Electricity Traffic over the Barriers of Networks:
The Case of Germany and The Netherlands

Hans Andeweg

André Dorsman

Kees van Montfort[*1]

Abstract

Since the electricity market was liberalized at the end of the last century, the authorities no longer fix prices, and there is now a variable price determined by the market. Every system has its own price-forming process. However, these systems are not completely isolated. It is possible to have a restricted measure of electricity traffic between the systems. This article describes a value-creating trade strategy on the basis of the prices of electricity in The Netherlands and Germany, making use of the restricted electricity traffic between the two countries, providing empirical evidence on exploitable pricing inefficiencies in the electricity markets and potential trading strategies based thereupon. This research has not been conducted before and will provide a better understanding of the interaction between separate electricity markets.

Key words: Efficient markets, Electricity markets, Electricity traffic, Trade strategy
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* H.C. Andeweg was an employee of the Energy Data Company (E.D.Mij) and is now working for EDF Trading Ltd. (email: hans.andeweg@edftrading.com) , A.B. Dorsman and K. van Montfort are both full professors at Nyenrode Business University and both also have links with VU University Amsterdam. Email addresses: adorsman@feweb.vu.nl and kvmontfort@feweb.vu.nl

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1 - Introduction

Historically, electricity networks in Europe have been nationally oriented. Electricity traffic between the networks is limited. In this article we investigate whether a strategy based on the limited capacity of electricity traffic between Germany and The Netherlands creates value. A necessary condition for such a strategy is that prices differ between those two countries. Looking at the daily price pattern, we see that, on average, prices in The Netherlands are higher than in Germany. However, while the price during peak hours is higher in The Netherlands during the day, during off-peak hours it is the other way around. This is firstly the result of the different ways in which electricity is generated: Germany uses coal-fired plants, while gas-fired plants are used in The Netherlands. Gas is more expensive than coal, and the price difference between gas and coal influences the electricity prices between Germany and The Netherlands. Secondly, a large number of the gas-fired plants are industrial CHP (Combined Heat Power) plants, which are often required to run during the night because of the demand for heat. This means that in The Netherlands the gap between the supply of electricity during the day (peak hours) and during the night (off-peak hours) is much smaller than that in Germany. Nonetheless, the demand for electricity during peak hours is much higher than during off-peak hours. This leads to greater price volatility during the day in The Netherlands than in Germany.

The goal of this article is to investigate whether a value creating trading strategy based on the limited transport capacity between two countries, in this case Germany and The Netherlands, is possible. The existence of such a strategy is in conflict with the efficient market hypothesis. Furthermore, this research has never previously been conducted and will provide a better understanding of the interaction between separate electricity markets.

Electricity markets change very rapidly, and this has led to day-ahead markets – in which prices are set for the next day - being coupled to reduce price volatility. In November 2006, the markets between France, Belgium and The Netherlands were coupled, meaning that transport capacity would no longer be auctioned. Instead it would be used to automatically direct flow from the low-price market to the high-price market until the prices were equal or the entire available capacity at the interconnections was being used. There are plans for Germany and perhaps Luxembourg to also join this market in the future.

Electricity has a number of specific characteristics that differ substantially from all other commodities. The main characteristics are:

- firstly, in most cases, electricity cannot be stored or is very difficult to store;
- secondly, the electricity network must always be kept in balance - it is not possible to generate more electrical power than is being used, on penalty of overloading the system;
- thirdly, the transport of electricity follows the laws of nature (see Centolella, 1996, p.42). Its distribution cannot be delayed and therefore there are obstinate characteristics of power that may lead to so-called parallel path flows. Due to this, part of a power transport system will make use of the system's agreed route, while use is also made of a remote third-party system.

Owing to the limited possibility of storing electricity, price fluctuations on the electricity market are large in comparison with other markets. In Norway, where electricity is generated using hydropower, the possibilities for storing electricity are greater, and this has subdued fluctuations in price . At present, the Dutch and the Norwegian systems are being linked and once this link has been effected the expectations are that price fluctuations in The Netherlands will decrease.

The issue has been dealt with in various academic articles, although the number of relevant articles is limited. Pilipovic (1998) was one of the first to address the special characteristics of the price of electricity. In addition, Lucia and Schwartz (2002) considered the price-making forces of derivatives, the underlying value of which is the price of electricity, while Borovkova and Geman (2006) elaborated on this theme in their paper 'Analysis and Modeling of Electricity Forward Curves'. Boogert & Dupont (2005) examined the relationship between the day-ahead market and the real-time electricity markets in The Netherlands. Their article is interesting because the Amsterdam Power Exchange (APX) trades electricity for the next day (day-ahead market).

Traditionally, electricity markets have been developed within national borders. This also applies to the system. It is true that there is electricity traffic between The Netherlands and its neighbours Germany and Belgium, but this is limited. The systems in The Netherlands and Germany operate more or less as two isolated systems, with a restricted possibility of electricity traffic between them. The capacity to import electricity from Germany or to export electricity to Germany is auctioned. In addition, as mentioned above, electricity is generated by different means in the two countries, causing a difference in daytime price patterns between them. The pertinent question to be addressed in this article is whether it is possible to develop a value-creating trade strategy, given the limited capacity for electricity to be imported from or exported to Germany.

There has been some previous research on cross-border electricity price differences. The studies carried out by Bower (2002), Boisseleau (2004) and Armstrong and Galli (2005) compared the day-ahead wholesale prices of electricity at various power exchanges in Europe. Bower (2002) concluded that some integration of European markets was already in evidence in 2001, especially in relation to The Netherlands and its neighbours and within the NordPool area. Boisseleau's PhD dissertation provided a thorough analysis of Dutch and German power exchange and their price correlations, with some empirical evidence of inefficient transmission pricing in Europe also being provided. Armstrong and Galli (2005) and Zachmann (2005) studied the evolution of price differentials between France, Germany, The Netherlands and Spain during the period 2002-2004 and concluded that European electricity markets converged during this period. Nevertheless, the above-mentioned papers do not investigate whether the cross-border market differences which are illustrated lead to exploitable pricing inefficiencies, that is, practical relevant inefficiencies. Gathering empirical evidence on such inefficiencies in the power markets and developing potential trading strategies based on this evidence is an appealing prospect.

Following this introduction, Section 2 of this article will describe the development of electricity traffic between The Netherlands and Germany, as well as considering the differences in price fluctuations between the two countries. A description of the trade strategy will be provided in Section 3, while Sections 4 and 5 will provide an account of the empirical research. Our research is based on historical data and it is assumed that given the same circumstances, a trade strategy that was operational in the past could also be operational in the future. However, the electricity market is far from constant, thus, Section 6 will deal with some possible developments that could influence the trade strategy investigated in Sections 4 and 5. The final section summarizes our conclusions.

2 - Electricity traffic between The Netherlands and Germany

In The Netherlands, electricity is traded bilaterally as well as at the APX [2]. The APX is a so-called day-ahead market, which means that the prices are set for the next day. Ultimately, the price of electricity in The Netherlands may be more than 20 percent higher than that in Germany. In addition to this, prices on the APX have a greater volatility than those on its German counterpart the EEX (European Energy Exchange) due to the smaller market.
Looking at the prices on the APX and the EEX on working days, it is apparent that they are generally higher on the APX during peak hours (07.00 through to 23.00 hours), but that they are lower during off-peak hours (23.00 hours through to 07.00 hours).[3] The difference between peak and off-peak prices is in The Netherlands substantially higher than in Germany and must be attributed to the different ways of generating electricity in The Netherlands and in Germany. The price of electricity in The Netherlands has a 'mean reversion' as well as high and low spikes (see Brand, Verbaten and Dorsman, 2005).

In the dynamic electricity market, the need for a method that allocates transmission capacities for cross-border interconnections has arisen. The need for such a method has been particularly strongly felt in the market between the Netherlands and its neighbouring countries. For this reason, the four Transmission System Operators (TSOs) concerned decided on the joint auctioning of cross-border electricity transfer capacity in Spring 2000. The four TSOs are the Belgian ELIA System Operator, the Dutch TenneT and the two German operators, RWE and E.on Netz. They have commissioned TSO auction, a wholly owned subsidiary of TenneT, to auction the limited transport capacity in daily, monthly and annual markets. Buyers of import capacity at the daily auctions have to sell the electricity on the APX. This

[2] Approximately 15% of Dutch energy consumption is traded on the APX.

[3] For the sake of completeness we would point out that the EEX has different peak hours, namely 08.00 hours through to 20.00 hours. This difference in the duration of the peak hours is only a question of definition.

obligation to trade the permitted capacity at a daily auction straight on to the APX is a flaw that may well create barriers for some of the would-be callers for this capacity. Users of energy who want to spread their supplies across borders profit from the delivery of the electricity which is purchased. The obligation to sell the electricity bought at the daily auction back to the APX makes this possibility less viable for such companies. However, for traders/arbitrageurs the obligation to sell/buy the electricity bought/sold on the import/export market the next day on the APX is not such a barrier. In fact, traders / arbitrageurs are not long-term investors but are interested in realizing short-term results.

When buying a 1 MW (Megawatt) annual contract at an auction, the buyer acquires the right to decide whether or not to bring 1 MW into operation for all 8760 (= 365 days * 24 hours): the buyer has purchased 8760 options on the use of the power. The monthly auction operates on the same principle, however, the daily auction operates differently. At the daily auction a price is set for every single hour of the following day. Therefore, it would be more accurate to call it an hourly auction, but in line with common practice, for the purposes of this article we will continue to use the term ‘daily auction’.

As mentioned above, prices are higher in The Netherlands during peak hours, but higher in Germany during off-peak hours. This implies that electricity will be conveyed during peak hours from Germany to The Netherlands, and will flow in the reverse direction during off-peak hours. However, in Germany, cheaper day contracts related to all 24 hours are being bought for electricity which is to be transported from Germany to The Netherlands. For this reason, electricity is transported to The Netherlands even in off-peak hours. The fact that these cheap day contracts exist in Germany is inconsistent with an efficient price-establishing process and is probably the result of the fact that the market is still developing. From this point of view it is better to trade at the daily auction than at the monthly or annual auction, as options are bought on the latter two auctions for all hours (peak and off-peak),including those hours that traders are not interested in. At the daily auction options can be bought for peak hour capacity without any obligation to buy off-peak hours.

A trade strategy does not guarantee delivery. The obligation to sell the available capacity at the daily auction does not restrict the obligation to do the same at the APX. As mentioned above, this possible barrier is relevant for potential buyers who want a delivery and primarily make use of the monthly and annual auctions. In spite of this tendency, these buyers can actually make use of the daily auction. To do so they merely have to repurchase the electricity that they are obliged to buy at the APX, for which the buyers concerned pay a fee for trading at the APX of two times €0.14 per MW. Consequently, these parties are hampered by the legislation governing the APX, which makes this form of trading less attractive at best. Nonetheless, they are actually active at the daily auction and the absence of some of these bidders may have an oppressive influence on the price struck , creating more favourable conditions for the remaining bidders. At first sight, a trade strategy based on daily auctions seems to offer the best perspective for an arbitrageur.

3 - Description of the trade strategy

As described above, there are daily, monthly and annual auctions at which the average price in Germany is lower than in The Netherlands. This means that the export capacity to Germany is of little or no value in relation to the monthly and annual auctions.
The import capacity from Germany may be of value for monthly and annual auctions. However, this value based on the difference in price between The Netherlands and Germany is expressed in the spread on the OTC market. A value creating strategy based on monthly and annual auctions is not possible because the expected price differences are included in the spread. Therefore, our investigation has been limited to the daily auction. The data used in this article consists of the hourly prices on the APX and the EEX from 2001 to 2005 and the daily results of the auction of transport capacity from TenneT to RWE, RWE to TenneT, TenneT to E.on and E.on to TenneT. TenneT is the Dutch grid operator; RWE and E.on are the grid operators in Germany to which TenneT is connected.

Import from Germany to The Netherlands.

On the actual day of the daily auction, the corresponding spread on the day-ahead market per hour is not known. On the basis of data collated from four previous years, a valuation of this spread has been made for every hour on every weekday in every month. The valuation of the spread for a specific hour in 2005 is the weighted average of the spreads for the years 2001 up to and including 2004, whereby the year 2001 is weighted by a factor of 0.1, 2002 by a factor of 0.2, 2003 by a factor of 0.3 and finally 2004 by a factor of 0.4. There is a considerable amount of literature on forecasting electricity prices from Australia and the UK (see Angelus, 2001, Conejo et al., 2005, Carnero et al., 2007, Chan et al., 2008, Huisman et al., 2007, Karakatsani and Bunn, 2008, and Nogales et al., 2002). Nevertheless, their approaches are not developed to give *predictions* of *hourly* prices. Our formula for the expected spread in year y, month m, day of week d, and hour h is:

$E(S_{y,m,d,h}) = 0.4(S_{y\text{-}1,m,d,h}) + 0.3(S_{y\text{-}2,m,d,h}) + 0.2(S_{y\text{-}3,m,d,h}) + 0.1(S_{y\text{-}4,m,d,h})$

During the period observed, the electricity market grew very rapidly, for example in the number of contracts traded on the Amsterdam Power Exchange (APX). In stead of an unweighted average of the years 2001-2004 we used an approach such that the weight of year t was higher than the weight of year t-1. In this way, the estimated spread for hour 15 on every Wednesday in October will be €26.93. In the calculation, the average spread for this hour (on this weekday, in this month) in 2004 has a weight of 0.4, in 2003 0.3 and so on. Taking into account the costs of trading on the APX (€0.14) and the EEX (€0.05), the bid price at a TSO Auction then becomes €26.74 (= 26.93-0.14-0.05). This means:

$B_{y,m,d,h} = E(S_{y,m,d,h}) - C_{APX} – C_{EEX}$,

whereby

$B_{y,m,d,h}$ = the bid price on the import capacity by a TSO auction for the specific hour,

C_{APX} = the costs of trading on the APX market,

C_{EEX} = the cost of trading on the EEX market.

Only when the price is below € 26.74 the (import) electricity will be bought and will sold the next day at the auction.. In our computer computations, these prices are compared with the average price for transport capacity paid for that specific hour from RWE to TenneT and from E.on to TenneT. Thus, we have not chosen a specific network to trade on, and have taken the average price of trading on both networks, that is, $T = (T_{RWE} + T_{E.On})/2$ where T_{RWE} is the price of RWE and $T_{E.On}$ is the price of E.On**.** This decision influences the criterion of whether the transport capacity is obtained or not, and thus the calculation of the results. Also, a position has to be closed on the APX and, later in the morning, an opposite position on the EEX. Owing to the fact that the EEX is only put up for auction on working days, a position must already be closed on the EEX for Sunday and Monday prior to the corresponding transport capacity being obtained. If the estimated spread in any direction is greater than the €0.19 trading costs, the transport capacity in this direction will be bought. Consequently, this transport capacity has to be obtained in order to prevent buying or selling on the imbalance of the German market. Therefore, a high critical price will be used in the auction for these days to minimize the risk of being drawn into the German imbalance. As a result, on such days our simulation considers the transport capacity to have been obtained at the settlement price paid at the auction.

The development of electricity prices also depends on the day of the week. Sundays, for example, show a deviating pattern. However, this is not the reason why the strategy is only used from Tuesdays through to Saturdays. The real reason is the fact that the EEX is only open on working days, and this changes the order of trading. This is a good reason for making a distinction between the various days of the week when setting the reserve price. The same applies to the distinction between different months and different hours of the day.

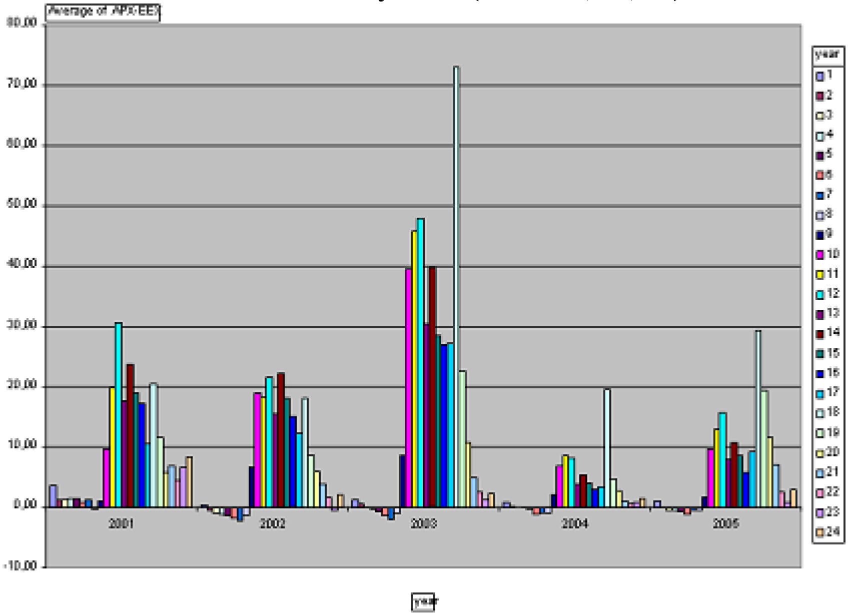
Export from The Netherlands to Germany

The strategy that has been developed concerning import from Germany to The Netherlands can also be applied by analogy to export from The Netherlands to Germany in the case of a negative spread.

4 - Empirical research

For the empirical research, we have used hourly based data for the years 2001 up to and including 2005. The data for 2001, 2002, 2003 and 2004 has been used to predict the expected spreads in 2005 (see formula in Section 3). Thereafter, these predictions of spreads are used to calculate the bid prices. Finally, the results of our trade strategy are obtained for each day. If the bid price is higher than the market price, then the trader will be able to buy the electricity against the market price. The next day it will turn out whether the action will be profitable, because the trader has the obligation to sell the electricity on the market. (see Section 3). Day-ahead prices for The Netherlands and Germany are provided by the APX and the EEX. Auction results for transport capacity can be found on the TSO Auction website. The average spreads APX-EEX (in euros) during the years 2001-2005, on an hourly basis (hour = 1, …, 24), are shown in Figure 1.

Figure 1: **Average spread (in euros) APX-EEX during the years 2001-2005 on an hourly basis (hour = 1, …, 24)**



In 2005, 365 day results were obtained for the following four trade strategies:

(1) only export (1 MW at one time);
(2) only import (1 MW at one time);
(3) import (1 MW at one time) and export (1 MW at one time);
(4) import (1 MW at one time) and export (3 MW at one time).

It appears from the correlation between the day results that no periods show a positive result over a number of consecutive days, nor are there any periods that show a negative result over a number of consecutive days. The correlation between the day (day t) and the following day (day t + 1) does not differ significantly from 0 for any strategy (see Table 1). This also applies to the day (day t) and for the same day a week later (day t + 7). In other words, the day result does not have a predictive value, either for the next day or for the same day a week later. It can be concluded that the decision on whether or not to import or whether or not to export does not need to be influenced by the results obtained immediately before, as these results provide no indication of future results.

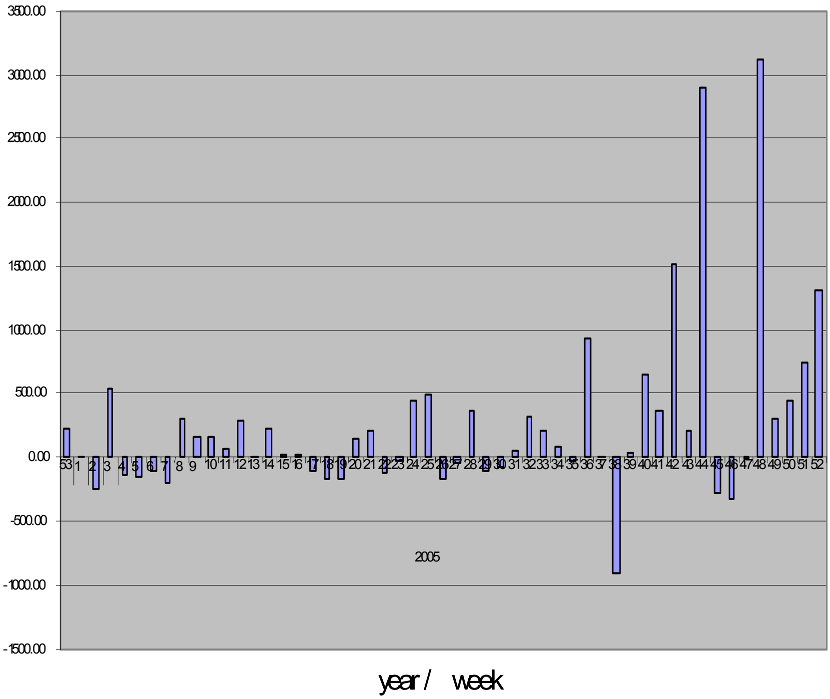
Table 1: **Correlations of daily results compared to the day before and the week before**

Import		**Export**		**Imp. + Exp.**		**Imp.+3* Exp.**	
Daily base	**Weekly base**	**Daily base**	**Weekly base**	**Daily base**	**Weekly base**	**Daily base**	**Weekly base**
-0.043	0.012	0.059	-0.009	-0.048	0.017	-0.04	0.027

However, the results on a daily basis do show that the import results for the latter part of 2005 were more volatile (see Figure 2, week results). This can be explained by a rise in prices on the APX as well as on EEX. This gives the spread on the day-ahead market more volatility, because the amounts involved are much larger. The unexpected onset of cold weather might have been one of the reasons for these high prices in Europe. Due to the fact that export particularly takes place in off-peak hours, the price increases do not influence the volatility of the export results, because off-peak hours are less sensitive to spikes in prices.

Our computer computations with respect to the year 2005 indicate that the export result would be €439.26 if one MW at one time (MWh per hour) had been traded in 2005 (trade strategy (1)). Import of electricity would have resulted in an amount of €13,415.04 in the same period (trade strategy (2)). This large difference is due to the fact that more import than export occurred over more hours (4797 hours compared to 2125 hours out of a total of 8760 hours). Furthermore, the import amounts involved at the APX, the EEX and TSO Auction per hour are many times greater than those involved in export because import from Germany mainly takes place during peak hours. Finally, our computations show that the strategies combining import and export obtain the highest trade results, that is, € 13,785.76 and €14,754.99.

Figure 2: **Results of the import strategy in 2005 on a <u>weekly basis</u> in €/MW (The numbers of the weeks in 2005 can be found on the horizontal axis.)**



The fact that trade on the EEX is only possible on working days has been incorporated into the day results for Sundays and Mondays, but not for days following German public holidays. In our investigation we treated the days after a German public holiday as normal weekdays, in order to avoid computing problems in the Monte Carlo simulation which we carried out at a later date.

Nonetheless, the results of our investigation will only change marginally: firstly, because it deals with a limited number of days, and secondly, because the day results for the relevant days hardly differ from the other days.

5 - Risk analyses

The decision to trade with Germany on a daily basis is extremely risky as the results on a daily basis are highly volatile. The more that trade can be spread over several days, the more this risk is reduced by diversification. For this reason, this study looked into the risk on an annual basis rather than a daily basis. By using a Monte Carlo simulation, several annual results were obtained, making it possible to estimate the risk on an annual basis.

The Monte Carlo simulation was applied using the following steps sequentially:

Step 1:

From the population, a set of 7 x 52 random samples of the expected daily spreads were taken, to give a simulation of one year (52 Mondays from the population of Mondays, 52 Tuesdays from the population of Tuesdays, and so on). Each random draw of the expected daily spread for a specific day of the week was taken from a triangular distribution with a mean value and a standard deviation, which was estimated by the actual daily spreads of that specific day in the year 2005. The 365 expected daily spreads were used to calculate the corresponding 365 daily bid prices. If the bid price was higher than the market price, we would buy the electricity. The realized profit (or loss) for the next day could then be calculated as the difference between the APX price and the EEX price (minus the transaction costs). Finally, the total result over the year 2005 could be computed by counting the 365 daily results.

Step 2:

This step 1 procedure was repeated several times, providing several total annual results. In this Monte Carlo simulation, 200 years were simulated by repeating the procedure described in step 1.

The abovementioned Monte Carlo simulation was carried out separately for each of the four trade strategies (see Section 4). Of the 200 simulations, an average annual result per strategy could be calculated on an annual basis with a corresponding standard deviation. As expected, the average annual results were almost equal to the real results in 2005, see table 2. This resolved the problem of the strategy being tested over only one year. However, while this period might seem insufficiently long to draw conclusions, when the results per day are considered it provides us with 365 results. More results are

available on an hourly basis. As the hourly results are strongly dependent on the day on which they are obtained, simulating on the basis of results per day is more logical. Furthermore, the daily results are not interdependent and a year of importing and of exporting can only be correctly simulated on their basis. Only in this way can the results per day for export and import which had a negative correlation in 2005 be taken into account, as import as well as export take place in one day, but not in one hour.
The decision to draw 52 times out of each weekday and not just draw 365 times out of the total population was based on the fact that the results were affected by different conditions on Sundays and Mondays, because the EEX is only open for auction on working days. By taking 52 draws from each day, the weight of these days in the simulated annual result will be equal to the actual weight.

The results of the Monte Carlo simulation for our four trade strategies are given in Table 2:

Table 2: **The results of the Monte Carlo simulation**

	Import (1)	**Export (2)**	**Exp. + Imp. (3)**	**3*Exp.+Imp (4)**
Average res.	€ 13,425.27	€ 438.14	€ 13,863.41	€ 14,739.69
St. dev.	€ 4,554.78	€ 531.35	€ 4,498.04	€ 4,571.54
St. dev. (in %)	33.93 %	121.27 %	32.45 %	31.02 %

As shown in Table 2, importing one MW during these hours produces a much better result than the same strategy applied to exporting. In addition, the risk of the import strategy is reduced. The export of electricity, however, is recommended in combination with import, because then the risk will be significantly reduced. The reason for this is that the daily import results have been negatively correlated to the export results. This risk can be reduced even more in percentage terms by exporting a larger volume. In this Monte Carlo simulation we have opted for the ratio of 3:1, because Germany is expected to be more expensive for about a quarter of the hours in 2005. By adhering to this ratio, approximately the same volume (MWh) is exported on an annual basis as is imported. Of the trade strategies distinguished in Table 2, the latter strategy provides the higher average result and the lower standard deviation in terms of percentage and is, therefore, preferable to the other three strategies.

The import strategy produced a better result than the export strategy, but the level of risk can be reduced by combining both strategies. The risk can be further reduced by exporting a larger volume per hour than by importing. According to the Monte Carlo simulation, a combination of import and export will lead to an anticipated positive result at an acceptable risk.

The border capacity that is offered at the daily auction lies between about 500 and 2000 MW for import and between 2000 and 2500 MW for export. It is difficult to ascertain which of the strategies described will influence the price realized at the TSO Auction. It is not very likely that the results presented will decrease significantly if there is no buy quantity above 50 MW for conveying the electricity, as - generally speaking - this will only be a small percentage of the available capacity on the day trade. The margin quickly becomes visible when three times the export capacity is bought every hour. Opposed to this, however, is the fact that the larger part of the costs incurred through export comprises the compensation paid for trading on the APX and the EEX. Therefore, the result will not be greatly influenced by a slight increase in the price related to export capacity. Besides, the available capacity at the border is almost always larger for export than for import.
Furthermore, bids are not made at a very high reverse price at the TSO Auction for the daily auction on weekdays. Consequently, there is no trading in hours that are at too high a price.

Finally, the prices on the APX and the EEX will not be influenced by pursuing a trade strategy, because the volumes in these markets are large.

6 - Perspective

Value-creating trade strategies exist due to the imperfections of the market. The question of whether in the future it will still be possible to generate value with an already developed trade strategy depends on future imperfections. The electricity market is a rapidly developing market and one of the characteristics of such a market is that existing imperfections will be reduced in the future or may even disappear.

One of the imperfections concerns entry into a closed market. When bidders and suppliers are not able to easily enter into a market or withdraw without any risk or costs, a deviant price-making process may arise. Electricity markets are public markets and electricity traffic is limited between such markets. As the markets of The Netherlands, Belgium and France have been coupled since 21 November 2006, the imperfections between the three markets will gradually disappear. This is not presently the case between the markets of The Netherlands and Germany, where it is only expected that electricity traffic will also occur through market coupling in the future.

Another condition for successfully applying our trade strategies is based on the fact that there are differences in prices between the markets of The Netherlands and Germany, and that with the aid of historical data these differences in prices can be predicted to a certain extent. On the basis of the different methods used to generate electricity, it can be assumed that prices will be higher in The Netherlands than in Germany in the near future and during peak hours, while in the off-peak hours it will be the other way around. These differences will continue to exist in the future.

However, as mentioned above, the Norwegian and Dutch systems are being linked by means of a cable in 2008. In Norway, hydropower-generated electricity is easier to store and, thus, linking the Norwegian and the Dutch systems will have an equalizing influence on the price of electricity in The Netherlands. Expectations are that the differences in price between The Netherlands and Germany will therefore decrease, having a negative impact on the result of the trade strategy. Nevertheless, our results show that the electricity market between The Netherlands and Germany is not efficient at this moment (see, among others, Shleifer, 2000).

7 - Conclusion

An electricity market that provides opportunities for electricity trade with Germany has not yet developed. We have examined this situation from the perspective of an arbitrageur and on this basis have argued for limiting trading to daily contracts. A positive result may be achieved by predicting the APX-EEX spread rather than the market, but this is not without risk. For example, the spread may be smaller than what has been paid for transport capacity at the daily auction, or may even develop in the opposing direction, which, at least in theory, makes the risks unlimited. This investigation estimated the value of transport capacity by predicting the APX-EEX spread on the basis of historical differences in price on the Dutch and German day-ahead markets. From Tuesdays to Saturdays, the predicted value is used as a deposit at the daily TSO Auction. This only applies for the days mentioned, firstly because a bid has to be made on the transport capacity and secondly as a position needs to be closed on the APX and the EEX. On Sundays and Mondays, a very high price will be bid at the daily auction for the hours where the expected spread is greater than € 0.19, as a result of which the transport capacity will almost certainly be obtained and consequently traded within those hours.

Market imperfections can have effects. In our empirical research we calculated the bid price by subtracting the cost of trading on the APX market and the EEX market. Thus, our results are adjusted for transaction costs. Other imperfections are too small to completely explain the positive results obtained.

The positive result might also be obtained by a better estimation of the spread on a day-ahead market rather than the price that will be realized on the TSO Auction. Due to the fact that there are few participants in this market and that trade is certainly not risk-free, the price for the transport capacity that is realized at the daily auction is often too low.

However, there are some other comments to be made about this study. The various strategies were tested for only one year, because the historical data was limited. On addition, the number of parties trading on the border with Germany is expected to increase over the next few years, although this will not be at a high rate. The period of testing did not disclose any large changes in the Dutch and German markets, such as the link that has been planned with Norway, which, as mentioned, will have an impact on the prices on the APX and, therefore, also on the spread with Germany.

The strategy that has been described in this study can be expanded even further, for example, through adjusting the pattern using more recent data, so that the strategy is not only defined on the basis of results over the four years in question. Depositing a minimum sales price on the APX that is equal to the anticipated price on the EEX could also improve the results for import (the reverse is also possible: depositing a maximum sales price on the APX for export equal to the anticipated price on the EEX). In addition, transport capacity has not always been fully made use of. Any expansion is very complicated because the day-ahead market is very hard to predict. The inclusion of the imbalanced German market or the intraday market could also improve the results, especially with a sharper reverse price at the daily TSO Auction for days that follow non-working days. If, in such cases, no transport rights can be obtained, then the electricity bought or sold earlier on the EEX has to be sold or bought on the basis of the German imbalance. In that case the maximum price for transport capacity can be determined by the value of not trading on the German imbalance, but by buying or selling on the APX.

The daily auction is an easier alternative for a company than trading in electricity with Germany. One advantage that the daily auction has over the monthly or annual auctions is that no substantial investments are involved. It is also easier to change the daily market strategy. Value can be created at a lower risk level by combining import and export strategies. Assuming that the costs of implementation will not be too high, this would be a good way of becoming active in the auction of border capacity.

If use of a pattern of investment at the daily auction of TSO Auction occurs as described in this article, it is of the utmost importance that changes in the Dutch and the German markets are closely monitored. For example, now the cable with Norway is in use, the pattern of investment must be adapted to this situation. At such a moment, it would not be advisable to continue with investments that have been calculated purely on the basis of historical data.

In conclusion, the results of this research are incompatible with the efficient market hypothesis. This article has developed a value-creating trading strategy based on the limited capacity to transport electricity from Germany to The Netherlands and vice versa. However, if Germany joins the system already in place between Belgium, France and The Netherlands, the profit potential will be lost. In such a case, the strategy could nevertheless be adjusted to take into account the limited transport capacity between other electricity networks.

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