive in 2008 and 2009.

The remainder of this section is organized as follows. First, we analyze cost and revenue estimates. Second, we present the results on average margin and profitability. Third, we discuss possible extensions and refinements. The above results include costs for CO_2 allowances. The Appendix provides a sensitivity check, excluding costs for CO_2 allowances.

Cost and revenue estimates

In this section we describe the cost and revenue estimations used to asses the profitability of potential new generation capacity. For this purpose we use the future prices of input fuel and electricity. We understand that suppliers rely on future prices to make forward-looking decisions like the investment in new generation capacity. For practical reasons, we focus on year-ahead futures. These products feature the best data availability throughout. In particular, this enables a consistent matching of input costs and electricity prices.

Total costs of operation and installation of new plants are based on the cost model provided by RWE.[40] The RWE cost model produced estimates of variable, operating and capital costs of generation on a €/MWh basis based on the inputs to the model. Table 6 displays the 2008 cost estimates for two types of generation plants: a new hard coal plant and a new CCGT plant.

[39] Here and throughout this chapter, calendar year refers to the time of electricity production and sales. For example, calculations for the year 2008 are based on year-ahead future input costs and year-ahead electricity prices in the year 2007.

[40] We evaluated the RWE cost model under various input scenarios. These sensitivity checks produced plausible cost estimates confirming the reliability and robustness of the model. However, we did not audit all the details underlying the RWE cost model.

Table 6: Estimates of average costs per MWh by plant type, calendar year 2008

Type of plant	Hours operated per year	Variable costs €/MWh	Operating costs €/MWh	Capital costs €/MWh	Total costs €/MWh
New hard coal, 750 MW	7000	36	6.1	18	60
New CCGT, 425 MW	4500	47	7.1	16	71

Source: Bloomberg TTF, RWE Supply & Trading, API2, European Climate Exchange, RWE.

The first column of Table 6 specifies the type of plant. The second column shows the number of hours the plant is estimated to operate per year. Operation times depend on a plant's variable costs (which are an important element of the respective marginal costs). The lower the variable costs, the more often a plant is dispatched.[41] Variable cost estimates shown in the third column are based on year ahead future prices of fuel and emissions: gas and coal future prices and CO_2 emission allowances.[42] Operating costs shown in the fourth column include the maintenance, staff, insurances, capacity reserves and overhead costs. Capital costs shown in the fifth column are calculated as the weighted average capital cost (WACC) multiplied by capital investments with adjustments for taxes, depreciation tax shield and inflation. Annual operating costs and capital costs were allocated over a plant's assumed yearly load to arrive at costs per MWh as shown in Table 6. The last column sums up all hourly cost positions and reports total average costs per MWh for each plant. Variable and operating costs are lower for base-load hard coal plants than for CCGT plants; consequently, hard coal plants run longer hours than CCGT plants.

The figures reported in Table 6 are for the year 2008. For the years 2005 to 2007 and 2009, we adjusted the relevant inputs in the RWE cost model to arrive at similar cost estimates. Once again year-ahead future prices were used for gas, hard coal and CO_2 emission allowances for each year. We obtained plant capex estimates throughout the period from RWE and capital costs were based on the interest rates prevalent for each year. Finally, the efficiency level of the new plants was updated for each year.[43] The rest of the assumptions remained unchanged. Estimates of the total generation costs for the two types of plants and years 2005–2009 are presented in Table 7.

41 Annual load estimates were provided by RWE.

42 Taking into account costs for CO_2 emission allowances for investment decisions assumes that these had to be purchased to run a new generator. This has not been the case so far, but appears relevant for investment decisions regarding the future. Appendix 4 contains a sensitivity check without costs for CO_2 emission allowances.

43 Generally, the fuel to electricity transformation efficiency increases for newer plants as the technology advances. With the efficiency increase variable costs of electricity generation go down, as less fuel is required to generate the same amount of electricity.

Table 7: Total average generation costs per MWh, calendar years 2005 - 2009, by plant type

	2005	2006	2007	2008	2009
Hard coal plant, €/MWh	48	54	55	60	78
CCGT plant, €/MWh	50	67	84	71	92

Source: Bloomberg TTF, RWE Supply & Trading, API2, European Climate Exchange, RWE.

Table 7 shows that total average generation costs for hard coal as well as for CCGT plants have increased from 2005 to 2009. These dynamics reflect increasing prices for hard coal (as of 2007 onwards), gas, CO_2 allowances and capex.

Our revenue estimates are based on the daily year-ahead future electricity prices.[44] There are two types of future products traded in the market: baseload and peakload electricity futures. Baseload futures are for delivery of electricity for all 24 hours of the day and the peakload futures are for delivery of electricity from 8 a.m. to 8 p.m. Table 8 shows the average year-ahead peakload and baseload electricity prices for each year.

Table 8: Average future electricity prices per MWh, calendar years 2005-2009, by product

	2005	2006	2007	2008	2009
Baseload, €/MWh	33	41	55	56	70
Peakload, €/MWh	49	56	81	79	99

Source: European Energy Exchange.

For each year, the baseload and peakload average electricity year-ahead future prices are used to determine average revenues for coal and CCGT plants, respectively, over lifetimes of the respective plants. This means, for each year we determine whether a new plant could be built profitably, provided the pre-existing price (and cost) conditions would prevail throughout the lifetime of the plant. By using these average future prices, we assume that hard coal plants operate during all baseload hours and CCGT plants operate only during peakload hours. This assumption could be considered a rough approximation for the actual operation of new hard coal and new CCGT plants, which are estimated to run over 7000 and 4500 hours per year as shown in Table 6.

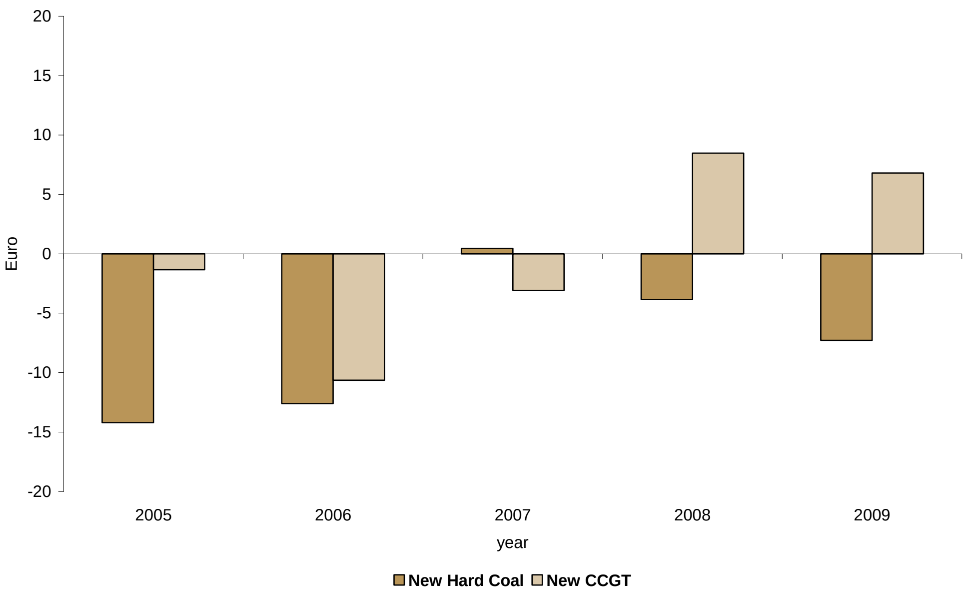
[44] Data on the daily price of year-ahead future electricity products was provided by RWE.

Average margins and profitability

The difference between the average revenue and average total cost discussed above gives the average margin of generation on a per MWh basis. Figure 10 shows the average margin for each of the two types of plants for each year from 2005 to 2009. Since the four types of plants considered are of different capacities, we present the margin on a per MWh basis for each type of plant.[45]

In Figure 10, two bars for each year show the average margin for new plants. Average margins for both types of new plants are negative for the years 2005 and 2006. In the long run, such price levels would not render capacity additions profitable. Average margins and profitability increased for new plants in the years 2007 to 2009. Nonetheless, such price levels, if persisting in the long run, would still not have induced new hard coal plant installations (in 2008 and 2009). In this sense, there has been a lack of incentives to invest in new baseload capacity installations in the past years. However, our analysis shows positive margins for new CCGT plants in 2008 and 2009.

Figure 10: Yearly margin by plant type per MWh, calendar years 2005-2009



Source: Bloomberg TTF, RWE Supply & Trading, API2, European Climate Exchange, RWE, European Energy Exchange.

According to Figure 10, the yearly margin of the hard coal plant, being negative for the majority of years, had been increasing from 2005 to 2007, became positive in 2007 at 0.5 €\MWh, and was dwindling in 2008 and 2009, ending at -7

[45] Average margin multiplied by capacity would give the total profitability of each plant.

€\MWh. Such dynamics were driven by hard coal input and baseload electricity prices. Specifically, from 2005 to 2007 the baseload price increased by 67% from 33 €/MWh to 55 €/MWh, while the hard coal price fell by 11% from 55 €/ton to 49 €/ton. On the contrary, over the period 2007 to 2009, the hard coal price more than doubled, while the electricity prices went up only by 27%.

As for the CCGT's margin, we observe an increase from 2006 to 2008 with an decrease again in 2009. The rise can be explained by a growth of the peak load price, which went up by 41% from 56 €/MWh to 79 €/MWh. In contrast, margin drops in 2006 and 2009 result from sudden hikes in the gas prices. The gas price moved to 7 €/MWh (from 13 €/MWh) in 2006 and to 10 €/MWh (from 21 €/MWh) in 2009.

Our finding jars with the study conducted by London Economics on behalf of the European Commission which concluded that German electricity suppliers earned on average more than their total average costs throughout the years 2003 and 2005. However, London Economics looked at overall profits of electricity suppliers, averaging over all existing respective plants, and thus violating the fundamental economic principle of looking at marginal contributions (Ockenfels 2007).[46] Moreover, even when using the same data and method used by London Economics, Ockenfels (2007) identified that the average margins for new plants in 2003 and 2004 were most likely negative; the average profitability between 2003 and 2005 was driven by the newly issued CO_2 emission allowances in the year 2005.

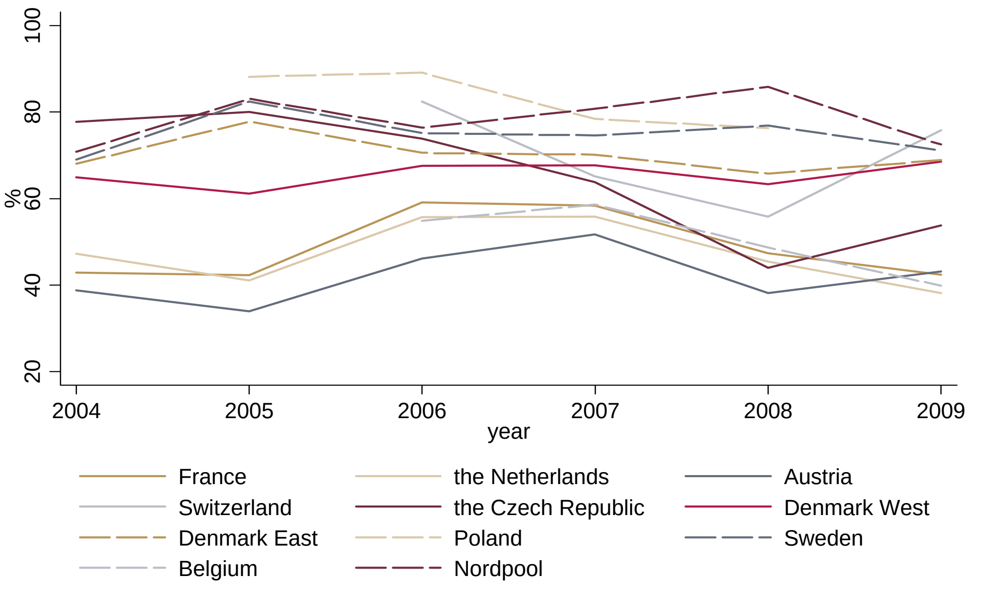
In conclusion, price levels as in 2005 and 2006 appear insufficient to cover the costs of building and running new plants. At such prices, if persistent, investors would have no incentives to finance the construction of new plants. The lack of new capacity eventually makes the available capacity scarce and more expensive. Thus, leaving even aside increases in input costs, it is not surprising to see increasing future price levels. Higher price levels reflect scarcity and eventually provide the economic incentives necessary for investments in new capacity. Indeed, these dynamics are consistent with a functioning and competitive market.

One caveat to the analysis presented here regards the treatment of CO_2 emission allowances. In this section, costs for CO_2 emission allowances enter the variable costs of electricity generation. However, given that currently emission allowances are granted to some extent for free they affect pricing but not in full the cost for a given increase in capacity. To that end the analysis represents forward looking investors for CO_2 emission allowances not being granted for free as of 2013 onwards. With an average plant lifetime between 40 and 25 years for a new hard coal and a new CCGT plant, respectively, the inclusion of CO_2 costs appears as the appropriate scenario. However, Figure 25 in the Appendix reports our final results if CO_2 costs were neglected.

[46] See Ockenfels, A. (2007), "Marktmachtmessung im deutschen Strommarkt in Theorie und Praxis – Kritische Anmerkungen zur London Economics-Studie", Energiewirtschaftliche Tagesfragen, 09 2007.

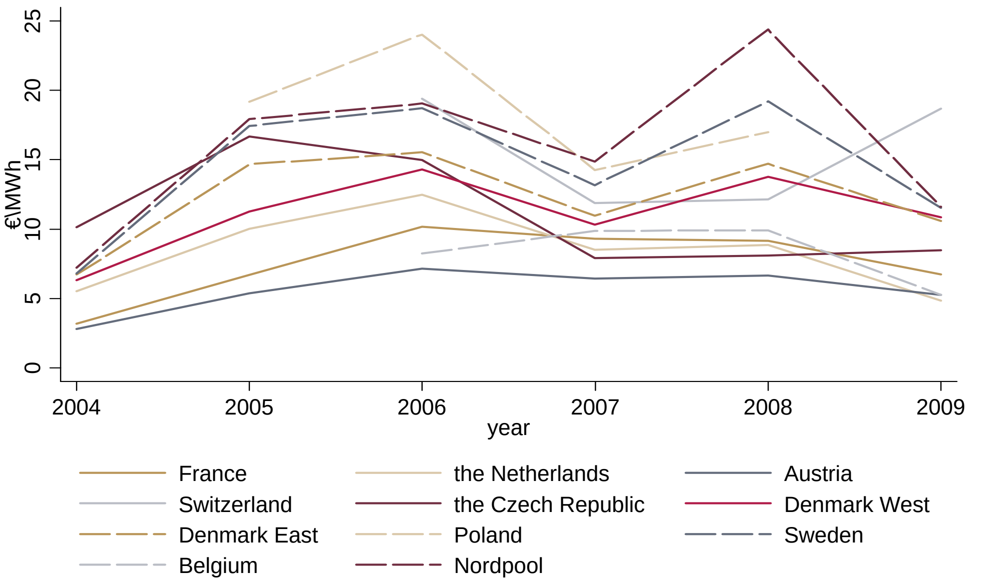
Appendix 1
Further analyses of price convergence and price correlations

Figure 11: Share of hours in which day-ahead spot exchange market price spread is more than 10% of the German day-ahead spot exchange market price



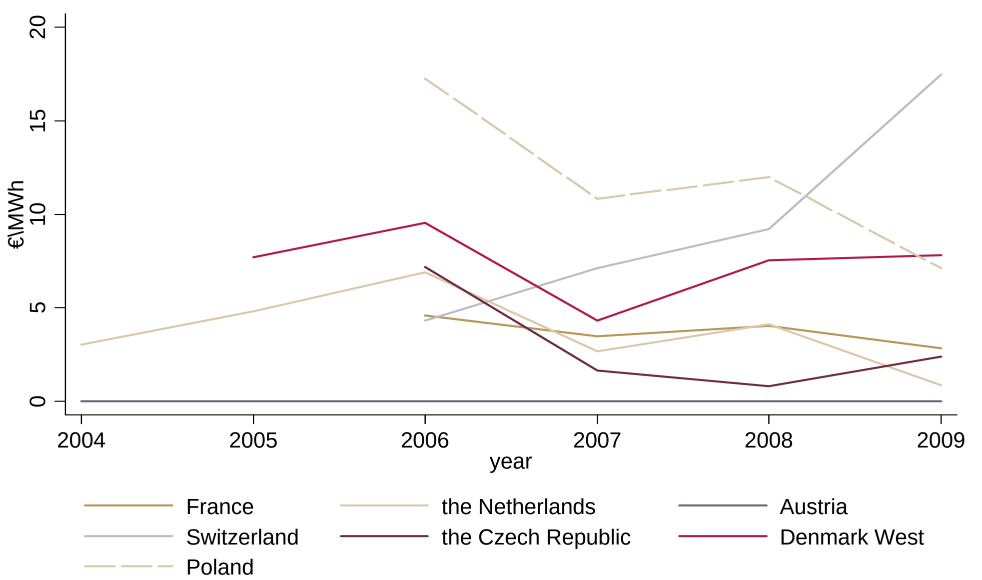
Source: Powernext, APX Group, Energy Exchange Austria, European Energy Exchange, OTE, Power Exchange Central Europe, Polish Power Exchange, Belpex, Nord Pool.

Figure 12: Absolute annually averaged day-ahead spot exchange market price differences



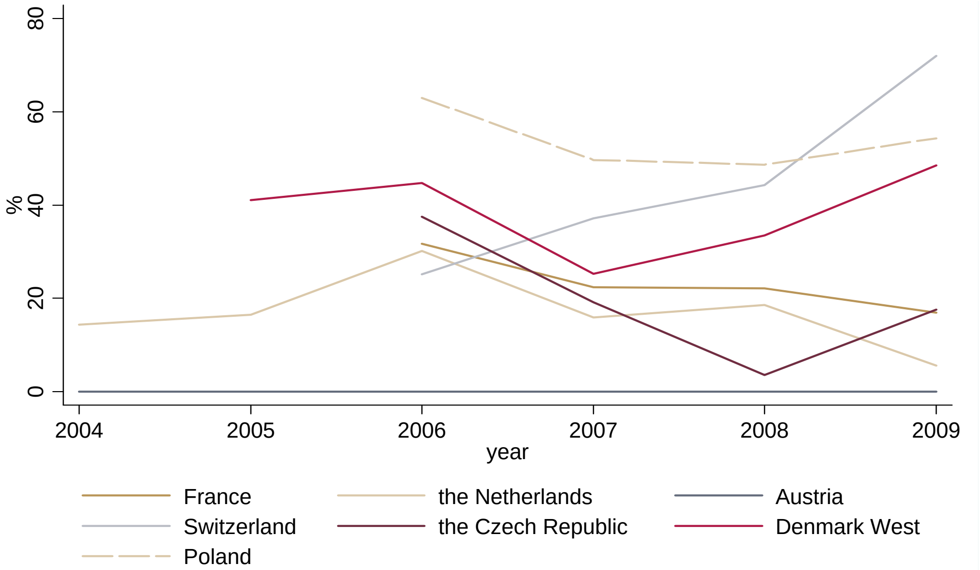
Source: Powernext, APX Group, Energy Exchange Austria, European Energy Exchange, OTE, Power Exchange Central Europe, Polish Power Exchange, Belpex, Nord Pool.

Figure 13: Absolute annually averaged day-ahead interconnection prices



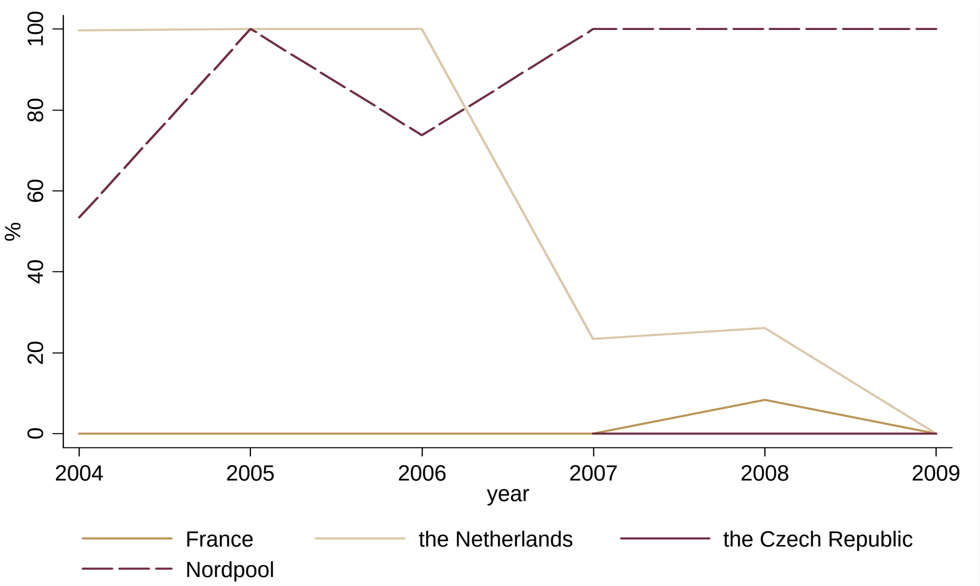
Source: The data are provided by respective TSOs.

Figure 14: Share of hours in which interconnection price exceeds 10% of the German day-ahead spot exchange market price



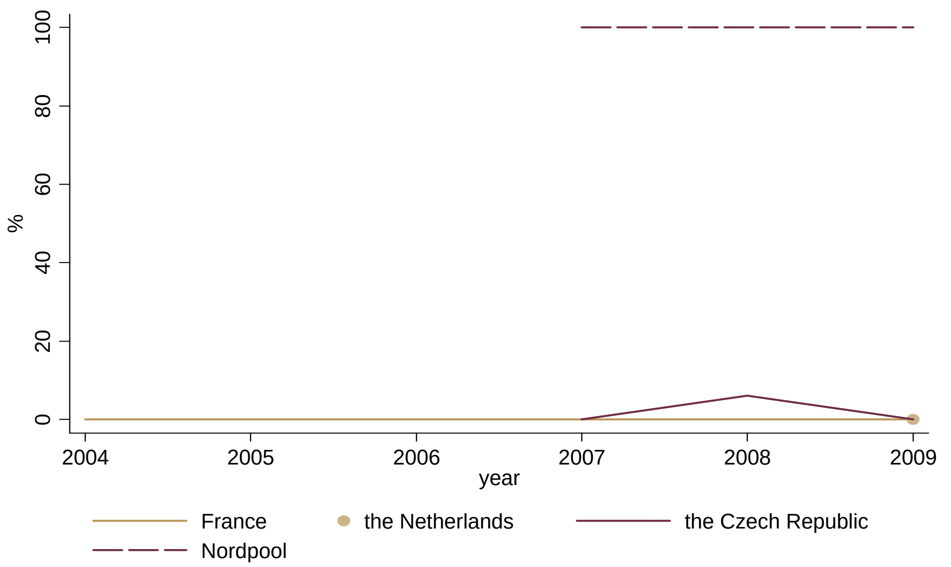
Source: The data are provided by respective TSOs, European Energy Exchange.

Figure 15: Share of hours in which future baseload price spreads exceed 10% of the German future price



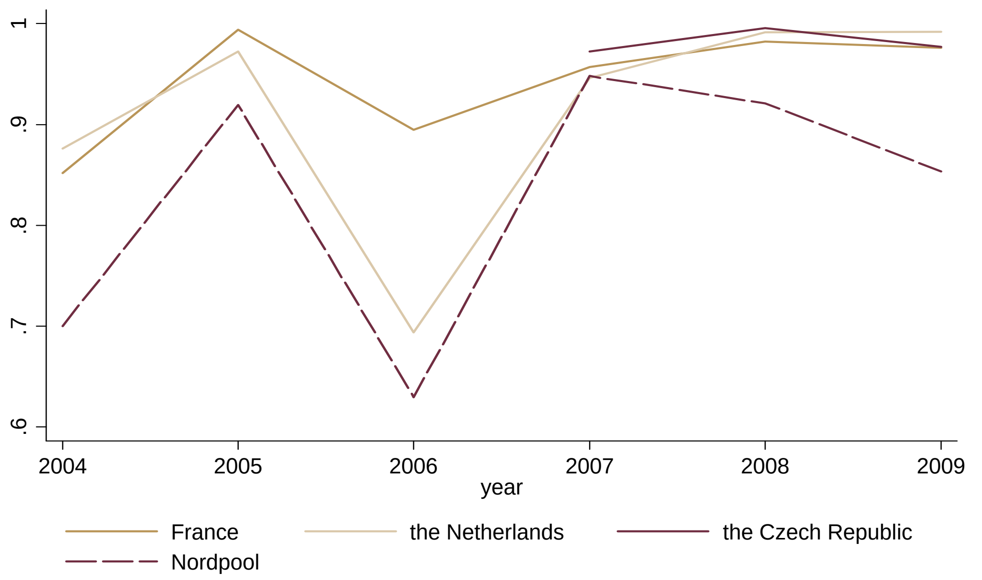
Source: Powernext, APX Group, European Energy Exchange, OTE, Power Exchange Central Europe, Nord Pool.

Figure 16: Share of hours in which future peakload price spreads exceed 10% of the German future price



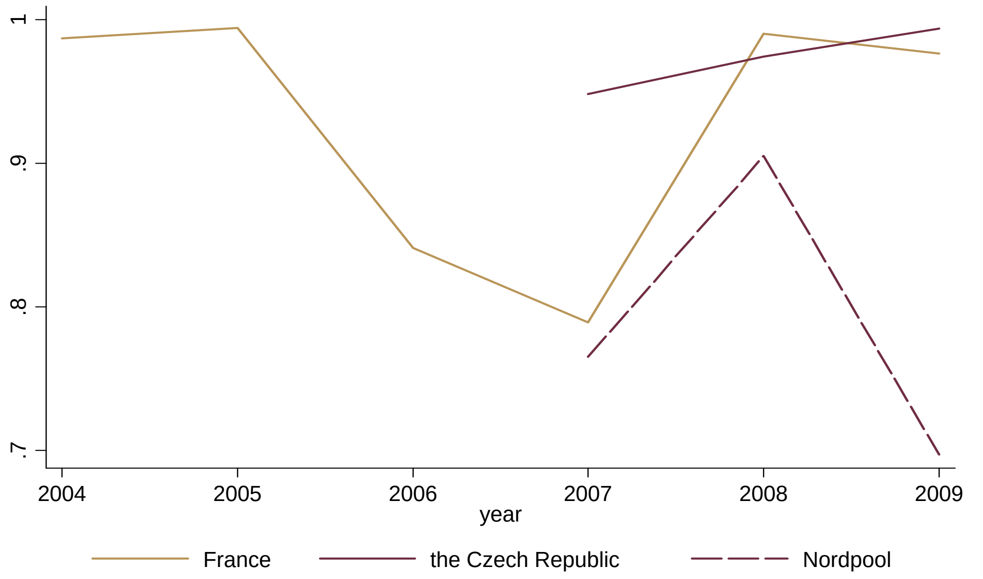
Source: Powernext, APX Group, European Energy Exchange, OTE, Power Exchange Central Europe, Nord Pool.

Figure 17: Baseload future price correlations



Source: Powernext, APX Group, European Energy Exchange, OTE, Power Exchange Central Europe, Nord Pool.

Figure 18: Peakload future price correlations



Source: Powernext, European Energy Exchange, OTE, Power Exchange Central Europe, Nord Pool.

Appendix 2
Test statistics for the co-integration analysis

Table 9: KPSS statistics for the price level\ first differences, 5% critical values and H_0 hypotheses[47]

	Germany	The Netherlands	France	Austria	5% critical values for the levels\ first differences	H_0 hypothesis
2003–2004	0.125	0.451	0.142	0.196	0.463	H_0: level stationarity[48]
2007–2008	0.166\0.069 3	0.249\0.034 7	0.225\0.031 8	0.169\0.062 5	0.146\0.463	H_0: trend stationarity\ H_0: level stationarity

Source: ESMT CA analysis.

Table 10: Number of lags used for the trace test, trace statistics and 5% trace test critical values for the country pairs in 2007-2008

	Number of lags[49]	Trace statistics	5% critical values
France and Germany	22	6.526	12.25
The Netherlands and Germany	7	9.854	12.25
Austria and Germany	22	5.663	12.25

Source: ESMT CA analysis.

[47] The maximum lag order, used for the KPPS test, is selected on the basis of automatic bandwidth selection procedure proposed by Newey and West (1994).

[48] Visual analysis of the price series indicates that in 2003-2004 there was no linear trend in the data; in contrast, in 2007-2008 there was a noticeable uprising trend. These considerations determine the H_0 hypotheses.

[49] Number of lags for the pairs France-Germany and Austria-Germany are identified on the basis of HQIC. For the pair Netherlands-Germany presence of 7 lags is assumed, HQIC indicates 8 lags for this pair.

Table 11: Estimates of the price relationship coefficients and their standard errors

	2003-2004	2007-2008
	France and Germany	
β	0.4	0.7
β std error	0.02	0.05
μ	-0.0002	0.0225
μ std error	0.0016	0.0049
Constant in the cointegration relationship[50]		-6.4
α	17	5
	the Netherlands and Germany	
β	0.2	0.9
β std error	0.01	0.04
μ	0.0035	0.0063
μ std error	0.0020	0.0044
Constant in the cointegration relationship		-6.3
α	18.9	-1.3
	Austria and Germany	
β	0.7	0.9
β std error	0.02	0.01
μ	0.0007	0.0110
μ std error	0.0012	0.0011
Constant in the cointegration relationship		-1.1
α	8.6	1.9

Source: ESMT CA analysis.

[50] Johansen's cointegration method, in contrast to OLS, does not provide empirical errors with zero mean. Consequently, one should calculate empirical mean of the estimated errors of the cointegration equation and increase constant terms in the equation by a value of the mean.

Appendix 3
Competitive constraints through foreign suppliers

A3.1
Critical loss formula

In order for a SSNIP by a hypothetical monopolist to be profitable, the loss of margin from sales lost as a result of customers switching away needs to be lower than the critical loss level. The critical loss level is hence the percentage loss of sales resulting from the price increase at which the total margin earned is the same before and after the price increase.

The above can be expressed in the following formula:

$$(P(1+X)-C)Q(1-Y) = PQ-CQ$$

The left hand side of this equation is equal to the margin after the price increase where P is price, X is the price increase, C is marginal costs, Q is the quantity sold and Y is the volume loss resulting from the price increase. The right hand side of the equation is equal to the margin before the price increase.

The left hand side is the total margin after the price increase and the right hand side of the equation is the current margin. If we would assume that marginal costs are 0 (and hence marginal profits are 100%):

$$C = 0,$$

then the equation above can be re-written as follows:

$$Y = X/(1+X)$$

Hence the critical volume loss at a price increase of 5% at a margin of 100% is

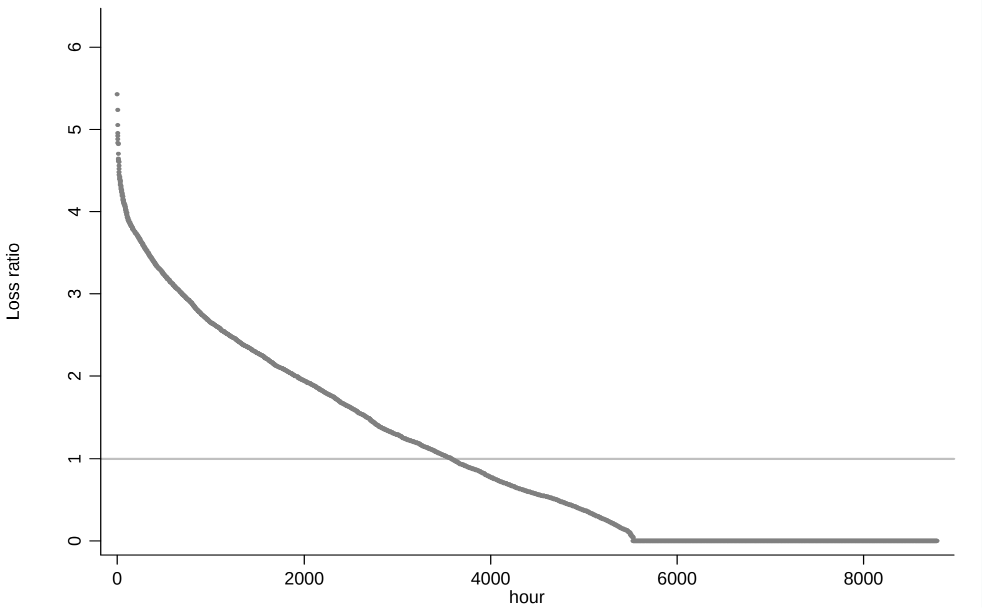
$$Y = 0.05/1.05 = 0.0476 \text{ or } 4.76\%$$

Or put differently, if marginal costs are zero/margins are 100%, then a 5% price increase will be profitable so long as it does not cause sales to drop by more than 4.76%.

If the margin is 90% (i.e. marginal costs of 10%), the above leads to a critical volume loss of 5.2% and so on. The table in the main text provides an overview of critical volume loss levels at different margin/marginal cost levels.

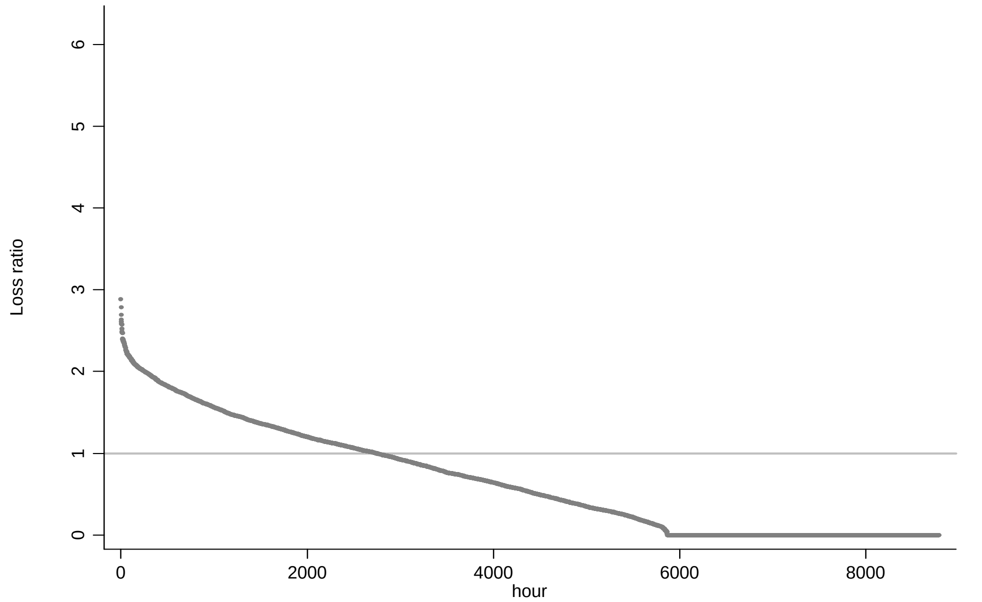
A3.2 Sensitivity checks on the number of hours in which the actual loss exceeds the critical loss

Figure 19: Actual loss / critical loss of a 5% price increase by all German suppliers on an hourly basis in 2008 (small prices are not equalised, see Section 0 for details)



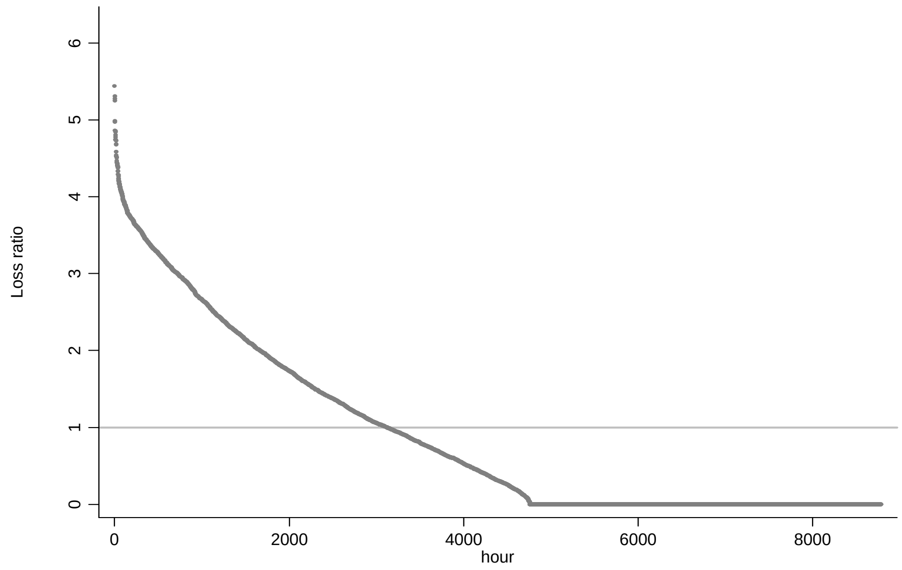
Source: European Energy Exchange, Nord Pool, European Climate Exchange, API2, TSOs, Union for the Coordination of Transmission of Electricity, European Network of Transmission System Operators for Electricity.

Figure 20: Actual loss / critical loss of a 10% price increase by all German suppliers on an hourly basis in 2008 (small prices are not equalised, see Section 0 for details)



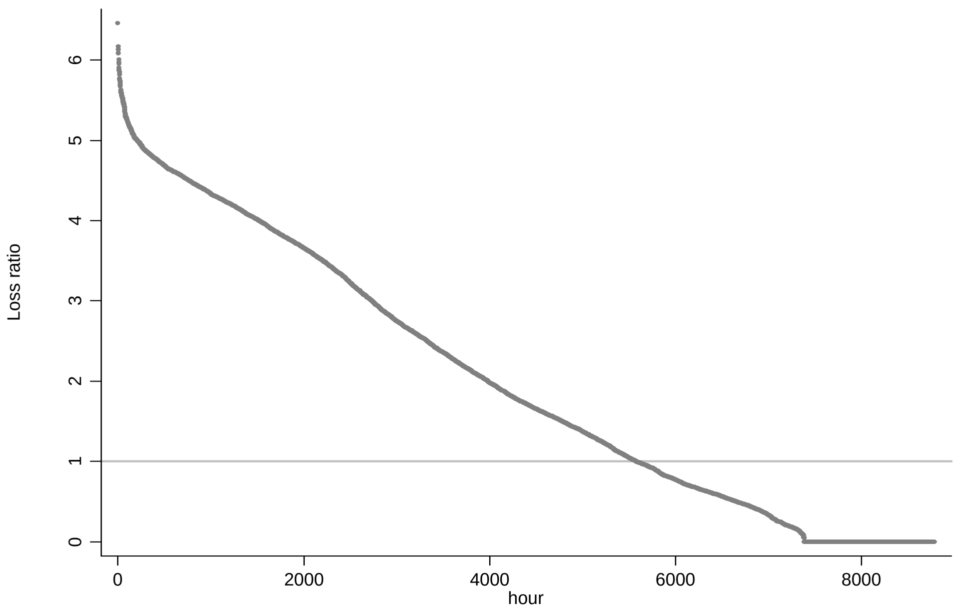
Source: European Energy Exchange, Nord Pool, European Climate Exchange, API2, TSOs, Union for the Coordination of Transmission of Electricity, European Network of Transmission System Operators for Electricity.

Figure 21: Actual loss / critical loss of a 5% price increase by all German suppliers on an hourly basis in 2008 (variable costs are higher by 20%, see Section 0 for details)



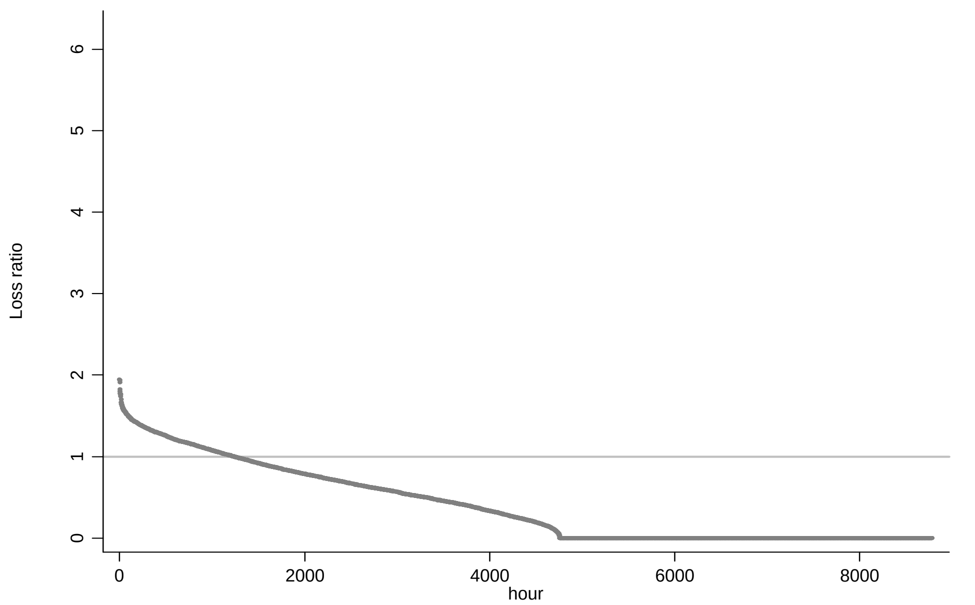
Source: European Energy Exchange, Nord Pool, European Climate Exchange, API2, TSOs, Union for the Coordination of Transmission of Electricity, European Network of Transmission System Operators for Electricity.

Figure 22: Actual loss / critical loss of a 5% price increase by all German suppliers on an hourly basis in 2008 (variable costs are lower by 20%, see Section 0 for details)



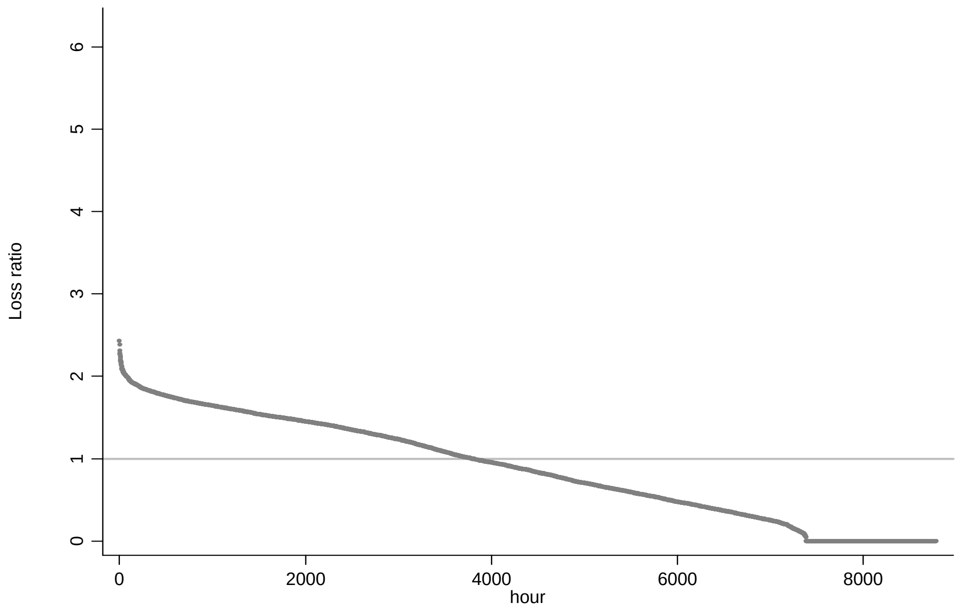
Source: European Energy Exchange, Nord Pool, European Climate Exchange, API2, TSOs, Union for the Coordination of Transmission of Electricity, European Network of Transmission System Operators for Electricity.

Figure 23: Actual loss / critical loss of a 10% price increase by all German suppliers on an hourly basis in 2008 (small prices are not equalised, variable costs are higher by 20%, see Section 0 for details)



Source: European Energy Exchange, Nord Pool, European Climate Exchange, API2, TSOs, Union for the Coordination of Transmission of Electricity, European Network of Transmission System Operators for Electricity.

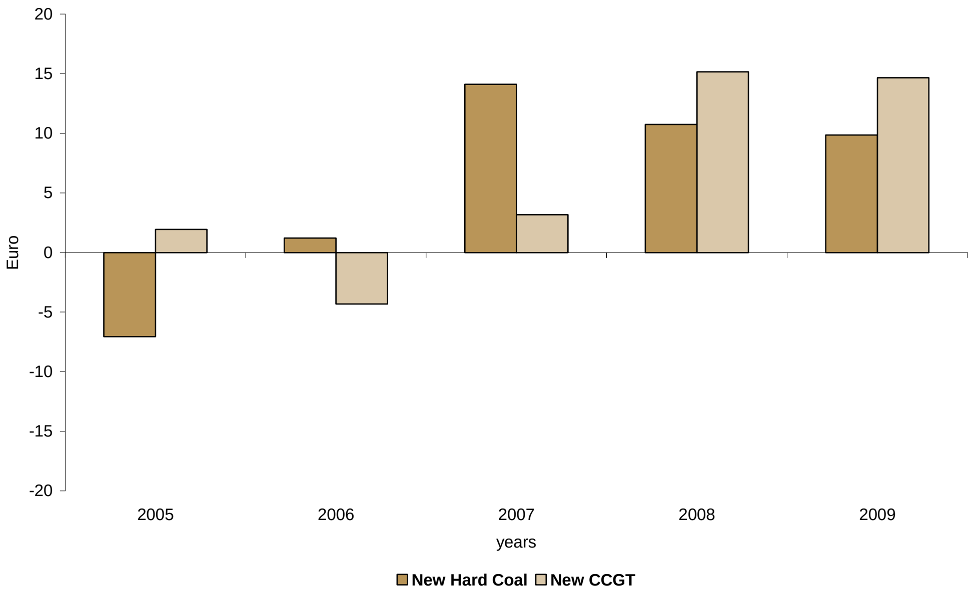
Figure 24: Actual loss / critical loss of a 10% price increase by all German suppliers on an hourly basis in 2008 (small prices are not equalised, variable costs are lower by 20%, see Section 0 for details)



Source: European Energy Exchange, Nord Pool, European Climate Exchange, API2, TSOs, Union for the Coordination of Transmission of Electricity, European Network of Transmission System Operators for Electricity.

Appendix 4
Plant profitability excluding CO_2 costs

Figure 25: Yearly margin by plant type per MWh, calendar years 2005-2009 (prices of CO_2 allowances are not included in the costs)



Source: Bloomberg TTF, RWE Supply & Trading, API2, European Climate Exchange, RWE, European Energy Exchange.

Appendix 5
List of data sources

Table 12: Data sources

Day-ahead spot exchange market electricity prices		
Germany	http://www.eex.com/en/	European Energy Exchange
France	http://www.powernext.com/	Powernext
The Netherlands	http://www.apxgroup.com/	APX Group
Czech Republic	http://www.ote-cr.cz/, http://www.pxe.cz/	OTE, Power Exchange Central Europe
Nord Pool	http://www.NordPoolspot.com/	Nord Pool
Austria	http://www.exaa.at/	Energy Exchange Austria
Switzerland	http://www.eex.com/en/	European Energy Exchange
Sweden	http://www.NordPoolspot.com/	Nord Pool
Poland	http://www.polpx.pl	Polish Power Exchange
Belgium	http://www.belpex.be/	Belpex
Denmark West	http://www.NordPoolspot.com/	Nord Pool
Denmark East	http://www.NordPoolspot.com/	Nord Pool
Future electricity prices		
Germany	http://www.eex.com/en/	European Energy Exchange
France	http://www.powernext.com/	Powernext
The Netherlands	http://www.apxgroup.com/	APX Group
Czech Republic	http://www.ote-cr.cz/, http://www.pxe.cz/	OTE, Power Exchange Central Europe
Nord Pool	http://www.NordPoolspot.com/	Nord Pool
Interconnection prices to and from		
France	TSOs	
The Netherlands	TSOs	
Switzerland	TSOs	
Czech Republic	TSOs	
Austria	TSOs	
Poland	TSOs	
Denmark West	TSOs	
Interconnection capacity	http://www.etso-net.org/	European Network of Transmission System Operators for Electricity

Interconnection prices to and from		
German network load	http://www.ucte.org/	Union for the Coordination of Transmission of Electricity
Future prices of CO2 allowances	http://www.ecx.eu/EUA-Futures	European Climate Exchange
CCGT and Hard Coal plant's capital costs	RWE estimates	RWE
CCGT and Hard Coal plant's efficiency factor	RWE estimates	RWE
Gas future prices	http://www.rwe.com/web/cms/de/158406/rwe-supply-trading/, http://www.bloomberg.com	RWE Supply & Trading, Bloomberg TTF
Hard Coal future prices	http://www.argusmccloskeycoal.com/	Argus/McCloskey API2

Source: ESMT CA.

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