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Anders Plejdrup Houmøller
Tyttebærkvisten 7
5500 Middelfart
Denmark

+45 28 11 23 00
CVR/SE no. 33 16 20 30
anders@houmollerconsulting.dk
www.houmollerconsulting.dk

Investigation of forward markets for hedging in the Danish electricity market



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1. Executive summary

The *Commission Regulation (EU) 2016/1719 of 26 September 2016* establishes a guideline on forward capacity allocation.

According to the regulation, TSOs on a bidding zone border shall issue long-term transmission rights (LTTRs) unless the competent regulatory authorities of the bidding zone border have adopted coordinated decisions not to issue long-term transmission rights on the border.

In article 30, the regulation states that the decision on whether to issue LTTRs *shall be based on an assessment, which shall identify whether the electricity forward market provides sufficient hedging opportunities in the concerned bidding zones.*

Therefore, the Danish Energy Regulatory Authority (DERA) has asked Houmoller Consulting ApS to carry out an investigation of the hedging options at the Danish electricity market. This report contains the results of the investigation.

Concerning the method employed in the investigation: as can be seen from table 1.3, the Danish market players do not regard Nasdaq's System Price contracts as a suitable hedge against the Danish spot prices. Hence, if Danish market players want to use Nasdaq's power derivatives for hedging, they need both a System Price contract and an EPAD.

This is also illustrated by the correlation between the prices. Table 1.1 gives the correlation between the monthly average prices

Correlation between average monthly prices			
Year	DK1	DK2	SE4
2007	0.86	0.87	-
2008	0.66	0.73	-
2009	0.82	0.53	-
2010	0.62	0.94	-
2011	0.76	0.70	-
2012	0.73	0.75	0.95
2013	0.34	0.69	0.80
2014	0.39	0.47	0.59
2015	0.88	0.85	0.96
2016	0.90	0.91	0.94

Table 1.1 The green numbers give the correlation between the monthly averages of the System Price and the monthly averages of the spot prices of DK1, DK2 and SE4. The Swedish bidding zone SE4 was established 1 November 2011.

Therefore, this report investigates the liquidity and the spreads of Nasdaq's Danish EPAD contracts. Further, the report investigates the risk premiums for the hedging system consisting of Nasdaq's System Price contracts and EPADs.

As for liquidity: there is no agreed threshold beyond which a market is considered liquid. A churn rate of 10 is generally seen as the minimum for a mature market, according to the British energy regulator Ofgem (ref. 7). Oxford Institute for Energy Studies has written a report on the European gas markets (ref. 5). For the Spanish gas market, the report notes: *the churn rate quoted is a very poor 1.77*.

The liquidity of Nasdaq's Danish EPAD contracts is nowhere near the numbers quoted above, as can be seen from the figures 1.1 – 1.4.

Further, measured as a percentage of the consumption, the exchange turnover and the Open Interest of Nasdaq's Danish EPAD contracts is declining. So is Nasdaq's turnover of Nordic power derivatives.

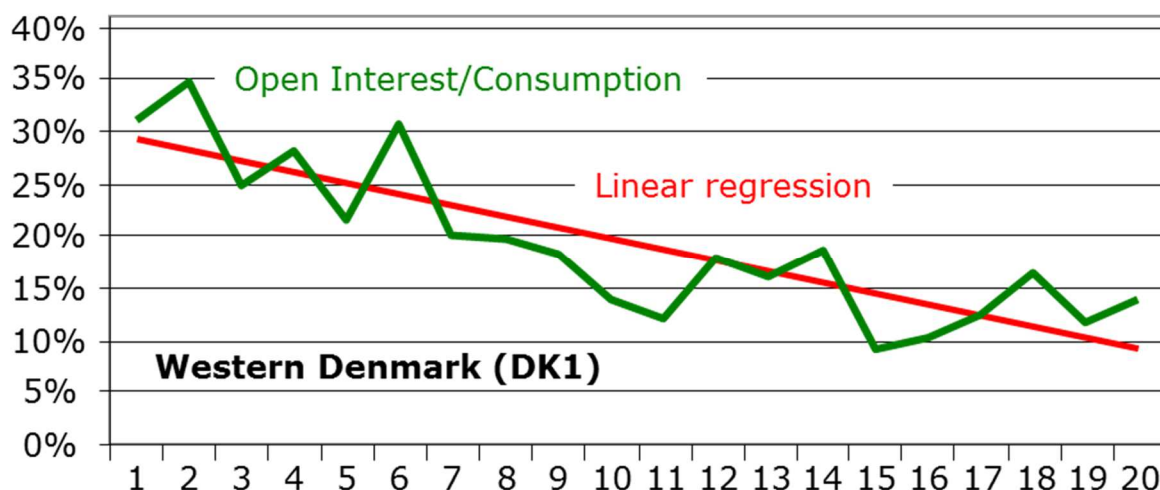


Fig. 1.1 (Open Interest)/Consumption for DK1 quarter EPAD contracts. Data for the 20 quarters from Q1-2012 to Q4-2016. Open Interest one of the last three trading days before delivery. Due to the cascading of the annual contracts, this contains the contribution from both annual and quarter contracts.

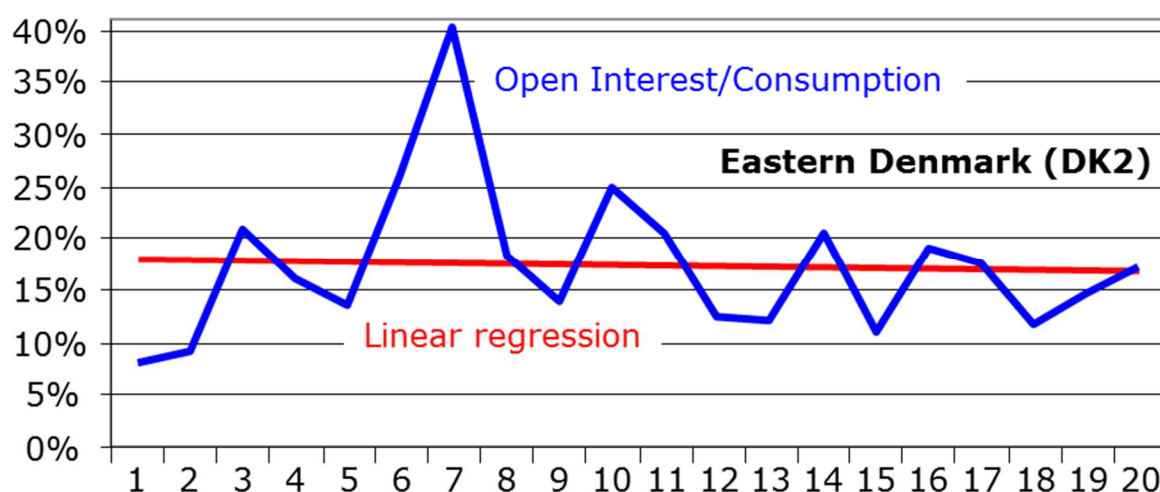


Fig. 1.2 (Open Interest)/Consumption for DK2 quarter EPAD contracts. Data for the 20 quarters from Q1-2012 to Q4-2016. Open Interest one of the last three trading days before delivery. Due to the cascading of the annual contracts, this contains the contribution from both annual and quarter contracts.

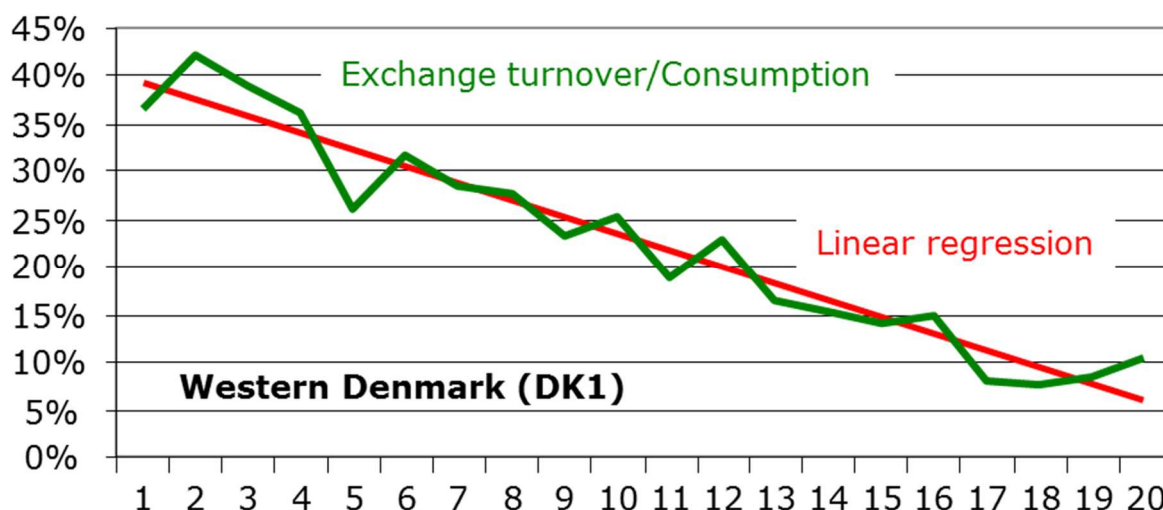


Fig. 1.3 (Exchange turnover)/Consumption for DK1 EPADs. Data for the 20 quarters from Q1-2012 to Q4-2016. For each quarter, this is the turnover for both the quarter contract and the corresponding annual contract. The contribution from the annual contracts is calculated as described in the footnote of the table in appendix 11.

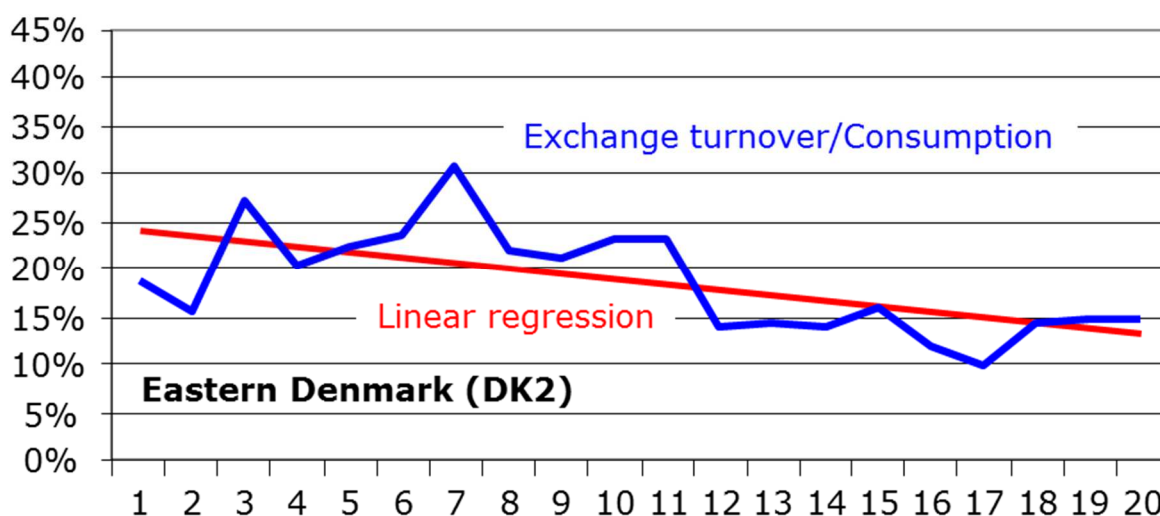


Fig. 1.4 (Exchange turnover)/Consumption for DK2 EPADS. Data for the 20 quarters from Q1-2012 to Q4-2016. For each quarter, this is the turnover for both the quarter contract and the corresponding annual contract. The contribution from the annual contracts is calculated as described in the footnote of the table in appendix 11.

Concerning the risk premiums: Table 1.2 shows how the risk premiums would look, if all hedging was done the last trading day before the start of the delivery period. In addition to this calculation, chapter 7 shows how the risk premiums look, when the calculation of risk premiums is done by modelling hedging.

	DK1	DK2	SE4 ¹	Contribution from System Price contracts
Quarter contracts The 44 quarters Q1-2006 – Q4-2016	-3.4	-3.6	-1.9	-1.6
Annual contracts The 15 years 2002 – 2016	-3.3	-3.2	-5.1	-1.6

Table 1.2 For the period indicated in the first column, the numbers give the average ex-post risk premium in €/MWh.
 Using the quarters as an example: for each quarter, the risk premium is calculated as

$$(\text{quarter's forward price}) - (\text{quarter's average spot price})$$

 The forward price is the closing price/daily fix of the contract's last trading day.

For the interconnectors linking Sweden/Norway and Denmark, the majority of the energy companies interviewed to this report support introduction of LTTR auctions. Table 1.3 and 1.4 contain a summary of the interviews with the market players.

¹ For SE4, the calculation uses the 5 years 2012-2016 and the 20 quarters Q1-2012 – Q4-2016.

Question	Yes/For	No/Against
<i>Does your company use EPAD contracts?</i>	6	0
<i>Do your company clear all EPAD contracts at Nasdaq's clearing house? *)</i>	4 (one interviewee had filled in both boxes)	3 (one interviewee had filled in both boxes)
<i>Do your company sometimes participate at the PTR auctions for (some of) the following links DK1-DE, DK2-DE, DK1-DK2</i>	6	0
<i>Is your company for or against introduction of PTR/FTR auctions on the following interconnectors: DK1-SE, DK1-NO, DK2-SE</i>	5	1
<i>Do you find the present products or combination of products offered on forward markets represent a sufficient hedge against the volatility of the day-ahead price of in DK1?</i>	1	5
<i>Do you find the present products or combination of products offered on forward markets represent a sufficient hedge against the volatility of the day-ahead price of in DK2?</i>	1	5
<i>For DK1: do you find the present products or combination of products offered on forward markets are efficient?</i>	2	4
<i>For DK2: do you find the present products or combination of products offered on forward markets are efficient?</i>	2	4
<i>Do you find a System Price contract gives sufficient hedging against the spot price in DK1?</i>	0	6

<i>Do you find a System Price contract gives sufficient hedging against the spot price in DK2?</i>	0	6
<i>*) If "no": if possible, please give an estimate of the volume of contracts, which are cleared</i>	A range of 70% to 100% is stated.	
<i>If possible, can you please give an estimate of the percentage of your company's EPAD contracts, which are traded via Nasdaq's exchange?</i>	A range of 70% to 100% is stated.	

Table 1.3

	Increase	Decrease	No influence
<i>In your point of view, what influence have these PTR auctions had on the turn-over of EPADs for Eastern Denmark?</i>	5	0	1
<i>In your point of view, what influence have these PTR auctions had on the turn-over of EPADs for Western Denmark?</i>	5	0	1
<i>In your point of view, what influence have these PTR auctions had on the spreads of the EPAD for Eastern Denmark?</i>	1	4	1
<i>In your point of view, what influence have these PTR auctions had on the spreads of the EPAD for Western Denmark?</i>	1	4	1

Table 1.4 The introduction to the question was this: *From January 2014, there were PTR auctions on the Kontek interconnector linking Zealand and Germany. From July 2014, there were PTR auctions on the Great Belt interconnector linking Western and Eastern Denmark.*

Currently, there are PTR auctions for the Great Belt interconnector and the interconnectors linking Denmark and Germany. The data analysed in this investigation do not indicate any harm done to Nasdaq's EPAD system by the auctions.

The report *Methods for evaluation of the Nordic forward market for electricity* (ref. 4) has suggestions on how to investigate risk premiums and correlation between prices. This report uses the methods suggested in ref. 4. Further, this report has additional calculations of risk premiums and correlation of prices. This is because some of the methods suggested in ref. 4 do not reflect the world, in which the consumers and the market players operate.

2. Introduction

The Danish Energy Regulatory Authority (DERA) has asked Houmoller Consulting ApS to carry out an investigation of the hedging options at the Danish electricity market.

The background is the *Commission Regulation (EU) 2016/1719 of 26 September 2016*. This regulation establishes a guideline on forward capacity allocation.

According to the regulation, TSOs on a bidding zone border shall issue long-term transmission rights (LTTRs) unless the competent regulatory authorities of the bidding zone border have adopted coordinated decisions not to issue long-term transmission rights on the border.

The decision must be made per bidding zone border (i.e. not **one** decision for all bidding zone borders in a given region of Europe, for example). Further, for each bidding zone border, it's the affected national regulatory authorities/authority, which must decide on the issuing of LTTR rights (the regulation's article 30).

Apart from the Great Belt interconnector, there's currently no LTTR auctions inside the Nordic area. Therefore, in the spring 2017, the Nordic energy regulators will decide if LTTRs shall be issued for (some of) the interconnectors linking the Nordic countries.

In article 30, the regulation states that the decision on whether to issue LTTRs *shall be based on an assessment, which shall identify whether the electricity forward market provides sufficient hedging opportunities in the concerned bidding zones*.

Hence this investigation of the Danish power market.

3. The Danish electricity market

In 2015, the consumption was about 20 TWh in Western Denmark and 13 TWh in Eastern Denmark².

² Source: www.ens.dk.

	Consumption 2015 in TWh ³
Germany	521
Sweden + Norway	264
Nordic (Sweden+Norway+Finland+Denmark)	379

Table 3.1

Electrically, Denmark is a bridge between two electricity markets, which are much bigger than the Danish market, as can be seen from table 3.1. This gives Denmark special problems when it comes to the creation of a liquid financial market. The problems are exacerbated, because Denmark is split into two small bidding zones.

Denmark's interconnectors to neighbouring countries have large capacity compared with the Danish consumption. This means LTTR auctions is a possible way of providing hedging in DK1 and DK2.

According to a report from DERA, in 2015, about 76% of the electricity in Denmark was sold by means of fixed-price contracts⁴. Therefore, when studying the numbers in table 3.2, it must be noted that it's about 76% of the Danish consumption, which has a need for hedging. It is difficult to estimate the corresponding number for the Danish production, as this depends on the producers' risk management. For the renewables, it's also dependent on whether they are operating under a feed-in tariff system.

³ Source: ENTSO-E.

⁴ *Hvad kostede strømmen i 2015?* Report from DERA August 2016.

	Interconnector capacities	Sum of average interconnector capacities	Average load 2016	Estimated max. load 2016 (10-year winter equivalent)
DK1 ↔ NO2	1 632	2 932	2 276	3 660
DK1 → SE3	740			
SE3 → DK1	680			
DK1 → DK2	590			
DK2 → DK1	600	2 693	1 495	2 600
DK2 → SE4	1 700			
SE4 → DK2	1 300			
DK2 → DE	585			
DE → DK2	600			

Table 3.2 Interconnector capacities and average consumption 2016 for DK1 and DK2⁵.

All values in MW.

The capacities DK1↔DE are not included in the table, as the actual capacities offered at this border are fluctuating and much lower than the nominal capacity.

4. EEX and Nasdaq

4.1 Turnover at EEX and Nasdaq

At the start of the century, we had two big busts in the energy business. Enron went bankrupt December 2001. TXU Europe went into administration November 2002. After this, the US power companies left Europe. As can be seen from figure 4.1, Nasdaq never fully recovered from the crash in turnover, which was caused by these events.

In 2008, the financial crisis dealt a new blow to Nasdaq's turnover. Apart from a small uptick in 2016, Nasdaq's turnover of Nordic power derivatives has declined since the financial crisis.

⁵ Source for consumption: www.ens.dk. Source for capacities: ENTSO-E map of *maximum net transfer capacities* 15 February 2017. Source for estimated max. load: Energinet.dk's *Analyseforudsætninger 2016-2040* as of June 2016.

At EEX, the turnover also dipped after the financial crisis. In 2012, there was another dip in the turnover. However, since 2012, EEX's annual turnover has been steadily increasing.

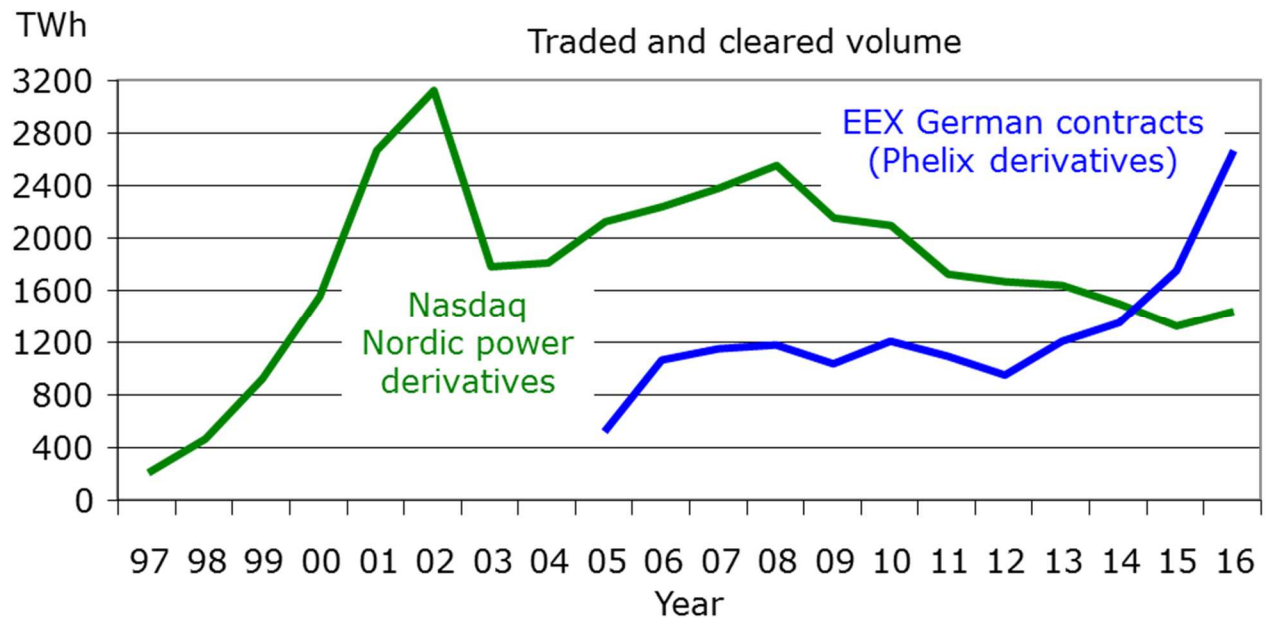


Fig. 4.1 Turnover of German contracts at EEX and turnover of Nordic power derivatives at Nasdaq⁶. For both EEX and Nasdaq, the figure illustrates the cleared volume: (contracts traded off-exchange and subsequently cleared) + (contracts traded at the exchange).

⁶ Sources: EEX press releases, Nasdaq press releases and Nasdaq/Nord Pool annual reports.



Fig. 4.2 Turnover of German contracts at EEX and turnover of Nordic power derivatives at Nasdaq during January. For both EEX and Nasdaq, the figure illustrates the cleared volume: (contracts traded off-exchange and subsequently cleared) + (contracts traded at the exchange).

The figures 4.2 and 4.3 illustrate the recent turnover at EEX and Nasdaq, respectively.

During February 2017, the turnover of EEX's German contracts were lower than during February 2016. Still, February 2017 was the next-best on record for the February turnover of EEX's German contracts.

January 2017 was the best on record for the January turnover of EEX's German contracts.

For EEX's German contracts, the combined turnover for January+February 2017 was the next-best on record for January+February.

For Nasdaq's Nordic contracts, the combined turnover for January+February 2017 was the lowest during the six years investigated (2012-2017).

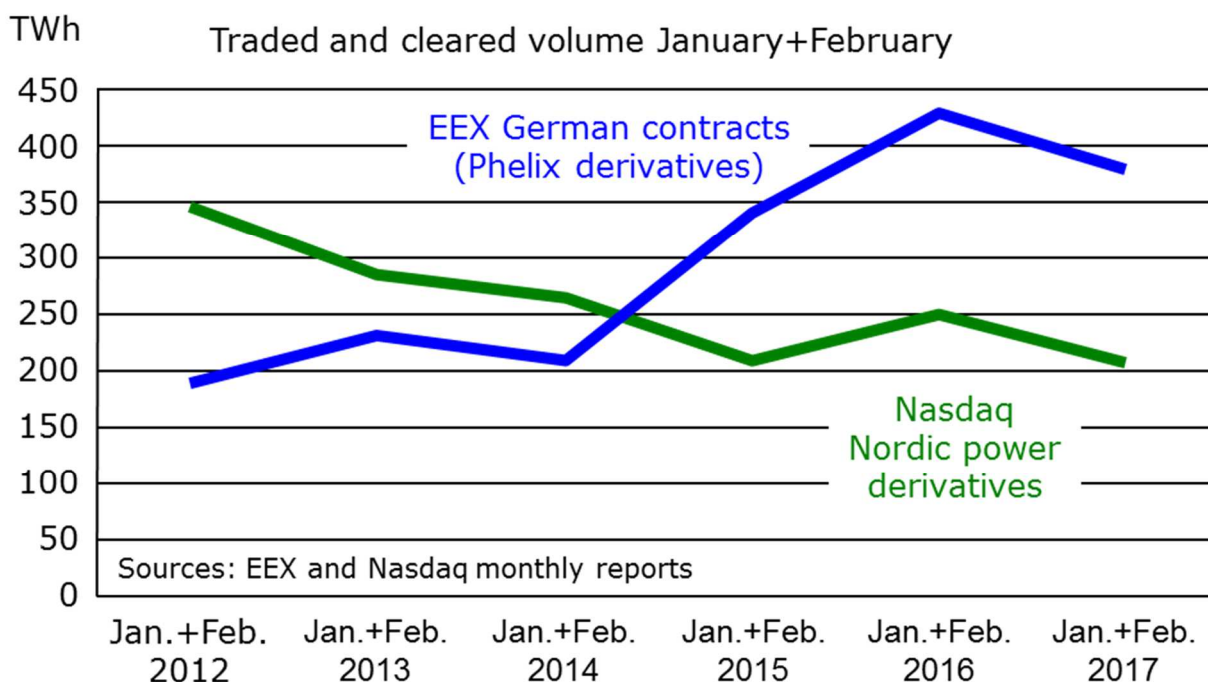


Fig. 4.3 Turnover of German contracts at EEX and turnover of Nordic power derivatives at Nasdaq during January and February combined. For both EEX and Nasdaq, the figure illustrates the cleared volume: (contracts traded off-exchange and subsequently cleared) + (contracts traded at the exchange).

4.2 Trading horizons

Nasdaq's System Price contracts have a trading horizon of about 10 years: you can trade System Price contracts for the 10 nearest calendar years. Nasdaq's Danish EPAD contracts have a trading horizon of about 3 years: you can trade the contracts for the 3 nearest calendar years.

EEX's German contracts have a trading horizon of about 6 years: you can trade the contracts for the 6 nearest calendar years. The time horizon for EEX's Location Spread contracts vary. A case: you can trade the Location Spread contracts Germany-France for the nearest 6 calendar years.

For the Great Belt interconnector, there have so far been only monthly PTR auctions.

For the interconnectors Denmark-Germany, there are monthly and annual PTR auctions. Currently, there are only monthly auctions in the direction DK1→DE, though.

5. The German power market

South of Denmark, you find EU's biggest electricity market. The German electricity market is very liquid, as can be seen from fig. 4.4. The combination of LEBA brokering and EEX's turnover gives a churn rate of more than 10. Hence, the German electricity market is a mature market, if you use the British energy regulator Ofgem's criterion (ref. 7).

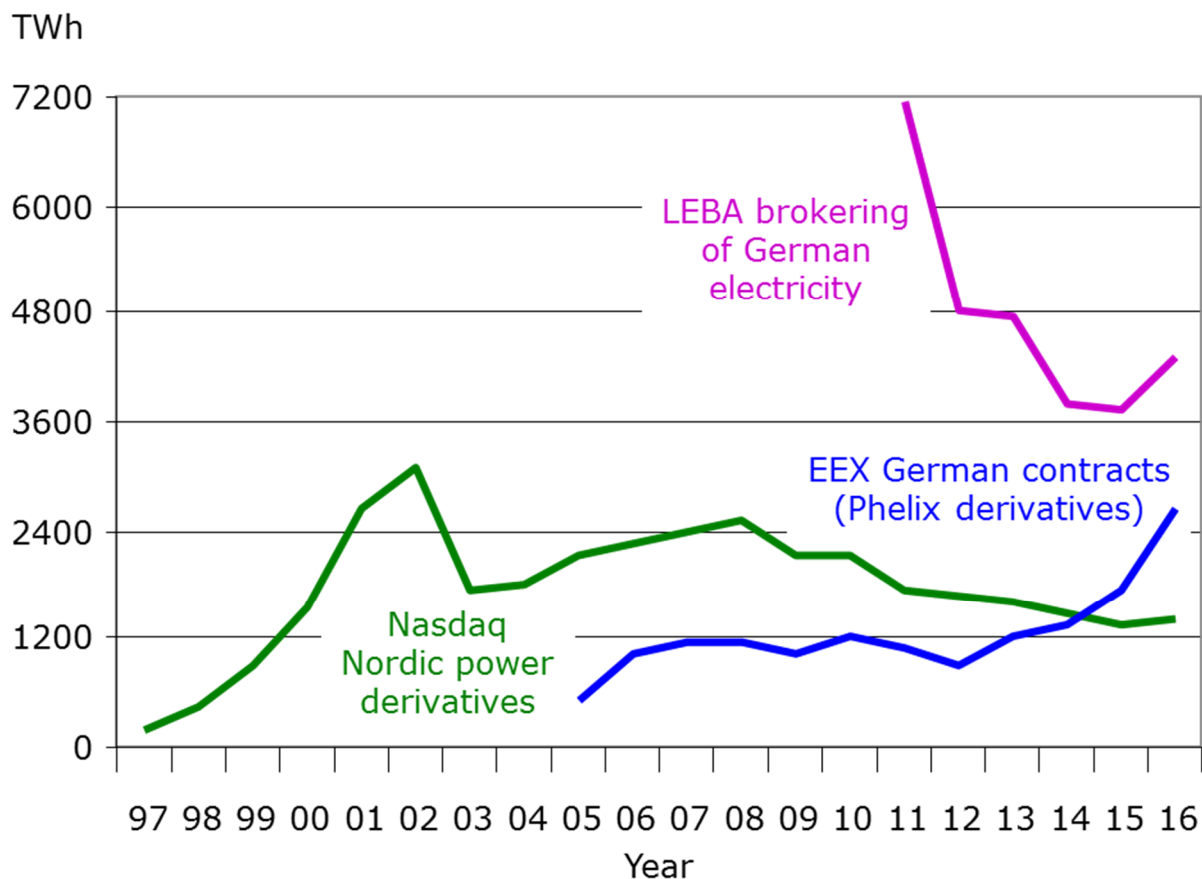


Fig. 4.4 Turnover of German contracts at EEX, turnover of Nordic power derivatives at Nasdaq and LEBA's brokering of German electricity⁷. For both EEX and Nasdaq, the figure illustrates the cleared volume: (contracts traded off-exchange and subsequently cleared) + (contracts traded at the exchange).

6. Hedging models

Currently, we have (at least) two European models for hedging and trading power derivatives.

⁷ Sources: EEX press releases, Nasdaq press releases, Nasdaq/Nord Pool annual reports and www.leba.org.uk. The LEBA data include all physical forward contracts for power arranged by the OTC brokers. The LEBA data do not include financially settled contracts for power.

6.1 Nasdaq's System Price model

One model, promoted by Nasdaq Commodities, is the so-called System Price model. As explained in appendix 1, the System Price is a virtual price. Nasdaq's System Price derivatives have this virtual price as the underlying.

For a bidding zone, where the spot price has high correlation with the System Price, a System Price contract can be used for proxy hedging. To qualify for hedge accounting, according to the IAS 39 accounting standard, the correlation coefficient between the System Price and the zone's spot price must be at least 0.8.

An EPAD contract can supplement the System Price contract for bidding zones, where the spot price does not have high correlation with the System Price. The EPAD contract hedges against the risk that there's a difference between the virtual System Price and the zone's spot price.

Hence, the Nasdaq model uses the System Price as the anchor for the hedging.

As illustrated in fig. 4.1, Nasdaq's turnover of Nordic power derivatives has dipped after 2002 and again after the financial crisis. However, many of Nasdaq's System Price contracts still have acceptable liquidity⁸.

However, for many Baltic-Nordic bidding zones, the liquidity of Nasdaq's EPAD contracts is low.

6.2 EEX's Location Spread model

Another model, promoted by EEX, uses the German spot price as the anchor for the hedging.

For example – you have hedge against the Dutch spot price if you enter into the following two contracts:

- * A German contract.
- * A Location Spread contract, where the underlying is the difference between the German and the Dutch spot prices (i.e. you hedge against the future price difference Germany – the Netherlands).

This model uses the fact that the German power market is very liquid, as illustrated by fig. 4.4.

Apparently, EEX does not publish aggregated data on the turnover of the Location Spread contracts. However, it seems as if EEX's Location Spread contracts currently suffer from the same problem as Nasdaq's EPAD contracts: the turn-

⁸ As can be seen from appendix 6: one of the interviewees points to the falling Nasdaq turnover and discusses if the Nordic power market is well functioning. The interviewee hopes introduction of PTR/FTR can stop the negative development of the liquidity.

over seems to be very low. Nevertheless, it takes only one glance at a map to realize why EEX has this vision: Germany is surrounded by countries, most of which are probably too small to establish liquid domestic financial power markets.

Country	Consumption 2015 in TWh
Austria	70
Belgium	85
Czech Republic	63
Denmark	32
France	475
Luxemburg	6
Netherlands	113
Poland	151
Switzerland	63

Table 6.1 Consumption for Germany's neighbouring countries 2015. Source: ENTSO-E.

EEX offers also Location Spread contracts, which have the difference between other spot prices as the underlying difference: France–Spain, the Netherlands–Belgium, Italy–France, and so forth.

With these contracts, EEX is using the price information from the LTTR auctions. At some points in time, the LTTR auctions provide a price signal for this kind of power derivatives. At the point in time, where you run the annual auction for a given border, you get the market's estimate of the next year's price difference at the border. Similarly for the monthly auctions. However, the next day the market may have another estimate of the future price difference.

Apparently, Nasdaq does not plan to use the price information from the auctions.

Via the PEGAS markets, EEX offers Location Spread contracts for the gas market. In 2015, according to the EEX annual report, 11 percent of the total volume on the PEGAS gas markets was generated from trading in Location Spreads.

7. Analysis of forward markets for hedging in Denmark

This chapter analyses the current hedging options in Denmark. For comparison, the chapter contains analyses of Germany and SE4 also.

7.1 Correlation between prices

For a given bidding zone, a System Price contract plus an EPAD contract hedge against the zone's spot price. This gives a perfect hedge, if we disregard the profile risk and the volume risk (which cannot be neglected in practice).

However, the liquidity for this system may be small and the risk premium may be high.

In this case, proxy hedging is an option. Instead of using
(System Price)+EPAD

a market player can enter into a contract, which does not have the local spot price as the underlying reference.

In the Nordic area, an alternative to (System Price)+EPAD is to have only the System Price as the underlying reference (i.e. use a System Price contract only). This is because there's still acceptable liquidity in many System Price contracts.

For a given bidding zone, with this proxy hedging, the correlation between the System Price and the zone's spot price becomes crucial. The proxy gives an acceptable hedge, if the correlation between the System Price and the zone's spot price constantly is high.

The report *Methods for evaluation of the Nordic forward market for electricity* (ref. 4) suggests investigating the correlation between long-term averages of the spot prices and the System Prices.

However, this does not reflect the world, in which the market players operate. As illustrated by the example in appendix 5, it's the correlation between the hourly prices, which must be high. Please also refer to the answers from the market players, which you find in appendix 8. The market players do not regard a System Price contract as a hedge against Danish spot prices, although there is high correlation between the annual averages of the Danish spot prices and the System Prices.

For sake of completeness, the correlations between monthly averages and annual averages are first displayed, though (table 7.1 and 7.2).

Correlation between average annual prices for the ten years 2007-2016		
Danish bidding zone	System Price	Germany
DK1	0.90	0.94
DK2	0.96	0.85

Table 7.1 The green numbers give the correlation between the annual averages of the System Price and the annual averages of the spot prices of DK1 and DK2. The red numbers give the correlation between the annual averages of the German spot price and the annual averages of the spot prices of DK1 and DK2. For the ten years 2007-2016, the correlation between the annual averages of the System Price and the annual averages of the German spot prices was 0.71.

Correlation between average monthly prices			
Year	DK1	DK2	SE4
2007	0.86	0.87	-
2008	0.66	0.73	-
2009	0.82	0.53	-
2010	0.62	0.94	-
2011	0.76	0.70	-
2012	0.73	0.75	0.95
2013	0.34	0.69	0.80
2014	0.39	0.47	0.59
2015	0.88	0.85	0.96
2016	0.90	0.91	0.94

Table 7.2 The green numbers give the correlation between the monthly averages of the System Price and the monthly averages of the spot prices of DK1, DK2 and SE4. The Swedish bidding zone SE4 was established 1 November 2011.

7.2 Correlation between hourly prices

The rest of this report discusses correlation between hourly prices.

As can be seen from table 7.3: in SE4, you cannot use the German spot price for proxy hedging. Further, neither in Germany nor in Denmark can you use the System Price for proxy hedging. The latter corresponds with the fact that you'd have difficulties finding an accountant or a market player, who would regard a System Price contract as a good hedge against the Danish spot prices.

In appendix 8, all the answers to the questionnaire point out that a System Price contract does not hedge against the Danish spot prices. One of the answers bring data from the event 7 June 2013. This event illustrates the point that a System Price contract does not provide hedging in the Danish price zone. Further, the event is a practical example of the point made in appendix 5: what matters is the correlation between the hourly prices.

Correlation between hourly prices				
Year	DK1		DK2	
	System Price	Germany	System Price	Germany
	SE4		Germany	
	System Price	Germany	System Price	Germany
2007	0.49	0.71	0.51	0.68
2008	0.65	0.76	0.67	0.74
2009	0.68	0.67	0.53	0.33
2010	0.54	0.87	0.65	0.27
2011	0.53	0.81	0.48	0.83
2012	0.61	0.79	0.68	0.77
2013	0.21	0.20	0.72	0.77
2014	0.62	0.73	0.68	0.70
2015	0.67	0.59	0.67	0.55
2016	0.75	0.81	0.84	0.70
2007-2016⁹	0.53	0.61	0.65	0.55

Table 7.3 The green and blue numbers give the correlation between the hourly System Prices and the hourly spot prices of DK1, DK2, SE4 and Germany.
The red numbers give the correlation between the hourly spot prices of Germany and the hourly spot prices of DK1, DK2 and SE4.
The Swedish bidding zone SE4 was established 1 November 2011.

⁹ For SE4, it is the correlation during the five years 2012 - 2016.

For comparison, for the years 2013–2016, table 7.4 gives the correlation between the System Prices and the spot prices of the Baltic-Nordic bidding zones.

Correlation between hourly prices															
Year	SE1	SE2	SE3	SE4	FI	DK1	DK2	NO1	NO2	NO5	NO3	NO4	EE	LV	LT
2013	0.89	0.89	0.87	0.83	0.67	0.21	0.72	0.94	0.93	0.94	0.93	0.94	0.47	-	0.33
2014	0.79	0.79	0.79	0.77	0.63	0.62	0.68	0.82	0.81	0.79	0.77	0.77	0.54	0.44	0.44
2015	0.92	0.91	0.89	0.84	0.48	0.67	0.67	0.94	0.94	0.94	0.93	0.92	0.46	0.18	0.18
2016	0.85	0.85	0.88	0.88	0.79	0.75	0.84	0.92	0.89	0.87	0.91	0.87	0.76	0.56	0.54

Table 7.4 The green numbers give the correlation between the hourly System Prices and the hourly spot prices of the Baltic-Nordic bidding zones.
Latvia's spot quotation was launched June 2013.

7.3 Spot prices and hedging prices – risk premium

For Nasdaq's Nordic power derivatives, the ex-post risk premium may be seen as the sum of a contribution from Nasdaq's System Price contract and a contribution from Nasdaq's EPAD contract.

To see this, let's adopt the following terminology:

P_{spot} Spot price for the bidding zone in question.

P_{system} System Price.

P_{SYS} Hedging price of System Price contract.

P_{EPAD} Hedging price of EPAD contract for the bidding zone in question.

R Ex-post risk premium. In this document, the following is the definition of the ex-post risk premium ("risk premium" in short version of the term)

$$R = P_{\text{spot}} - (P_{\text{SYS}} + P_{\text{EPAD}}).$$

Hence, a negative value is "negative" for consumers preferring fixed-price electricity contracts.

R_{SYS} System Price contract's contribution to ex-post risk premium

$$R_{\text{SYS}} = P_{\text{system}} - P_{\text{SYS}}.$$

R_{EPAD} EPAD contract's contribution to ex-post risk premium

$$R_{\text{EPAD}} = (P_{\text{spot}} - P_{\text{system}}) - P_{\text{EPAD}}.$$

$$\begin{aligned}
 R &= P_{\text{spot}} - (P_{\text{SYS}} + P_{\text{EPAD}}) \\
 &= P_{\text{system}} - P_{\text{system}} + P_{\text{spot}} - P_{\text{SYS}} - P_{\text{EPAD}} \\
 &= (P_{\text{system}} - P_{\text{SYS}}) + (P_{\text{spot}} - P_{\text{system}}) - P_{\text{EPAD}} \\
 &= R_{\text{SYS}} + R_{\text{EPAD}}.
 \end{aligned}$$

The analysis investigates if there's a systematic difference between the spot prices and the hedging prices of the forwards. If there are such systematic differences, this amounts to a risk premium for either the consumers or the producers.

The analysis calculates the so-called ex-post risk premium. The calculation is based on a comparison of the spot prices and the forwards' closing prices.

7.4 Calculating risk premiums

The report *Methods for evaluation of the Nordic forward market for electricity* (ref. 4) suggests calculating the ex-post risk premium separately for year and month contracts, based on a comparison of the spot prices and the forwards' last closing price before the contracts go to delivery.

In the analysis, using the last closing price before delivery is easy. However, this does not reflect how the market players hedge their positions: for hedging, very few players would wait until the last trading day before the delivery period.

The regulation requires an investigation of hedging (ref. 2). Hence, the calculation of risk premiums must model hedging as closely as possible.

However, for sake of completeness, this chapter shows how the risk premiums would look, if all hedging was done the last trading day before delivery.

The following chapters show how the risk premiums look, when calculate the risk premiums by modelling hedging.

	DK1	DK2	SE4 ¹⁰	Contribution from System Price contracts
Quarter contracts The 44 quarters Q1-2006 – Q4-2016	-3.4	-3.6	-1.9	-1.6
Annual contracts The 15 years 2002 – 2016	-3.3	-3.2	-5.1	-1.6

Table 7.5 For the period indicated in the first column, the numbers give the average ex-post risk premium in €/MWh.
 Using the quarters as an example: for each quarter, the risk premium is calculated as

$$(\text{quarter's forward price}) - (\text{quarter's average spot price})$$

 The forward price is the closing price/daily fix of the contract's last trading day.

7.5 Calculating risk premiums by modelling hedging

For the rest of this report, the risk premiums are calculated by modelling hedging.

Concerning modelling hedging: you may note the rule for the prices used by "*forsyningspligtselskaber*" (suppliers of last resort) uses the average of the closing prices during the last quarter before delivery (excluding the quarter's last 10 trading days).

Therefore, for the quarter contracts, the analysis uses this hedging rule: the spot prices are compared with the average of the closing prices during the last quarter before delivery (excluding the quarter's last 10 trading days). This average is compared with the actual spot prices. Historically, in Denmark, *forsyningspligtselskaberne* supplied a large part of the electricity. Therefore, this method investigates the hedging prices for a large part of the electricity sold in Denmark.

For the annual contracts, the spot prices are compared with the average of the closing prices during the last quarter before delivery (**not** excluding the quarter's last 10 trading days). This is because, according to the market players,

¹⁰ For SE4, the calculation uses the 5 years 2012-2016 and the 20 quarters Q1-2012 – Q4-2016.

the annual fixed-price contracts are normally signed during the last quarter before delivery. There's no rule indicating the last 10 work days before delivery should be excluded from the averaging.

Further, as described in appendix 4, for the Danish electricity market, the important derivatives are the annual and the quarter contracts. Hence, the analysis compares the spot prices and the hedging prices of the annual and the quarter contracts.

As described in appendix 1, the System Price is a virtual price. Therefore, it does not make sense to discuss the risk premium for Nasdaq's System Price contracts. However, you can discuss the System Price contracts' **contribution** to the risk premium.

	DK1	DK2	SE4 ¹¹	Contribution from System Price contracts	Germany ¹²
Quarter contracts The 44 quarters Q1-2006 – Q4-2016	-5.03	-4.40	-3.56	-2.51	-
Annual contracts The 15 years 2002 – 2016	-3.60	-3.11	-7.21	-1.66	-3.45

Table 7.6 For the period indicated in the first column, the numbers give the average ex-post risk premium in €/MWh.

Using the quarters as an example: for each quarter, the risk premium is calculated as

(quarter's forward price) – (quarter's average spot price)

The forward price is calculated as the average of the closing prices during the last quarter before delivery (excluding the last 10 trading days).

For the annual contracts, the forward price for each year is calculated as the average of the closing prices during the last quarter before delivery.

¹¹ For SE4, the calculation uses the 5 years 2012-2016 and the 20 quarters Q1-2012 – Q4-2016.

¹² For this report, the German quarter contracts were not investigated. A previous analysis made by Houmoller Consulting for the 28 quarters from Q1-2006 to Q4-2012 showed a German ex-post retailer risk premium for this period of 6.0 €/MWh

As can be seen from table 7.6: for the quarter contracts for DK1, DK2 and SE4, more than 50% of the risk premium can be traced to the System Price contracts.

For the annual contracts for DK1/DK2, a little less/more than 50% of the risk premium can be traced to the System Price contracts. For SE4, the EPAD contracts provide the main part of the risk premium.

As can be seen from fig. 4.1: there were several years, where EEX's turn-over of German contracts was modest. However, recently EEX has enjoyed increasing turnover for the German contracts. The average risk premium for the annual German contracts during the two years 2015-2016, where EEX's turnover of German contracts was bigger than Nasdaq's turnover of Nordic power derivatives, was -1.5 €/MWh. During the same two years, the System Price contracts' average contribution to the annual contracts' risk premium was -2.3 €/MWh.

7.6 Student's t test for the quarter contracts

You may investigate the statistical significance of the risk premiums. For this purpose, let's use the following terminology:

$MEAN_{forward}$ the mean of the quarters' forward prices.
 Here, for each quarter, the forward price is calculated as in table 7.6.

$MEAN_{spot}$ the mean of the quarters' spot prices.

Hypothesis H: $MEAN_{forward} \leq MEAN_{spot}$

The hypothesis H can be rejected with the confidence indicated in table 7.7.

For example, a confidence of more than 99% means the risk of rejecting a true hypothesis is less than 1%.

Quarter contract	DK1	DK2	SE4
Reject H with confidence more than	99.5%	99.0%	97.5%

Table 7.7

Example – DK1

The analysis above is based on the years 2006-2016. Assume the electricity market in DK1 the following years would more-or-less look like the market we had during these 11 years. In this case, we can say with more than 99.5% confidence that on the average the quarterly forward prices will be higher than the average spot prices.

However, we know the electricity market will change a lot. Hence, in this case, the student's t-test is of limited value.

7.7 Student's t test for the annual contracts

For the annual contracts, we have only 15 elements in each sample: the average spot prices and the hedging prices for the years 2002-2016. Further, the spread of each sample is large. You cannot get statistical significance for small samples with large spreads.

Among all the investigated contracts, the SE4 annual contract has the largest risk premium. However, there's only 5 elements in the sample.

7.8 The risk premiums in course of time – the annual contracts

This chapter illustrates the annual contracts' risk premiums during the 15 years 2002-2016. (It's other periods for SE4 and Germany, though.)

The red lines show an attempt to run linear regressions on the numbers from these 15 years. However, probably there is no trend – neither for Nasdaq's Danish contracts nor for the contribution from Nasdaq's System Price contracts. Probably, there are only fluctuations around negative means. This is indicated by the fact that the attempts to run linear regressions give lines sloping downwards for the annual contracts and sloping upwards for the quarter contracts.

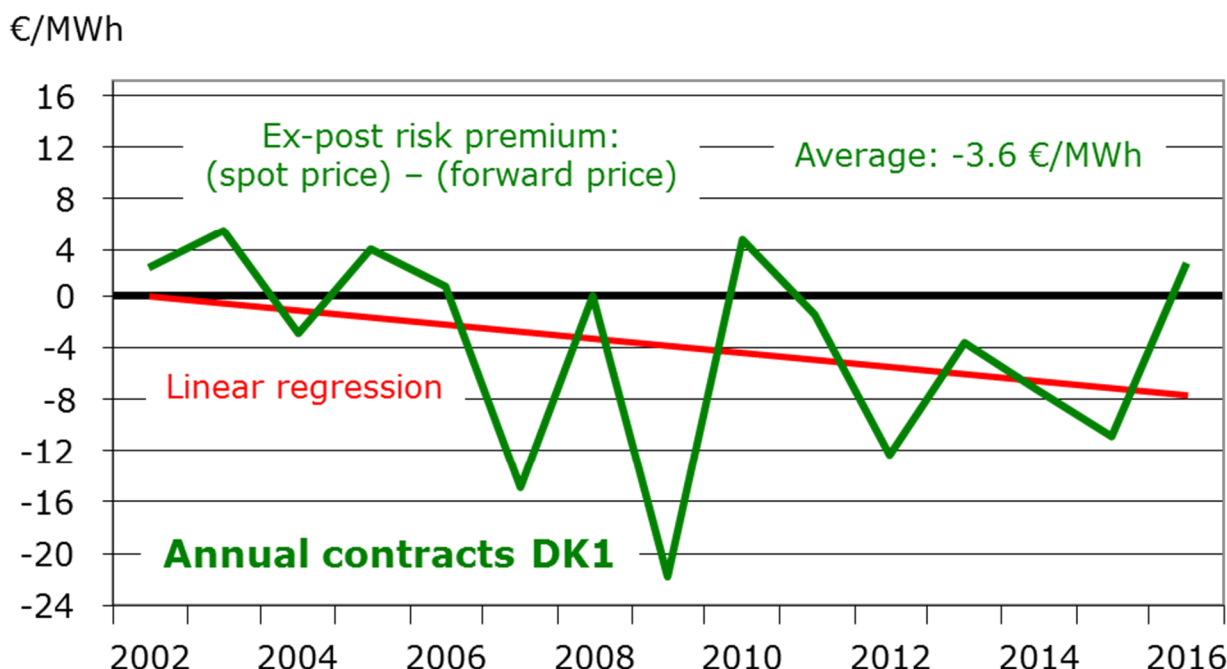


Fig. 7.1 The risk premium for DK1 annual contracts. The forward price is calculated as indicated in table 7.6.

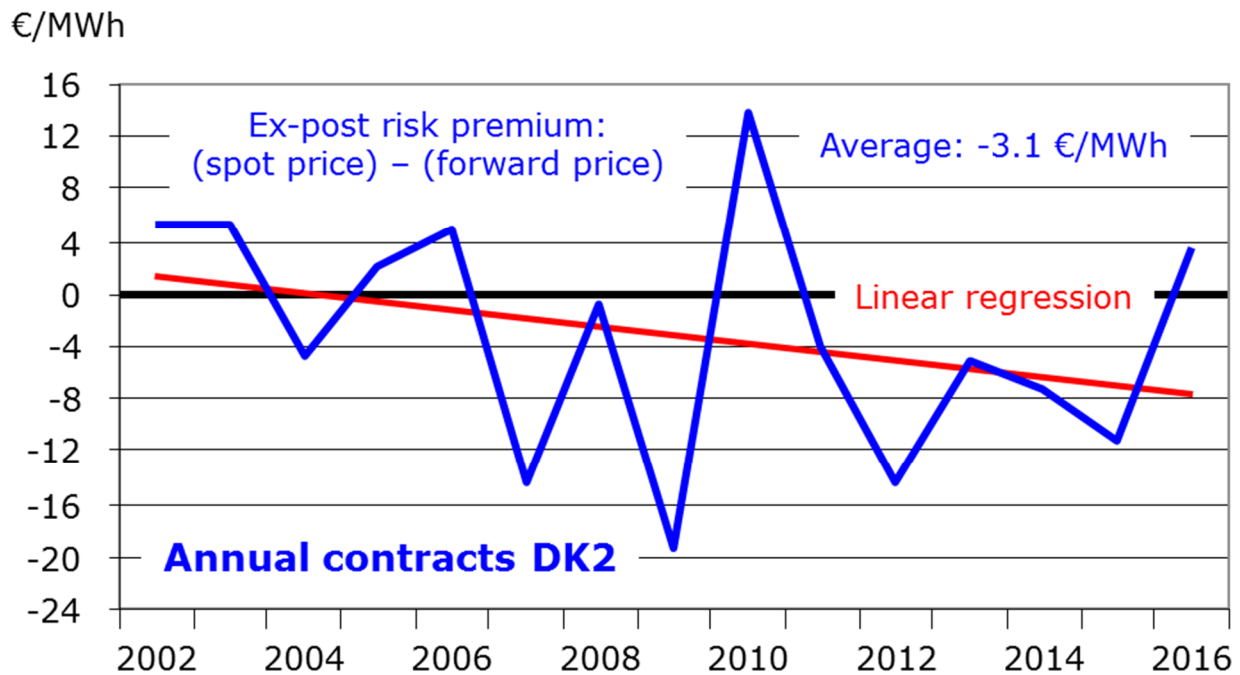


Fig. 7.2 The risk premium for DK2 annual contracts. The forward price is calculated as indicated in table 7.6.

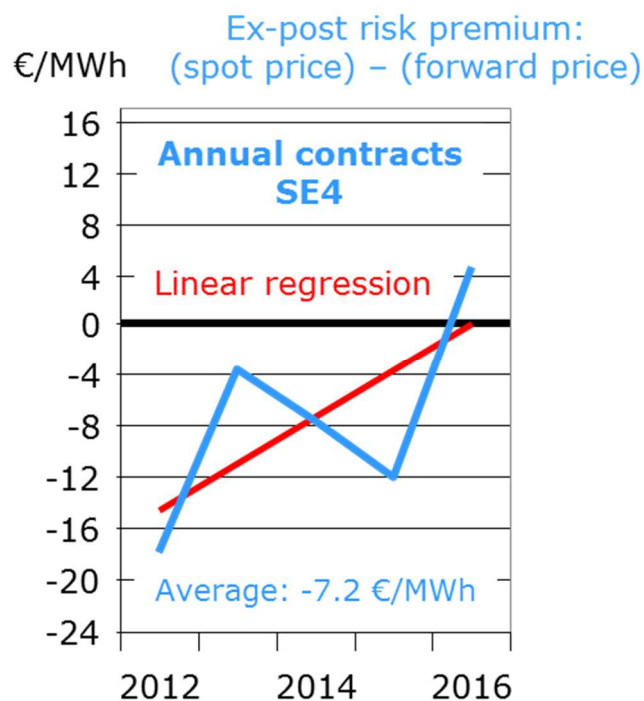


Fig. 7.3 The risk premium for SE4 annual contracts. The forward price is calculated as indicated in table 7.6.

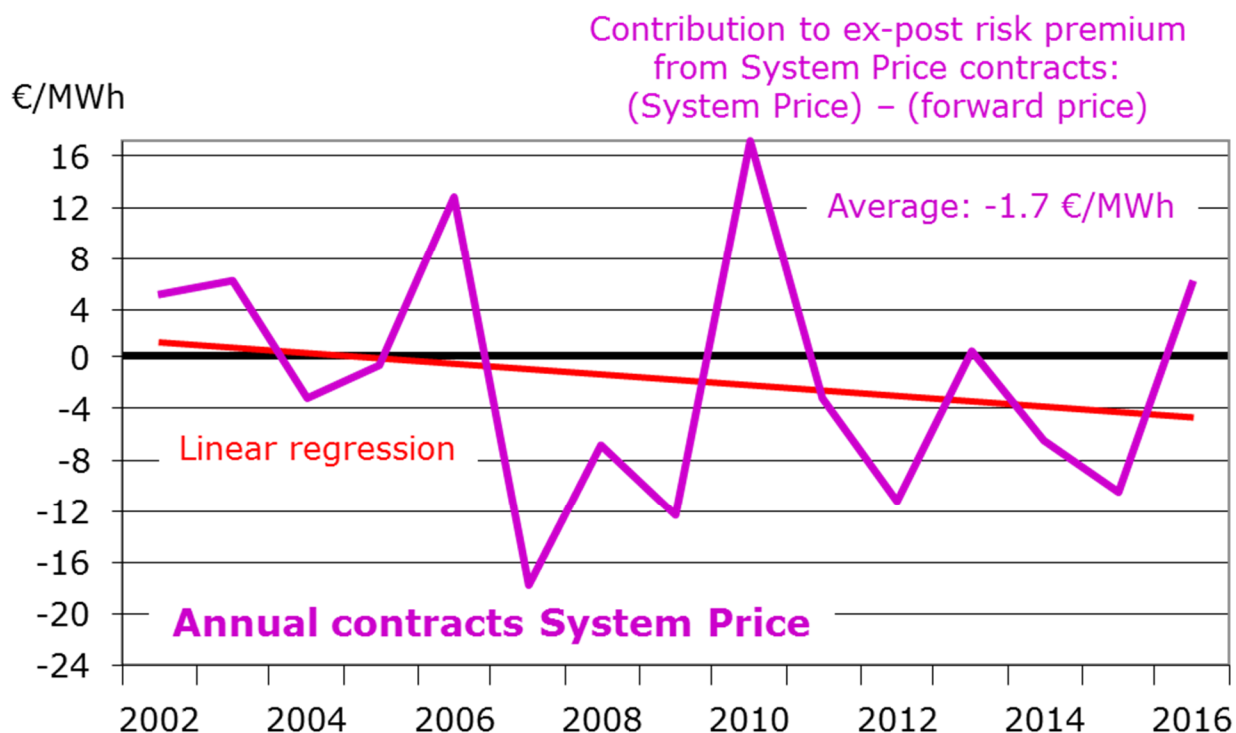


Fig. 7.4 The System Price contracts' contribution to the annual contracts' risk premium. The forward price is calculated as indicated in table 7.6.

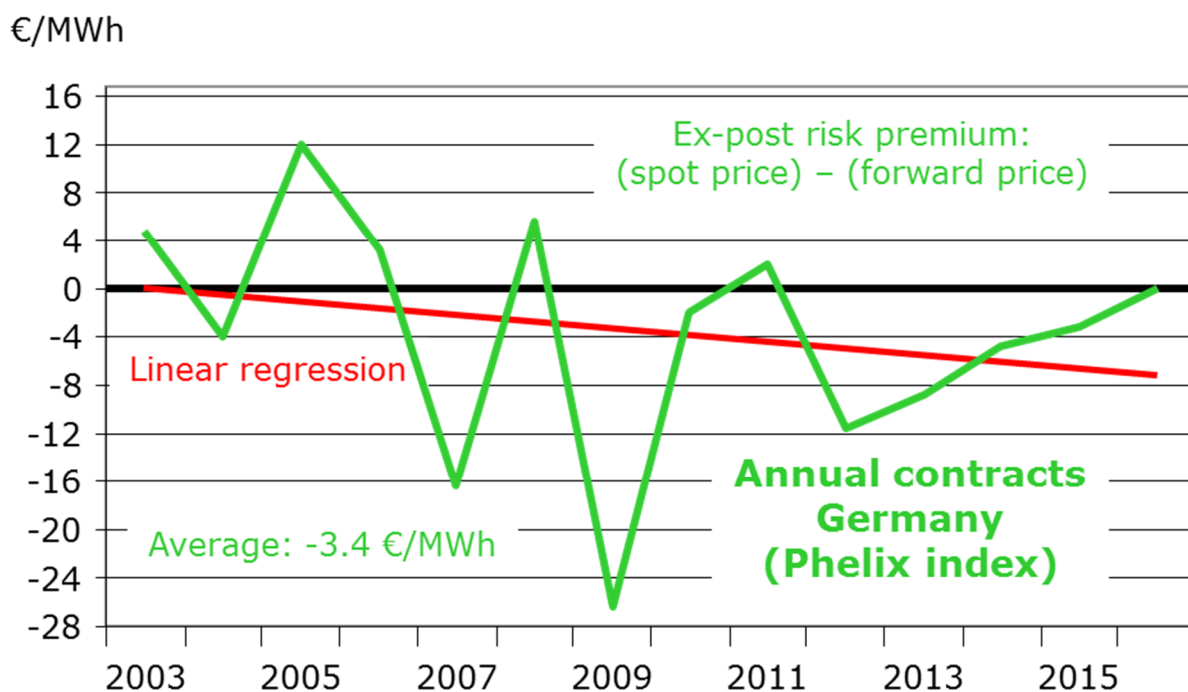


Fig. 7.5 The risk premium for German annual contracts. The forward price is calculated as indicated in table 7.6.

7.9 The risk premiums in course of time – the quarter contracts

This chapter illustrates the quarter contracts' risk premiums during the 44 quarters from Q1-2006 to Q4-2016.

For SE4, it's the 20 quarters from Q1-2012 to Q4-2016, though.

The red lines show an attempt to run a linear regression. However, as noted above, probably there is no trend – only fluctuations around a negative mean.

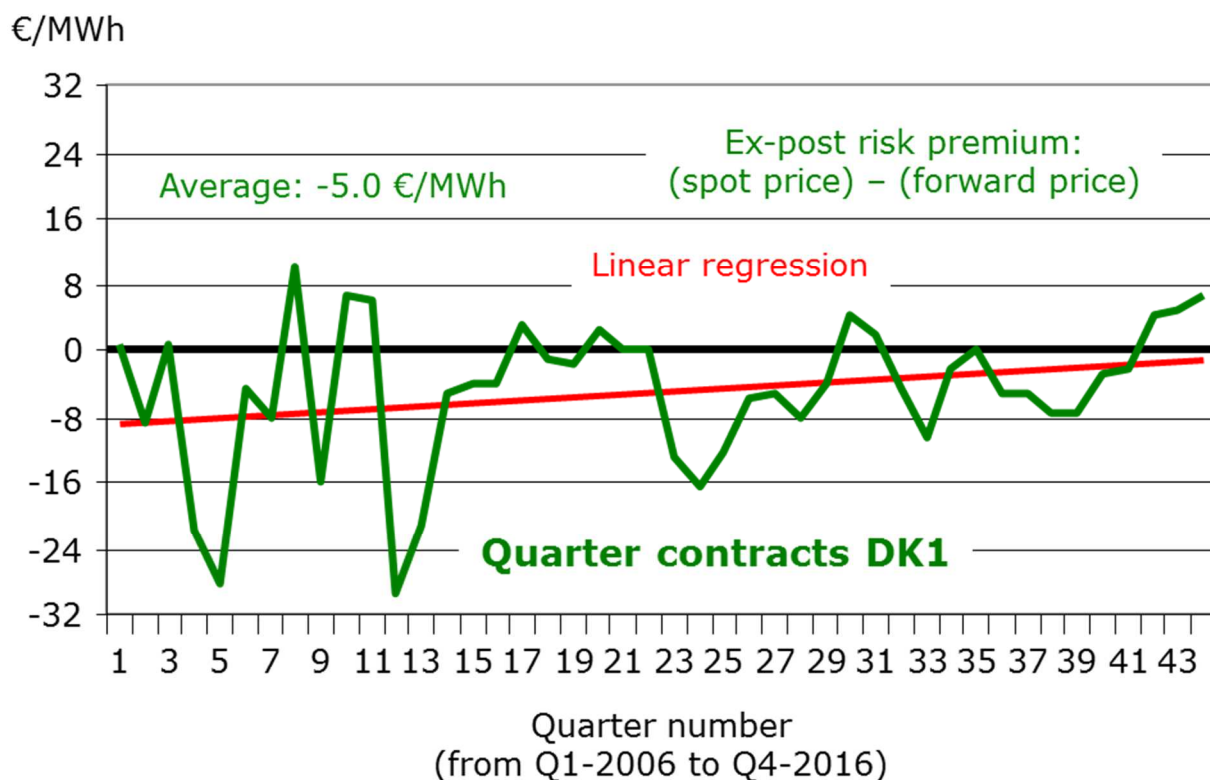


Fig. 7.6 The risk premium for DK1 quarter contracts. The forward price is calculated as indicated in table 7.6.

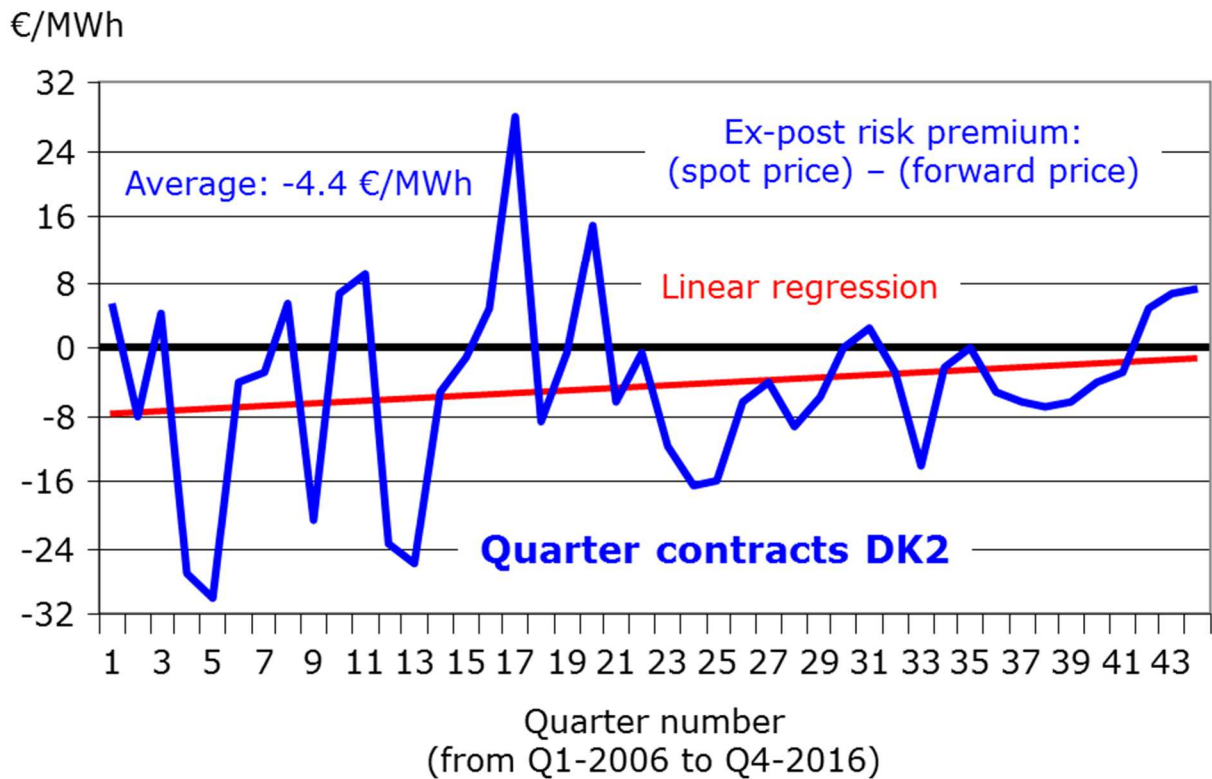


Fig. 7.7 The risk premium for DK2 quarter contracts. The forward price is calculated as indicated in table 7.6.

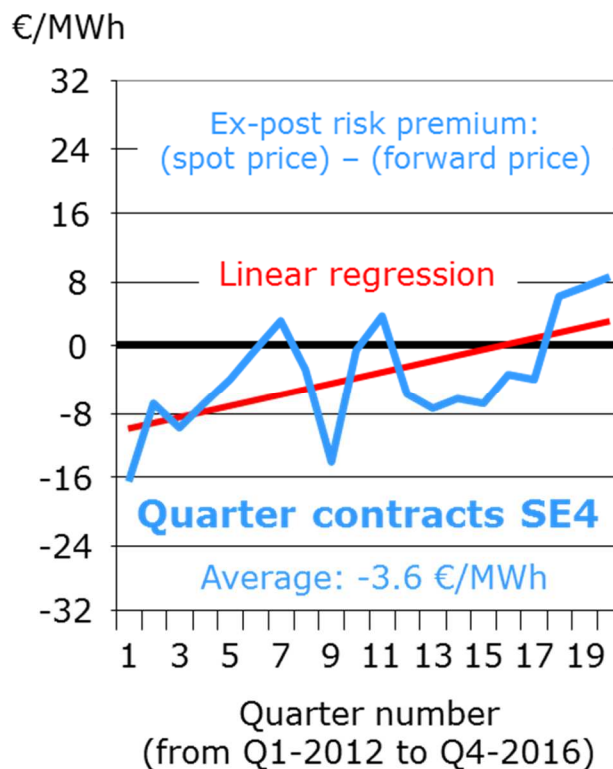


Fig. 7.8 The risk premium for SE4 quarter contracts. The forward price is calculated as indicated in table 7.6.

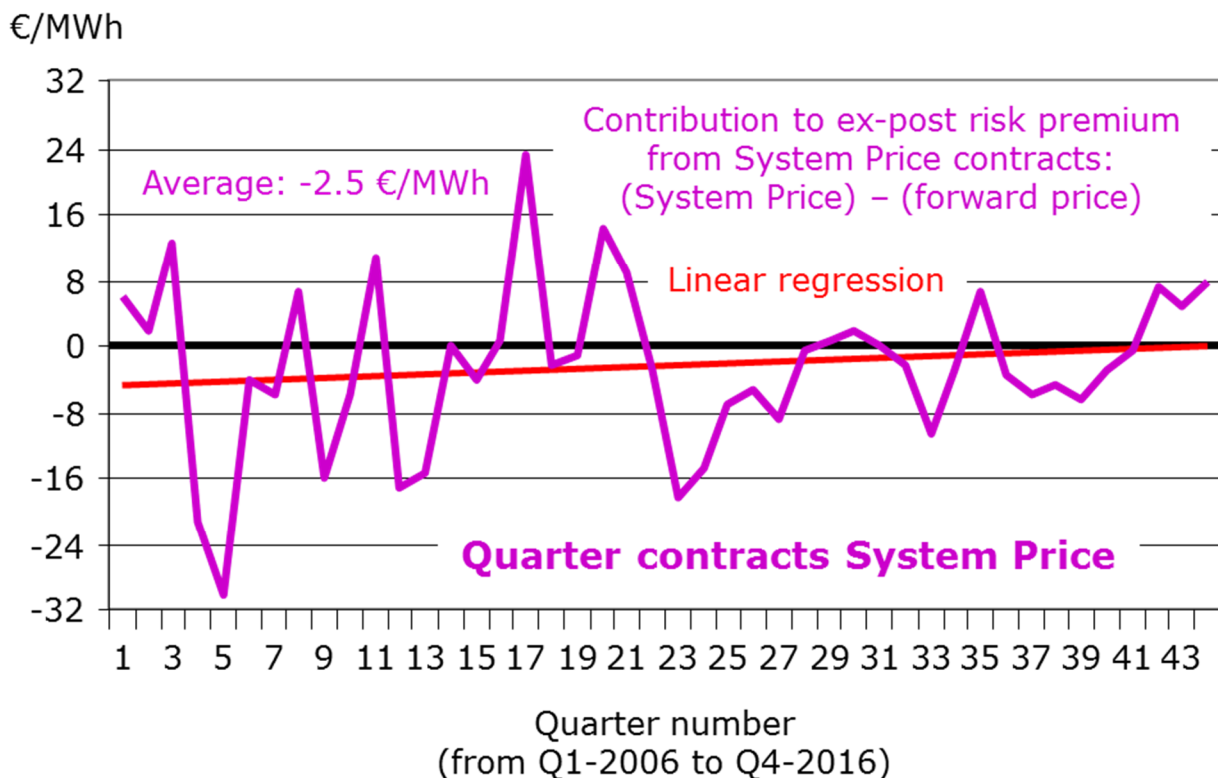


Fig. 7.9 The System Price contracts' contribution to the quarter contracts' risk premium. The forward price is calculated as indicated in table 7.6.

7.10 Liquidity

There is no general accepted measure of liquidity. In the paper *Liquidity in the GB wholesale energy markets*¹³, the British regulator Ofgem writes: *Liquidity is an important feature of a well functioning market. We can define liquidity as the ability to quickly buy or sell a desired commodity or financial instrument without causing a significant change in its price and without incurring significant transaction costs. A key feature of a liquid market is that it has a large number of buyers and sellers willing to transact at all time.*

For power derivatives, there are several potential indicators of liquidity. For a given contract, you may consider the contract's:

- * Open Interest (compared with the consumption).
- * Turnover (compared with the consumption).
- * Spreads.

In this paper, the two first indicators will be called volume indicators of liquidity.

¹³ Ref. 3.

7.10.1 Volume indicators of liquidity

Concerning hedging: as can be seen from table 7.4, for some Norwegian bidding zones, the correlation between the local spot price and the System Price is so high the players may use Nasdaq's System Price contracts only (i.e. proxy hedging).

However, as discussed in the chapters 7.1 and 7.2, this is not the case for Denmark (nor for the Baltic States). Danish players use the System Price contracts for speculation. However, for hedging both an EPAD contract and a System Price contract is needed. For a Danish player, the hedging price has the two components discussed in chapter 7.3:

$$\text{Hedging price} = (\text{hedging price of EPAD contract}) + (\text{hedging price of System Price contract})$$

Therefore, when investigating the volume of Danish hedging done by means of Nasdaq's power derivatives, we need only focus on Nasdaq's EPAD contracts.

The total cleared volume for each EPAD contract was not available for this investigation. Therefore, we are left with the EPAD contracts' OI and exchange turnover as the volume indicators of liquidity. However, as can be seen from the answers in the questionnaires, a large percentage of the Danish EPAD contracts seems to be traded via Nasdaq's exchange.

Concerning these volume indicators (OI and exchange turnover): there are not agreed thresholds, beyond which a market is considered "liquid". In a study of the European gas markets, for one of the markets investigated, *Oxford Institute for Energy Studies* writes it's *poor* that this market's turnover is only a factor of 1.77 bigger than the consumption (ref. 5). As can be seen from the figures in this chapter and from the tables in appendix 11, the exchange turnover of Nasdaq's Danish EPADs are nowhere near this factor.

In general, as can be seen from the figures in this chapter and the tables in appendix 11: even though we do not have agreed thresholds, it's hard to claim there's liquidity. Both the OI and the exchange turnover indicate very low liquidity for Nasdaq's Danish EPAD contracts.

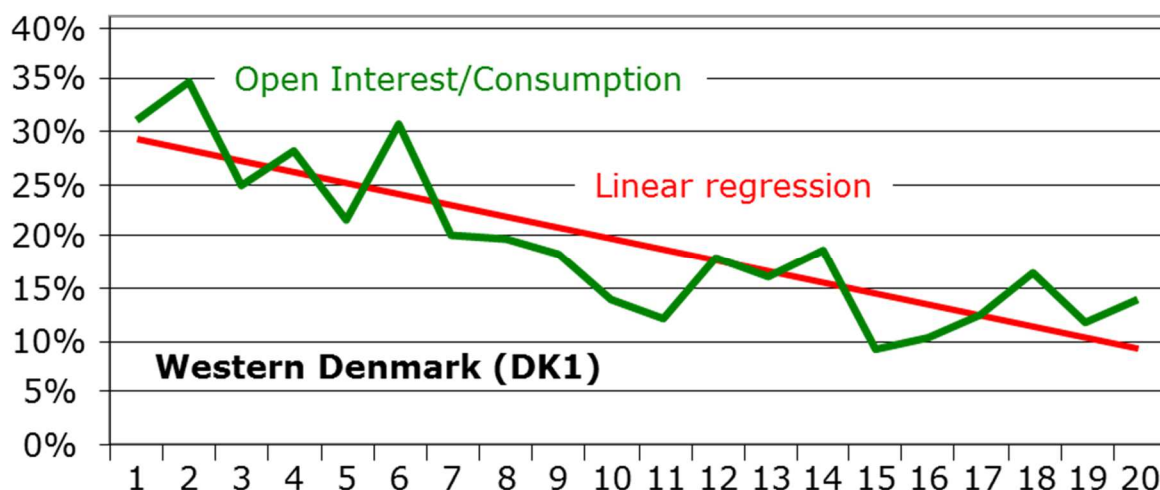


Fig. 7.10 (Open Interest)/Consumption for DK1 quarter EPAD contracts. Data for the 20 quarters from Q1-2012 to Q4-2016. Open Interest one of the last three trading days before delivery. Due to the cascading of the annual contracts, this contains the contribution from both annual and quarter contracts.

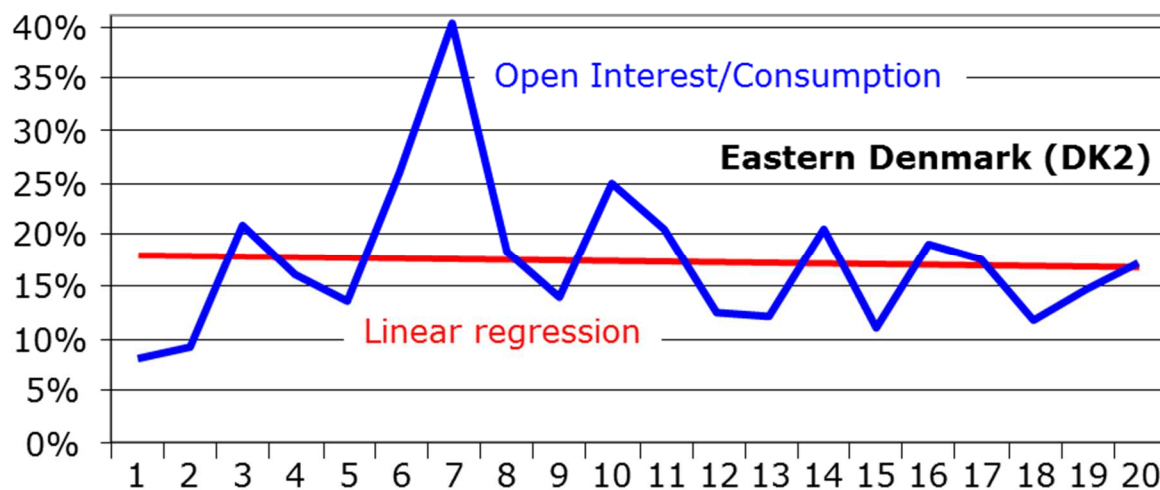


Fig. 7.11 (Open Interest)/Consumption for DK2 quarter EPAD contracts. Data for the 20 quarters from Q1-2012 to Q4-2016. Open Interest one of the last three trading days before delivery. Due to the cascading of the annual contracts, this contains the contribution from both annual and quarter contracts.

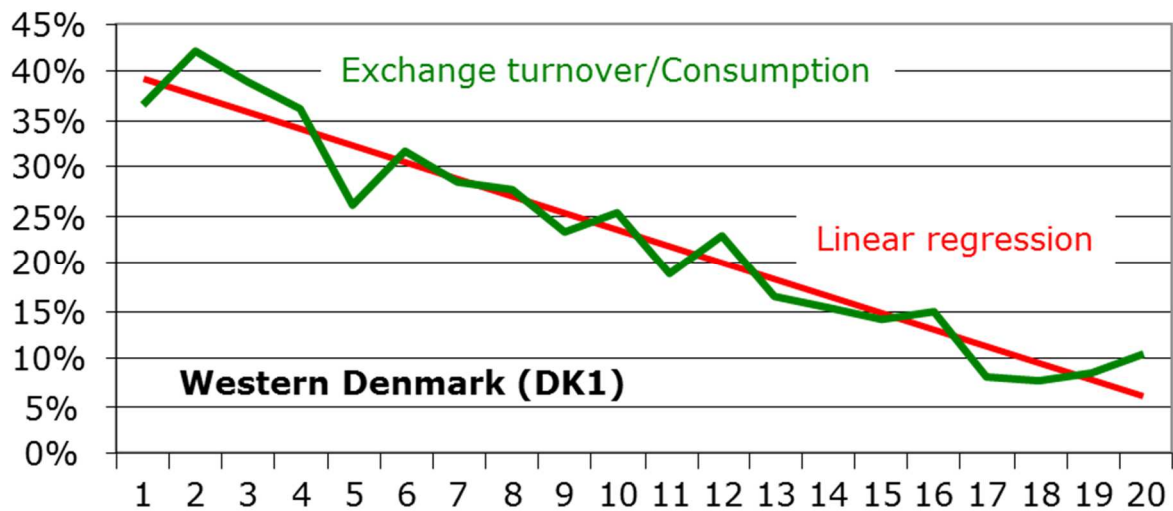


Fig. 7.12 (Exchange turnover)/Consumption for DK1 EPADS. Data for the 20 quarters from Q1-2012 to Q4-2016.
 For each quarter, this is the turnover for both the quarter contract and the corresponding annual contract. The contribution from the annual contracts is calculated as described in the footnote of the table in appendix 11.

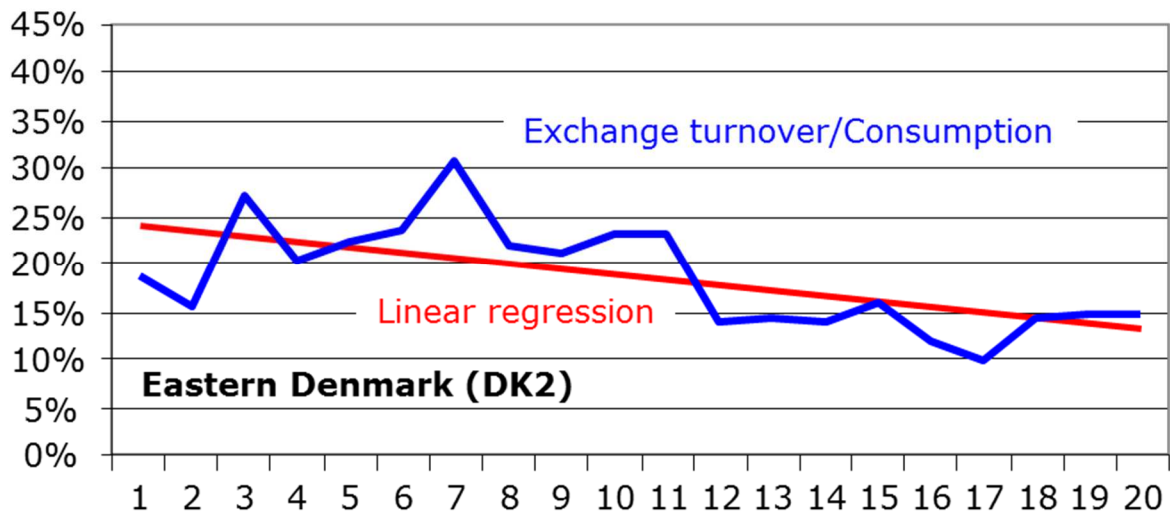


Fig. 7.13 (Exchange turnover)/Consumption for DK2 EPADS. Data for the 20 quarters from Q1-2012 to Q4-2016.
 For each quarter, this is the turnover for both the quarter contract and the corresponding annual contract. The contribution from the annual contracts is calculated as described in the footnote of the table in appendix 11.

7.10.2 Spreads

The spreads can also be used as a measure of liquidity. Again, we have the problem that there's no agreed level, beyond which a market is considered "liquid". However, we can study the **development** of the spreads.

Average spreads of Nasdaq's quarterly EPADs for DK2	
Before introduction of PTR on the Kontek interconnector ¹⁴	0.60 €
After introduction of PTR on the Kontek interconnector ¹⁵	0.60 €

Table 7.8

As can be seen from table 7.8: the spreads for Nasdaq's quarterly DK2 EPADs have remained the same after the introduction of PTR auctions on the Kontek interconnector.

During the period 2012-2016, as a percentage of the consumption, both the OI and the exchange turnover of Nasdaq's DK2 quarterly EPADs have a falling trend, as illustrated above.

Seen in the light of this falling trend it's remarkable that the spreads have not deteriorated. We cannot know if this is connected to the introduction of PTRs on the Kontek interconnector. However, a majority of the interviewees indicate the PTRs have had a positive influence on the spreads.

For comparison, table 7.9 gives the same data for DK1. Although DK1 and DK2 are connected via the Great Belt interconnector, we must assume the Kontek PTR auctions are less important for DK1.

¹⁴ This is the average spreads of the 9 quarter contracts SYCHPQ1-2012, ..., SYCHPQ1-2014. Note that the latter contract was mainly traded before the start of the Kontek PTR auctions.

¹⁵ This is the average spreads of the 11 quarter contracts SYCHPQ2-2014, ..., SYCHPQ4-16.

Average spreads of Nasdaq's quarterly EPADs for DK1	
Before introduction of PTR on the Kontek interconnector ¹⁶	0.45 €
After introduction of PTR on the Kontek interconnector ¹⁷	0.50 €

Table 7.9

For DK1, there's another important development during the period 2012-2016: the capacity offered at the PTR auctions DK1-Germany has been reduced significantly. This is indicated by data from both the Joint Allocation Office and Energinet.dk.

According to data from Energinet.dk, 577 MW was the average capacity offered at the auctions during the two years from 2012-2013. During the three years 2014-2016, only an average of 295 MW was offered¹⁸.

Also for DK1, the majority of the interviewees indicate the Kontek PTR auctions have had a positive influence on the spreads. However, all other things being equal, we must expect a greater impact from the decline in the capacity offered at the auctions DK1-Germany. This fits the observation of an increasing trend for the spreads. The difference is so small that we must consider it insignificant, though.

For the consumers' hedging in Denmark, the quarter contracts have historically been the most important, as noted in appendix 4. However, for sake of completeness, the spreads of the **annual contracts** have also been analysed. You'll find the results in appendix 11 and in fig. 7.15. For the periods before and after the introduction of Kontek PTR auctions, the shifts in the average spreads are insignificant.

Hence, the conclusion from the spread analysis is that there's no clear trend. At least we can conclude the introduction of PTR auctions on Kontek and Great Belt has not caused a deterioration of the spreads.

For the volume indicators, there is a falling trend during the period 2012-2016. However, there's no abrupt fall at the introduction of the Kontek PTR auctions.

¹⁶ This is the average spreads of the 9 quarter contracts SYARHQ1-2012, ..., SYARHQ1-2014.

¹⁷ This is the average spreads of the 11 quarter contracts SYARHQ2-2014, ..., SYARHQ4-16.

¹⁸ For the years 2012-2013, the number 577 MW is the average of the sum of the capacities offered in both directions. Similarly for the number 295 MW. Both Energinet.dk's data and the Joint Allocation Office's data indicate a clear decline of the offered capacity. Unfortunately, the two datasets do not give the same numbers for the decline.

Probably, the falling trend of the volume indicators should be seen in the light of the decline of Nasdaq's turnover of Nordic power derivatives.

7.10.3 The spreads in course of time

The figures 7.14 and 7.15 illustrate the spreads in course of time.

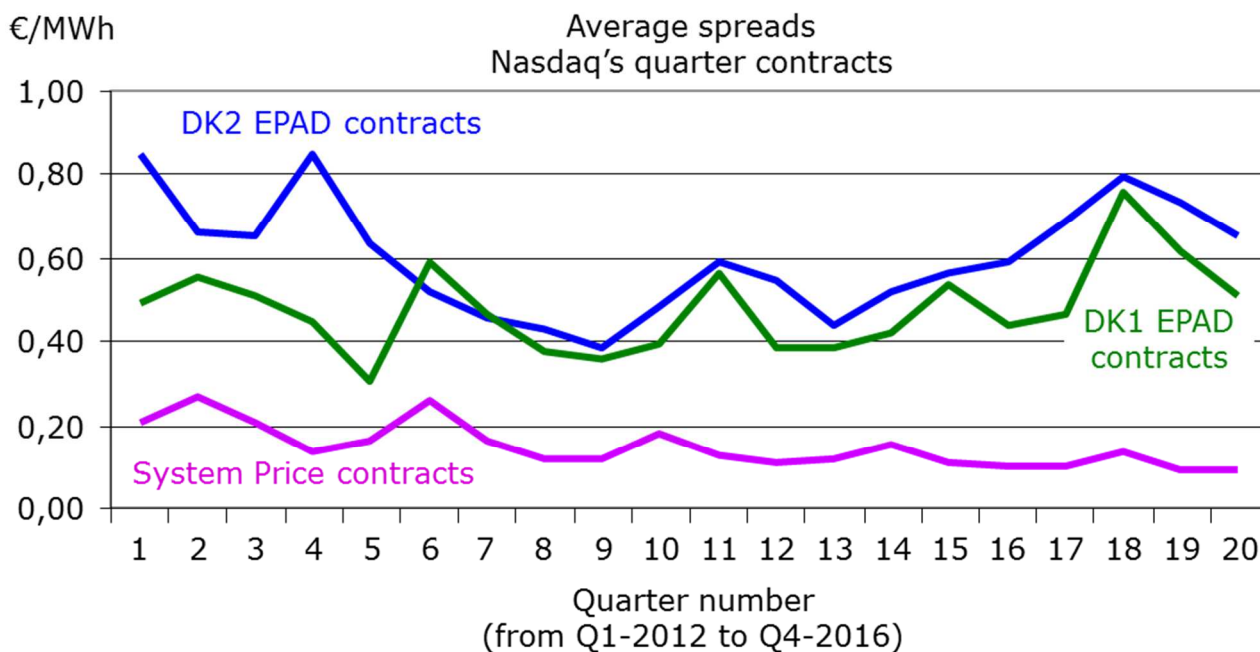


Fig. 7.14 The average spreads of Nasdaq's quarter contracts

Figure 7.14 shows the average spreads for Nasdaq's quarter contracts. For each of Nasdaq's DK1 and DK2 EPAD contracts, the averaging runs over the contract's trading period (about the last three quarters before the start of the delivery period). For each of Nasdaq's System Price contracts, the averaging runs over the last three quarters before the start of the delivery period.

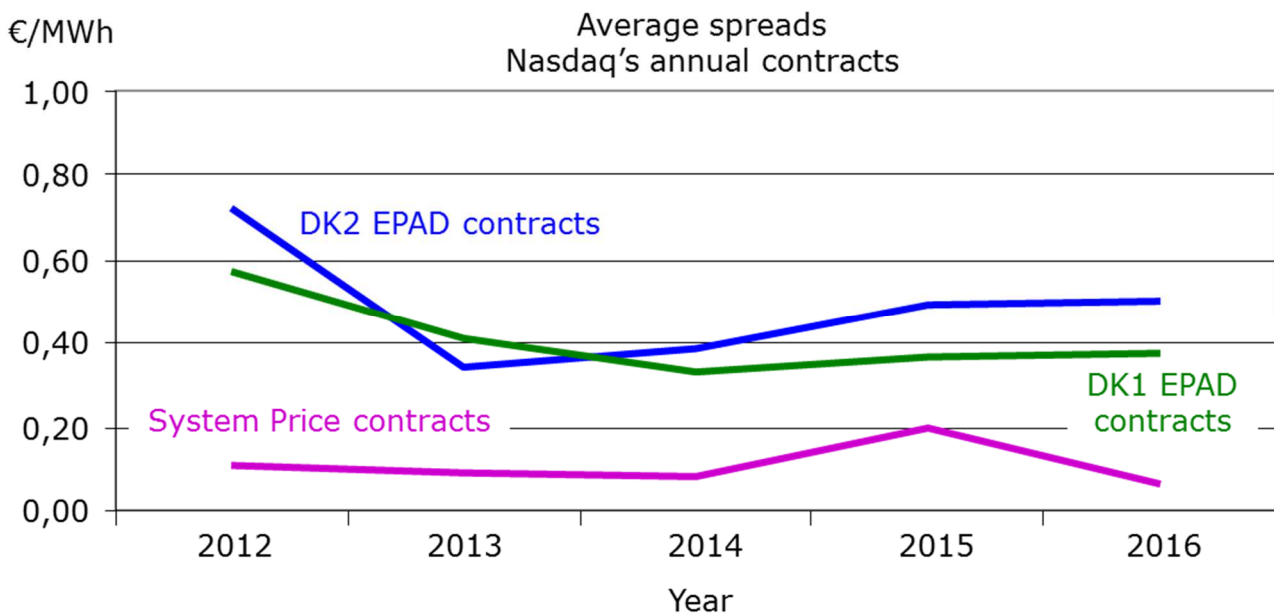


Fig. 7.15 The average spreads of Nasdaq's annual contracts

Figure 7.15 shows the average spreads for Nasdaq's annual contracts. For each contract, the averaging runs over the last year before delivery (for the 2012 EPAD contracts, it's the average spread from 28 April 2011 to the end of 2011, though).

7.11 Conclusion from the analysis

There is no agreed threshold beyond which a market is considered liquid. However, the liquidity of Nasdaq's Danish EPAD contracts is low compared with the statement in the report on the European gas market written by *Oxford Institute for Energy Studies* (ref. 5).

Further, measured as a percentage of the consumption, the exchange turnover and the Open Interest of Nasdaq's Danish EPAD contracts is declining. So is Nasdaq's turnover of Nordic power derivatives.

For Nasdaq's power derivatives, the risk premium R can be split into a sum of two components: a contribution from Nasdaq's System Price contracts and a contribution from Nasdaq's EPAD contracts

$$R = R_{\text{SYS}} + R_{\text{EPAD}}.$$

For Denmark, the contribution R_{SYS} from Nasdaq's System Price contracts is about 50%.

Currently, there are PTR auctions for the Great Belt interconnector and the interconnectors linking Denmark and Germany. The data analysed in this investigation do not indicate any harm done to the Nasdaq's EPAD system by the auctions.

8. Interviews with market players

To supplement the data analyses, interviews with the Danish players at the whole-sale market were carried out. The first questionnaire was sent to the market players during January 2017. In February 2017, this was supplemented with a new, shorter questionnaire. A third questionnaire was sent out 2 March 2017.

The number of Danish players at the whole-sale market is limited, as the Danish consumption is only about 33 TWh/year. Hence, there are only 6 players, which can be interviewed. A majority of the 6 companies are multinational players – operating in several European countries.

Some of the interviewees wanted to be anonymous. To ensure this, all the answers are anonymous.

The 6 companies are:

- Danske Commodities
- DONG Energy
- Energi Danmark
- EWII
- NEAS
- Scanenergi.

In telephone interviews and in the answers to the questionnaire, some market players support the link-to-liquidity concept: by having PTR auctions, the Danish market draws liquidity from the very liquid German market. According to some Danish traders, what happens is that players take speculative positions in the future price difference between Germany and the Nordic countries.

Note that speculation is necessary in order to have liquidity. Without speculation, there would be no liquidity anywhere. For example, all Nasdaq's System Price contracts and all EEX's German contracts would be illiquid if there was only hedging (see also ref. 1).

Appendix 6, appendix 7 and appendix 8 contain the answers to the questionnaires. Table 8.1 and 8.2 give a summary.

Question	Yes/For	No/Against
<i>Does your company use EPAD contracts?</i>	6	0
<i>Do your company clear all EPAD contracts at Nasdaq's clearing house? *)</i>	4 (one interviewee had filled in both boxes)	3 (one interviewee had filled in both boxes)
<i>Do your company sometimes participate at the PTR auctions for (some of) the following links DK1-DE, DK2-DE, DK1-DK2</i>	6	0
<i>Is your company for or against introduction of PTR/FTR auctions on the following interconnectors: DK1-SE, DK1-NO, DK2-SE</i>	5	1
<i>Do you find the present products or combination of products offered on forward markets represent a sufficient hedge against the volatility of the day-ahead price of in DK1?</i>	1	5
<i>Do you find the present products or combination of products offered on forward markets represent a sufficient hedge against the volatility of the day-ahead price of in DK2?</i>	1	5
<i>For DK1: do you find the present products or combination of products offered on forward markets are efficient?</i>	2	4
<i>For DK2: do you find the present products or combination of products offered on forward markets are efficient?</i>	2	4
<i>Do you find a System Price contract gives sufficient hedging against the spot price in DK1?</i>	0	6
<i>Do you find a System Price</i>	0	6

<i>contract gives sufficient hedging against the spot price in DK2?</i>		
<i>*) If "no": if possible, please give an estimate of the volume of contracts, which are cleared</i>	A range of 70% to 100% is stated.	
<i>If possible, can you please give an estimate of the percentage of your company's EPAD contracts, which are traded via Nasdaq's exchange?</i>	A range of 70% to 100% is stated.	

Table 8.1

	Increase	Decrease	No influence
<i>In your point of view, what influence have these PTR auctions had on the turn-over of EPADs for Eastern Denmark?</i>	5	0	1
<i>In your point of view, what influence have these PTR auctions had on the turn-over of EPADs for Western Denmark?</i>	5	0	1
<i>In your point of view, what influence have these PTR auctions had on the spreads of the EPAD for Eastern Denmark?</i>	1	4	1
<i>In your point of view, what influence have these PTR auctions had on the spreads of the EPAD for Western Denmark?</i>	1	4	1

Table 8.2 The introduction to the question was this: *From January 2014, there were PTR auctions on the Kontek interconnector linking Zealand and Germany. From July 2014, there were PTR auctions on the Great Belt interconnector linking Western and Eastern Denmark.*

9. Potential remedies

As can be seen from the analysis and the input from a majority of the market players: the current situation is unsatisfactory. After more than 15 years, Nasdaq's Danish EPAD contracts are still illiquid. Further, for Nasdaq's Danish EPAD contracts, the volume indicators of liquidity are going downhill. So is Nasdaq's turnover of Nordic power derivatives.

Hence, remedies should be considered.

9.1 Stimulation of the forward markets

Both the Location Spread contracts and the EPAD contracts suffer from low liquidity, as mentioned above. In the Nordic countries, this has prompted some observers to suggest the Nordic TSOs should offer power derivatives.

There are several problems with this proposal. First, it would require the TSOs took commercial risks and engaged in commercial activities. For example, the TSOs would need trading departments, which would have to take decisions on when to trade, what volumes to trade, at which prices to trade, etc. Further, there would be the question whether this would subject the TSOs to MiFID regulations.

Second, the TSOs are monopolies and must consider carefully to have a balanced position towards exchanges and market players (awareness of potential undue discrimination). Hence, if the Nordic TSOs would offer EEX's Location Spread contracts, they would also have to offer Nasdaq's EPAD contracts. If more hedging systems should emerge, the TSOs would have to offer these contracts also. In a "worst-case" scenario, the TSOs would be obliged to trade any European power derivative, which can be cleared at a clearing house – including peak contracts, base contracts, etc.

At given points in time, the LTTR auctions give a price signal for the Location Spread contracts, as mentioned above. However, for the TSOs, there's a huge leap from LTTR auctions to having commercial departments trading a range of power derivatives.

In the autumn 2012, the Swedish authority *Näringsdepartementet* gave a consultant the task of writing a report on the Swedish price zone SE4¹⁹. January 2013, the consultant published the report "*Analys av möjliga åtgärder för att minska prisområdesproblematiken i Sydsverige*"²⁰. One of the report's proposals was that the Swedish TSO should offer Nasdaq's EPAD contracts.

¹⁹ Source: Montel Power News 1 November 2012.

²⁰ Source: Montel Power News 9 January 2013.

The report was circulated for comment. The Swedish Competition Authority rejected the proposal 1 March 2013 and wrote in its comment:

Det skulle skapa intressekonflikter i förhållande till affärsverkets roll som oberoende systemoperatör och skulle även innebära ekonomiska risker för Svenska kraftnät som inte är försvarbara. Det skulle sammantaget kunna skada förtroendet för Svenska kraftnät och därmed för marknadsfunktionen. Samtidigt skulle incitamenten för den finansiella marknaden att på egen hand långsiktigt lösa likviditetsproblemet för CfD:er i SE4 väsentligt försvagas²¹.

Later in March 2013, the proposal was also rejected by the Swedish Energy Agency, the Swedish Energy Markets Inspectorate and the Swedish TSO²². September 2013, the Swedish government rejected the proposal²³.

9.2 LTTR auctions

All interviewees use the present PTR auctions. Hence, all the interviewees currently use JAO's service. Therefore, they will not be exposed to new transactions costs originating from JAO registration, if JAO starts operating LTTR auctions on the SE/NO-DK interconnectors.

LTTR auctions provide liquidity to power derivatives, as explained in appendix 10. This is because

- * The existing power derivatives can be used to hedge the profit from a LTTR contract.
- * By combining LTTR auctions and the existing power derivatives, market players can take positions, where they speculate in the future price differences between price zones. See appendix 10.

For the TSOs, LTTR auctions pose the risk of underselling. Underselling means the TSOs' revenue from the LTTR auctions is smaller than the market coupling's congestion revenue.

²¹ Source: www.konkurrensverket.se/nyheter/konkurrensverket-avvisar-elomradesforslag

²² Source: Montel Power News 18 March 2013.

²³ Source: Montel Power News 19 September 2013.

2014	Revenue from PTR auctions	Market coupling: congestion revenue	Gain/loss for TSOs: (PTR auctions) – (congestion revenue)
DK1-DE	3 496 910	2 041 082	1 455 827
DK2-DE	3 999 564	3 299 300	700 263
DK1-DK2	1 271 961	1 302 818	-30 856

Table 9.1 The PTR auctions 2014 Great Belt and Denmark–Germany. All amounts in €. Source: Ref. 6.

For the year 2014, table 9.1 gives the data for the Great Belt PTR auctions and the PTR auctions Denmark–Germany. For these interconnectors, Energinet.dk does not expect more underselling in the future, according to ref. 6.

For annual and monthly LTTR auctions, the auctions take place at a given point in time. For example, for the monthly auctions, the auctions typically take place at the end of the preceding month. Hence, it will require the development of a secondary market, if LTTR auctions should be used as a hedging tool, which can be employed at any point in time.

For LTTR auctions, there's a discussion of the firmness. Will market players, who have bought LTTR capacity, get the corresponding revenue, if the interconnector has an unplanned outage?

9.3 The split liquidity argument

Some observers have worried about splitting of liquidity, if LTTR are introduced on the SE/NO-DK links.

However, the data do not indicate any harm done to the liquidity of Nasdaq's EPAD contracts by the existing LTTR auctions. Further, a majority of the interviewees indicate LTTR auctions provide liquidity to Nasdaq's EPAD contracts. Appendix 10 explains how LTTR auctions can provide liquidity to power derivatives.

Concerning the PTR auctions on the interconnectors linking Denmark and Germany: it should be noted that these auctions are not needed seen from the German side. The auctions enable German players to speculate in the future price differences between Germany and Denmark. This is positive, as it provides Denmark with German liquidity. However, as for hedging, Germany has a perfectly liquid financial power market. It's Denmark, who needs the auctions. On the other hand, Germany does not fear the auctions somehow will reduce the liquidity at the German power market.

Appendix 1 Terms and abbreviations

50Hertz Transmission GmbH	A German TSO. 50Hertz Transmission GmbH is the TSO in the former East Germany and in the state of Hamburg.
AC	Alternating current.
Area price	A day-ahead price for a bidding zone calculated by a spot exchange.
Bidding zone	A geographical area, within which the players can trade electrical energy day-ahead without considering grid bottlenecks.
Bilateral trading	Trading between two parties without the oversight of an exchange.
Border	In this document, this denote the border between two bidding zones. Hence, it may not be a border between two countries.
CfD	Contract for Difference. A power derivative where the underlying reference is the difference between two spot prices. Normally, the reference is the difference averaged over a certain time. At Nasdaq OMX, the name for this power derivative is today EPAD.
Churn rate	Churn is typically measured as the volume traded as a multiple of the underlying consumption or production level of a commodity, according to ref. 7.
Congestion rent	The arbitrage revenue earned by the market coupler on a border (by buying energy on one side of the border and selling on the other side).

DC	Direct current.
DE	Germany.
DERA	Danish Energy Regulatory Authority.
DK1	Denmark west of Great Belt. Please refer to Appendix 2.
DK2	Denmark east of Great Belt. Please refer to Appendix 2.
Double auction	A calculation method whereby the exchange's price is set by using the exchange's supply curve and demand curve. Please refer to the article <i>The Liberalized Electricity Market</i> . At www.houmollerconsulting.dk , you can download the article from the sub-page <u>Facts and findings</u> .
EEX	European Energy Exchange. See www.eex.de
Elspot	Nord Pool's spot market.
EMIR	European Market Infrastructure Regulation. The EU regulation on OTC Derivatives, Central Counterparties and Trade Repositories.
EPAD	Electricity Price Area Differential. A power derivative where the underlying reference is the difference between two spot prices. Normally, the reference is the difference averaged over a certain time. At Nasdaq OMX, the former name this power derivative was CfD.

Exchange turnover	Unless otherwise noted, in this report, this denotes the volume of contracts traded at the exchange. For a given derivative, in addition to the trading at the exchange, you have the bilateral trading. The bilateral trading can be split into two types: * Contracts traded bilaterally and subsequently cleared. * Contracts traded bilaterally and not cleared.
Explicit auctions	In this document, this refers to the TSOs' auctioning of PTRs.
Ex-post risk premium	Please refer to chapter 7.3.
FSE	Foreningen af Slutbrugere af Energi – see www.fse.dk. This is the Danish federation of energy consumers (i.e. the big users of electricity and gas). Periodically, FSE has been a member of IFIEC Europe. IFIEC is the International Federation of Industrial Energy Consumers.
Forward	In this document, this is the same as "forward contract".
Forward contract	In this document, a forward contract is a power derivative, where the underlying reference is a spot price (or the difference between two spot prices). Hence, in this document, the term "forward contract" covers the two types of contracts, which at Nasdaq OMX are called "futures" and "DS futures" (deferred settlement futures). Further, the term "forward contract" covers the contracts, which at EEX are called "forwards".
FTR	Financial Transmission Right. This can be FTR - option or FTR – obligation.

See the PowerPoint presentation *Financial transmission rights – how they work and how to hedge*. At www.houmollerconsulting.dk, you can download the article from the sub-page Facts and findings.

German contract	In this document, this is a power derivative having the German spot price as the underlying reference.
German spot price	See Phelix.
Grid parity	Grid parity occurs when an alternative energy source can generate power at a LCOE that is less than or equal to the price of purchasing power from the electricity grid.
IAS 39	An international accounting standard for financial instruments released by the International Accounting Standards Board. It was replaced in 2014 by IFRS, which becomes effective in 2018. IAS 39 was adopted by the European Union in 2004. In 2005, the EU also introduced the fair value and hedging provision of the amended version of IAS 39.
Implicit auction	The common term for market coupling and market splitting.
Interconnector	In this document, an interconnector is a power line connecting two bidding zones.
JAO	Joint Allocation Office. The JAO is a joint service company of twenty Transmission System Operators (TSOs) from seventeen countries. It mainly performs the yearly, monthly and daily auctions of transmission rights on 27 borders in Europe and

act as a fall-back for the European Market Coupling. Se www.jao.eu.

LEBA	London Energy Brokers' Association.
Location Spread contract	In this document, this is a power derivative having the difference between two spot prices as the underlying reference. For example, a Location Spread contract can have the difference between the German spot price and the Dutch spot price as the underlying reference.
LTTR	Long Term Transmission Right.
Market coupling	A day-ahead congestion management system, you can have on a border, where two spot exchanges meet. The day-ahead plans for the cross-border energy flows are calculated using the market players' spot bids and information on the day-ahead cross-border trading capacity. In this document, for simplicity, apart from Appendix 1, the term "market coupling" is used for both market coupling and market splitting.
Market coupler	The organization carrying out the implicit auction. In this document, it is assumed this organization also do day-ahead cross-border energy trading (shipping an amount of energy across the border as calculated in the implicit auction).
Market splitting	A day-ahead congestion management system, you can have on a border, where you have the same spot exchange on both sides of the border. The day-ahead plans for the cross-border energy flows are calculated using the market players' spot bids and information on the day-ahead cross-border trading capacity. In this document, for simplicity, apart from Appendix 1, the term "market coupling" is used for both market coupling and market splitting.

MiFID	Markets in Financial Instruments Directive. An EU law that provides harmonised regulation for investment services across the 31 member states of the European Economic Area (the 28 EU member states plus Iceland, Norway and Liechtenstein).
Nasdaq	In this paper, this is short-term for Nasdaq Commodities.
Nasdaq Commodities	See http://www.nasdaqomx.com/commodities
Nordic area	In this document, the term refers to the countries Denmark, Finland, Norway and Sweden.
Ofgem	The British energy regulator. Ofgem is acronym for Office of Gas and Electricity Markets.
OI	Open Interest.
Open Interest	For a given financial product, this is the <u>net hedging</u> done by means of the product. The sum of a financial product's exchange turn-over and bilateral turn-over will normally be bigger than the product's Open Interest. This is because traders may move in and out of positions in financial contracts. Note: For a given financial product, the Open Interest only measures the product's <u>cleared volume</u> (i.e. the volume of contracts where the contracts' settlements are done by a clearing house). In addition to this volume, there may be bilateral contracts made between parties who have chosen to do without clearing. For each such contract, the contract's two parties will themselves take care of the settlement. However, these contracts do not contribute to the market's transparency: the contracts' prices and volumes are not public known.

PEGAS

PEGAS is a gas trading platform, which allows its members with to trade natural gas contracts in the Belgian, Dutch, French, German, Italian and UK market areas.

PEGAS was launched as a cooperation between European Energy Exchange (EEX) and Powernext in 2013.

Since 2015, all business activities of EEX and Powernext on the European natural gas markets have been operated under the brand PEGAS.

See www.pegas-trading.com/en

Phelix

Physical Electricity Index. This is the spot price for the German/Austrian bidding zone. In this document, this is also called "the German spot price".

Profile risk

The vast majority of the current Nordic power derivatives tacitly assume the consumers/producers have a flat consumption/production profile.

For example – for a retailer wanting to hedge the purchase of electricity: for a bidding zone, where the intra-day price volatility is low, it's not a problem that the consumers do not actually have a flat consumption profile (normally they have high consumption during daytime and low consumption during night time).

However, for a retailer operating in a bidding zone with high intra-day price volatility, it's a problem that the power derivatives tacitly assume the consumers have a flat consumption profile.

Proxy hedging

At the outset, a commodity derivative should protect the contract's parties against price movements of the commodity in question.

However, to trade liquid derivatives, players may resort to commodity derivatives with an underlying price, which is not actually the price of the commodity the players are trading. This is called proxy hedging.

For example, a player in the oil market may hedge against the Brent oil index, although the player is not buying or selling Brent oil.

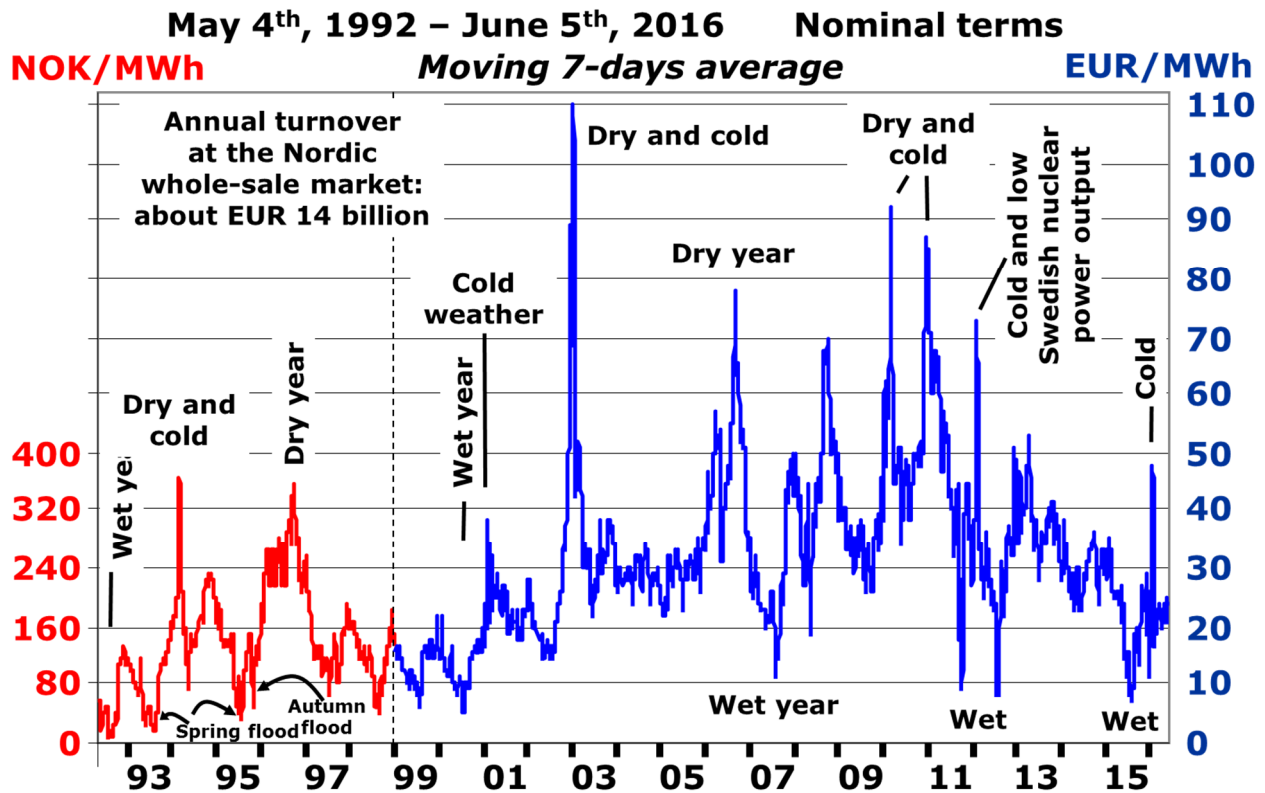
PTR	Physical Transmission Right.
Risk premium	In this document, this short-term for “ex-post risk premium”.
SE/NO-DK links	The refers to the interconnectors linking Sweden and Norway to Denmark. Hence, this refers to the Skagerrak cables linking Norway and Jutland, the Konti-Skan cable linking Sweden and Jutland and the cables linking Sweden and Zealand.
SE4	The southernmost Swedish bidding zone. Please refer to Appendix 2.
Spot exchange	In this document, a spot exchange is an exchange where * Electrical energy is traded day-ahead. * The exchange uses double auction to calculate the day-ahead prices. In this way, the exchange calculates a price for each hour of the next day. Please refer to the article <i>The Liberalized Electricity Market</i>. At www.houmollerconsulting.dk, you can download the article from the sub-page <u>Facts and findings</u>.
Spot price	A day-ahead price for electrical energy calculated by a spot exchange.
Spread	The difference between Best Buyer’s price and Best Seller’s price. Best Buyer is the buyer willing to pay the highest price. Best Seller is the seller willing to sell at the lowest price. For a derivative, it works the same way. However, for a derivate, the terms “willing to buy” and “willing to sell” are replaced with the terms “willing to take bid position” and “willing to take ask position”.

System Price	An artificial spot price. The System Price is the common price we would have in the Nordic area, if there were no grid bottlenecks. However, as there are grid bottlenecks, the System Price is a virtual price. At Elspot, the prices used for settlement are the area prices.
System Price contract	In this document, this is a power derivative which has the Nordic System Price as the underlying.
TenneT TSO GmbH	A German TSO. TenneT TSO GmbH is the TSO, you meet on the southern side of the border DK1-DE.
TSO	Transmission System Operator.
UIOSI	Use-It-Or-Sell-It. This applies to PTR auctions. With the UIOSI system, a player with capacity from the auctions can use the capacity himself to ship energy across the interconnector, or the player can give the capacity to the market coupling. If the player gives the capacity to the market coupling, the player will get the congestion rent (if any).
Volume indicators of liquidity	Open Interest and exchange turnover.
Volume risk	The risk that a market player did not hedge the right amount of electrical energy. For example, this can be a retailer who has hedged a volume, which turns out to be smaller than the customers' consumption.

Appendix 2 The Baltic-Nordic bidding zones



Appendix 3 The Nordic System Price



Appendix 4 Open Interest

The current hedging system offered by Nasdaq is EPAD+(System Price). For this system, the Open Interest and the exchange traded volume is investigated.

This appendix explains why the quarter contracts and the annual contracts are the important contracts for this investigation.

According to a report from DERA, in 2015, about 76% of the electricity in Denmark was sold by means of fixed-price contracts²⁴.

Of the 76%, about 55% of the electricity was sold by means of fixed-price contracts, where the fixed-price period was a quarter. In the following, this will be called fixed-price quarter contracts.

For the remaining 21%, the fixed-price period was longer than a quarter. DERA's report does not mention this, but according to market players, one year is a typical fixed-price period for the 21% of the sold volume.

Hence, to estimate the usage of the current hedging system, you may proceed as indicated in table A4.1. In table A4.1, hedging in Western Denmark for the calendar year 2016 is used as an example.

The monthly contracts may also be used for hedging. However, as explained below, by using the Open Interest for the quarter contracts (and ignoring the monthly contracts), you get a reasonable estimate of the volume hedged due to fixed-price quarter contracts. Therefore, the Open Interest for the monthly contracts is ignored in the investigation.

EPAD contract (hedging in Western Denmark)	EPAD contract's hedging period	Open Interest for this contract noted at this point in time
SYARHYR-16	Calendar year 2016	End of December 2015
SYARHQ1-16	Q1-2016	End of December 2015
SYARHQ2-16	Q2-2016	End of March 2016
SYARHQ3-16	Q3-2016	End of June 2016
SYARHQ4-16	Q4-2016	End of September 2016

Table A4.1

²⁴ *Hvad kostede strømmen i 2015?* Report from DERA August 2016.



Fig. A4.1 Hedging a retailer's fixed-price Q4 sale.

Referring to fig. A4.1: during September, the retailer can hedge Q4 and the two months October and November.

The red colour indicates the volume hedged by the retailer's Q4 contract. This matches the retailer's December sale. In order to adjust the net hedged volume for October and November, the retailer has ask positions in monthly contracts.

Some other player must have the bid positions corresponding to the retailer's ask positions for the October and November contracts. For example, this can be a producer adjusting the total hedged volume.

Our estimate of the total hedged volume would be too high, if we added the Open Interest for the Q4 contract and the month contracts October, November and December.

By simply using the Open Interest for the Q4 contract, we still get too high a volume. However, this may more-or-less be levelled out by the corresponding error stemming from ignoring the Open Interest from the monthly contracts January and February (fig. A4.2).

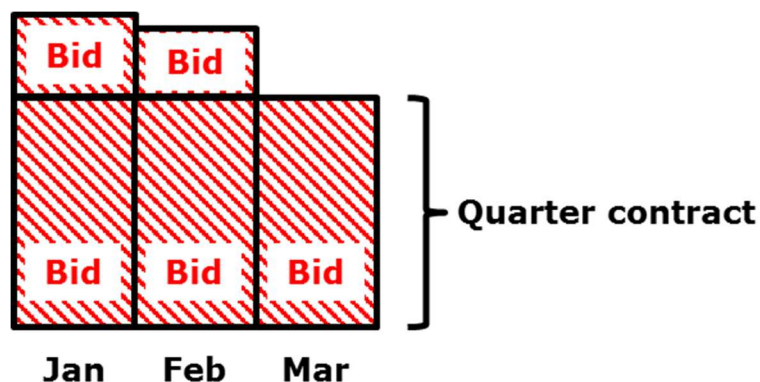


Fig. A4.2 Hedging a retailer's fixed-price Q1 sale.

Referring to fig. A4.2: during December, the retailer can hedge Q1 and the two months January and February. Hence, the red colour indicates the volume hedged by the retailer's Q1 contract. This matches the retailer's March sale. To adjust the net hedged volume for January and February, the retailer has extra bid positions in January and February contracts.

By simply using the Open Interest for the Q1 contract (and ignoring the Open Interest from the month contracts), we get too small a volume. However, this may more-or-less be levelled out by the corresponding error stemming from using the Open Interest for the Q4 contract (fig. A4.1).

By adding the Open Interests found as indicated in table A4.1, you will get an upper limit for the total hedging done by means of EPAD contracts. This is explained below.

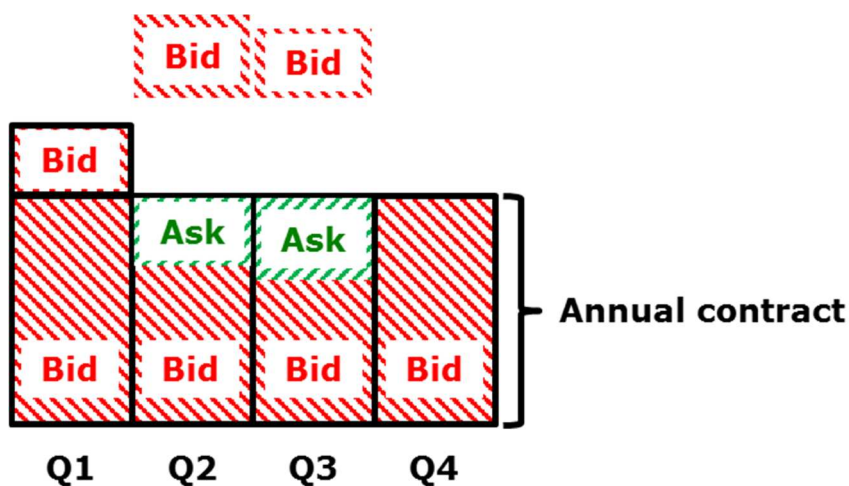


Fig. A4.3 Hedging a retailer's fixed-price sale for the front year.

Referring to fig. A4.3: during the last quarter of the current year, the retailer can hedge the front year and the quarters Q1, Q2 & Q3.

The red colour indicates the volume hedged by the retailer's annual contract. This matches the retailer's Q4 sale. To adjust the net hedged volume for the first three quarters, the retailer has positions in contracts for Q1, Q2 and Q3.

By adding the Open Interest for the annual contract and the Q1, Q2 and Q3 contracts, we get too big a volume. Hence, the method indicated in table A4.1 gives an upper limit of the hedged volume for the front year.

Appendix 5 Price volatility at the new and the old power market

Until recently, the power supply business' production units mainly used fossil fuels, nuclear fuels and hydropower. Hence, the contribution to the price volatility from the supply side came from fluctuations in the prices of fossil fuels and the content of the hydro power stations' reservoirs.

Therefore, as for the contribution from the supply side, the old power market had price fluctuations, which typically lasted months or quarters.

In contrast, the new power market has huge hourly price volatility. The production from wind turbines and solar cells can vary a lot from one hour to the next. On the other hand, during months or quarters, the average energy production from wind and solar is fairly stable. Hence, the contribution to the long-term price volatility from these units is very small.

If Europe moves towards a fossil-free energy supply system, the fossil fuels' contribution to the power market's price volatility will gradually disappear. This means the main contributor to Europe's long-term price volatility will gradually vanish. Simultaneously, the hourly price volatility will increase enormously.

At the outset, we must expect the demand side to have unaltered contribution to the price volatility. For example, spells of very warm or very cold weather creates price volatility from the demand side. As for the time duration, this price volatility lies normally between the old and the new power market's volatility: the surge in demand is seldom only for a few hours, and it seldom lasts several months.

Economic upswings and downturns have long-term impact on the power prices. For example, the financial crisis caused a fall in demand, which proved to be long-lasting.

In the figure in appendix 3, you see the combined effect of these contributions to volatility from the demand and supply side²⁵.

The current products at the financial power markets were designed for the old power market. EEX has made some attempts at launching products suited for the new power market. However, in truth we must say we are still awaiting the creation of power derivatives, which can hedge against the new power mar-

²⁵ By displaying a moving 7-days average price, the figure ignores the hourly price volatility. Hence, the figure displays the old power market's price volatility.

ket's hourly price volatility. Some market players have speculated that slicing up LTTRs into hourly products and selling them at a secondary market will do the job. It remains to be seen if this is the case. Among other things, in order to get liquidity for such products, this would probably require a clearing house taking care of the counterparty risk and settlement of such products.

For proxy hedging, high hourly price volatility is a challenge. To see why, let's consider an example.

Example

We'll consider a Danish retailer's trading for one hour. For simplicity, we assume the retailer has only fixed-price customers. By means of proxy hedging, the retailer has hedged 300 MWh/h. For example, the proxy hedging can be a contract hedging against the German price or hedging against the System Price.

We'll make the following assumptions for this hour:

- * The consumers' consumption was 300 MWh (i.e. we ignore volume risk and profile risk).
- * At the spot market, the retailer bought 300 MWh (i.e. no imbalance settlement).
- * The hedging price of the financial contract was 30 €/MWh. There's no settlement due to the financial contract, as the spot price of the proxy was also 30 €/MWh (i.e. the German spot price – alternatively the System Price – was 30 €/MWh).
- * The retailer's local spot price hits the ceiling (currently 3000 €/MWh).

At the spot market, the retailer's purchase is:

$$300 \text{ MWh} * 3,000 \text{ €/MWh} = 900,000 \text{ €}.$$

Even if the retailer has managed to sell at a price of 40 €/MWh, the value of the retailer's sale is only

$$300 * 40 \text{ €/MWh} = 12,000 \text{ €}.$$

Hence, for just one hour, the retailer can have a loss of about 900,000 €, when the local spot price spikes while the proxy price stays normal. In Denmark, we have seen this happening.

Hence, a high correlation between the annual averages of the local spot price and the proxy price is not of much use for the retailer. If you go bust today, it's cold comfort the proxy hedge on the average would have performed well over a 10-year period.

Appendix 6 Questionnaire no. 1

As a part of this investigation, six Danish energy companies were interviewed by means of questionnaires.

Some of the interviewees wanted to be anonymous. In order to fulfil this requirement, for those questions where the interviewees were asked to write answers, the sequence of the answers are not the same in the following (i.e., for each question, the first answer is **not** always from the same company).

In the following, for the first questionnaire, you'll find the questions and the corresponding answers. For each question, the broken lines separate answers from different companies. The first questionnaire was sent out January 2017.

General

1. Do you want to answer this questionnaire anonymously?

Yes ☐

No ☐

Answers

3

2

(one interviewee wanted anonymity for some answers)

EPAD contracts

2. Does your company use EPAD contracts?

Yes ☐

No ☐

Answers

6

0

2.1 If "yes":

For what purpose does your company use EPADs?

Our company uses the system based on EPADs for hedging purposes, and we believe the current system provides sufficient hedging opportunities. PTR's can in our opinion not replace EPADs only be used as a supplement as PTR's are limited to be equal to or less than the capacity on a curtail cable. EPADs are traded by many participants and are as such not limited in volume.

Hedging.

- Hedging market risk of supply contracts towards various end-user segments
- Hedging market risk of wind power purchase agreements
- Hedging market risk of power producers including decentralized CHPs
- Hedging cross-border market risk
- Prop. Trading

Hedging our exposure towards our customers and only in very small part as speculative trades.

Hedge and trading

Vi bruger EPADS til afdækning og til spekulativ trading.

If possible, can you please give an estimate of the percentage of your company's EPAD contracts, which are traded via Nasdaq's exchange?

Estimated exchange traded percentage:

80%-90%.

70-80%.

80%.

100 pct so far.

High. Approx 90 – 95 %.

Alt hvad vi ikke handler med kunder, bliver handlet eller clearet ind på Nasdaq.

Do your company clear all EPAD contracts at Nasdaq's clearing house?

Yes ☐

No ☐

Answers

4

3

(one interviewee had filled in both boxes)

If "no": if possible, please give an estimate of the volume of contracts, which are cleared

Estimated clearing percentage:

The three, who had filled in the "no" box, wrote:

High approx 90 – 95 %.

Nok mere end 70 % idet, det kun er det mod kunder vi ikke clearer.

80%.

3. From January 2014, there were PTR auctions on the Kontek interconnector linking Zealand and Germany. From July 2014, there were PTR auctions on the Great Belt interconnector linking Western and Eastern Denmark.

Here, one interviewee wrote:

In general we would say there are a correlation between increasing interest in EPADs in those periode in which there has been hold a PTR auction. *But no to little influence in the period further out the forward curve.*

In your point of view, what influence have these PTR auctions had on the **turn-over** of EPADs for **Eastern Denmark**?

Increased turnover DK2 ☐	Decreased turnover DK2 ☐	No influence DK2 ☐
Answers 5		1

In your point of view, what influence have these PTR auctions had on the **turn-over** of EPADs for **Western Denmark**?

Increased turnover DK1 ☐	Decreased turnover DK1 ☐	No influence DK1 ☐
Answers 5		1

In your point of view, what influence have these PTR auctions had on the **spreads** of the EPAD for **Eastern Denmark**?

Increased spreads DK2 ☐	Decreased spreads DK2 ☐	No influence DK2 ☐
Answers 1	4	1

In your point of view, what influence have these PTR auctions had on the **spreads** of the EPAD for **Western Denmark**?

Increased spreads DK1 ☐	Decreased spreads DK1 ☐	No influence DK1 ☐
Answers 1	4	1

Existing PTR auctions

4. Do your company sometimes participate at the PTR auctions for (some of) the following links
- * Western Denmark – Germany
 - * Eastern Denmark – Germany
 - * Great Belt

	Yes ☐	No ☐
Answers	6	0

If "no" – why not?

If "yes" – why does your company participate?

- Hedging our position in DK1 and DK2 (ref 2.1)
- Prop. Trading.

Hedging. Spreads on Epads are too wide, even thus I put my cross in the "Decreased Spreads box". On PTR/FTR-day is a day where more fair value are set.

After VPP ended – FTR/PTR is really the only way a company like ours has, to cover short term exposure as there are only traded monthly Epads. We do not have a set-up which makes it possible to trade intraday.

Hedge and trading.

Vi deltager i auktionerne både som en del af vores hedging, men også som et spekulativt værktøj.

For hedging purposes.

Potential future PTR/FTR auctions

5. Is your company for or against introduction of PTR/FTR auctions on the following interconnectors:

- | | | |
|----------------------------|------------------------------|----------------------------------|
| * Western Denmark – Sweden | For ☐ | Against ☐ |
| Answers | 5 | 1 |
| * Western Denmark – Norway | For ☐ | Against ☐ |
| Answers | 5 | 1 |

* Eastern Denmark – Sweden
Answers

For ☐
5

Against ☐
1

Please explain why your company is for or against

Those, who were for, gave these answers:

- Increased liquidity and reduced spreads in EPAD contracts for SE3, SE4, DK2 and DK1
- Access to PTR/FTRs as hedging instruments

It would attract more liquidity. DK1-Norway might not so much, as market to-day just trade Systemprice instead. No-influence is big on systemprice, and the interconnector is large.

We do think this potentially could provide more liquidity in the market. Of course dependent of the volume offered into the market. Also important in case it should be used for hedging purpose that the capacity offered are guaranteed. Particular in case the maximum spotprices increases to ex. (15.000 EUR/MWh)

Vi er generelt for indførslen af PTR/FTR fordi det er vores klare opfattelse, at det vil øge vores muligheder for at kunne hedge vores positioner på en mere effektiv måde end det vi kan i dag. Både fordi PTR/FTR i sig selv er godt værktøj til hedge men ikke mindst fordi vi forventer mere likviditet på de berørte områders EPADS og i mindre grad system strøm, hvis ovennævnte PTR/FTR bliver indført.

The interviewee, who were against, gave this answer:

Due to financial regulation

A change into FTRs before 3 January 2018 implies a risk of these trades (auctions) to be deemed financial instruments. If that is the case the Energinet.dk would be subject to several financial regulations, e.g. EMIR, MAR and MiFID I. The same goes for the market participants, although

current market participants are most likely subject to financial regulation already. Thus, the extra work, e.g. in terms of setting up EMIR reporting will not be that complicated. However, as the transactions in principle will count against EMIR clearing threshold, also documentary proof of hedging must be observed.

If a shift to FTRs takes place after 3 January 2018 an exemption for *primary electricity market* is in force according to Art. 8, litra (c) of Commission Delegated Regulation of 25.4.2016 supplementing Directive 2014/65/EU of the European Parliament and of the Council as regards organisational requirements and operating conditions for investment firms and defined terms for the purposes of that Directive. It is worth noting that this exemption does *not* exempt trades in the secondary market. This has a negative impact also for primary market as it makes it more costly to settle positions taken.

Liquidity reasons

The liquidity may suffer in case of capacity moved away from NordPool. All, available capacity should be subject to NordPool allocation (implicit auctions). Thus, EPADs continue as the hedging product.

- 6.** FTR auctions (instead of PTR auctions) may expose the TSOs to MiFID regulation etc. However, in the following please see the issue from your company's point of view only.

Assuming the current auctions Denmark-Germany and DK1-DK2 stay in place and/or auctions are introduced on the interconnectors between Denmark and Sweden/Norway. In this case – does your company prefer PTR auctions or FTR auctions?

Prefer PTR auctions ☐

Answers

2

(one interviewee was indifferent)

Prefer FTR auctions ☐

3

Please explain why your company has this point of view

Those, who were in favour of FTR auctions, gave these answers:

We prefer the FTR-product as is easier accessible. However, the difference between the two products is minimal, and if barriers exist to the implementation of FTRs, we prefer PTRs.

If action is as today with "Use It Or Sell It" trader will be compensated when price difference occurs, which give best consumer/producer surplus. FTR can attract more trading house, bringing liquidity, whereas PTR is/can be a barrier.

In case of PTR it would potentially prevent some smaller participant to be active compared to FTR. More administrative tasks (higher cost).

Those, who were in favour of PTR auctions, gave these answers:

The main reason is the risk of FTRs being financial instruments, and PTR trades might be easier to qualify as hedges. Further, we think the added option of physical delivery that PTR gives is useful, but it is not vital to us. In general, we do not believe that a shift from PTRs to FTRs will change the auction activity in any major way.

All systems has been set up for PTR so the cost would be minimum if keeping the setup as it is, whereas changing it would mean some unknown IT cost for the industry.

One interviewee gave this answer:

Vi vil sjældent, hvis nogensinde have brug for at nominere flow på kablerne og vi nok i de fleste tilfælde bruge kapaciteterne finansielt uden nominering, men måske kan det på sigt give mening at nominere i forhold til nogle eller lignende så derfor er nok indifferente om det bliver den ene eller anden løsning.

Other comments

Please feel free to give further comments to the investigation

There is not doubt that in an illiquid EPAD market, that the PTR/FTR are an improvement of the liquidity and market spreads. This has been proven on the DK2-DE auction. It is also clear that introducing a new product in the market will give more participants a natural position in the market which will increase turnover and narrow the spreads. Therefore the PTR/FTR will be an improvement for both DK1, DK2 and SE4 if the auctions are implemented.

Liquidity in epads (Denmark) is very low compared to total consumption in the area. Important to consider for an open and free market is the amount of regulations (admin) and cost imposed to the participants (esp. smaller). After the end of the VPP product there is a gap in the market for hedging short-term exposure. Of course a little outside the questionnaire purpose, but anyway, we see lacking hedging opportunities in the market on d/a exposure and do see a product similar to VPP could increase liquidity in the forward market.

Try with some of the capacity on a trial run on Skagerrak, Kontiskan and Øresund.

Generelt set har vi i de seneste år set en meget faldende likviditet på de nordiske strømkontrakter. Hvilket gør, at jeg mener at man kan diskutere, hvorvidt det nordiske strømmarked er velfungerende som det er. Jeg tror det vil være en rigtig god tilføjelse til det nordiske strømmarked med PTR/FTR og noget som måske kan være med til at stoppe den negative udvikling på likviditeten og dermed øge mulighederne for kunderne til at hedge sig på en effektiv måde.

Appendix 7 Questionnaire no. 2

As a part of this investigation, six Danish energy companies were interviewed by means of questionnaires.

Some of the interviewees wanted to be anonymous. In order to fulfil this requirement, for those questions where the interviewees were asked to write answers, the sequence of the answers are not the same in the following (i.e., for each question, the first answer is **not** always from the same company).

In the following, for the second questionnaire, you'll find the questions and the corresponding answers. For each question, the broken lines separate answers from different companies. The second questionnaire was sent out February 2017.

General

1. Do you want to answer this questionnaire anonymously?

Yes ☐

No ☐

Answers

2

4

2. Hedging against day-ahead price volatility in the price zones DK1 and DK2

2.1 Do you find the present products or combination of products offered on forward markets represent a sufficient hedge against the volatility of the day-ahead price of in DK1?

Yes ☐

No ☐

Answers

1

5

2.2 Do you find the present products or combination of products offered on forward markets represent a sufficient hedge against the volatility of the day-ahead price of in DK2?

Yes ☐

No ☐

Answers

1

5

2.3 Please feel free to elaborate on your answers to the questions 2.1 and 2.2

There is no tools for hedging for hedging day ahead, as far as I know there is no trading in day ahead products.

- We consider the DK1 area price risk to be high
- We find the interconnections between DK1 and the Nordic areas being often congested, which means that there is a substantial basis risk between the Nordic System Price and the DK1 price. Currently, the EPAD market is the only way to manage this risk. We find the products and their liquidity insufficient to fill the need for hedging DK1 price risk.
- We find the products offered inadequate to manage short term area price risks

After the end of the VPP product there is a gap in the market for hedging short-term exposure. Especially if we see an increase in the maximum spot-price to EUR 15.000 the risk of selling to consumers on a firm price will raise significant.

A yearly product similar to VPP and/or FTR could help hedging short-term exposures especially in case a single area has a significant price cap in some hours.

Also introduction of ex weekly/daily EPAD could be of interest. However doubtful if there will be the enough liquidity.

Ad 2.1 & 2.2] There is no dayahead market in DK1 and DK2, only option then is to make pricedepending bid/offers to Nordpool Spot, but then you don't know your price before the results are public, and result is physically. Several players build their own price quoting portal to quote prices to bilateral counterparts, that liquidity is never shown on the exchange. Then they take upon them to report to relevant Trade depository (Emir/remit). They might do this to save costs (to the Exchanges), but it drains away market liquidity.

The answer depends on how you read it. In the region (Nasdaq, Nord Pool Spot), or together with the PTR action to German. DK1 (and sometime also DK2) is linked to the Continent (Germany). In order to hedge price spikes it is necessary to use peak contracts (hour 9-20). Peak contracts for price areas are not available at Nasdaq.

3. Efficiency of the present forward markets in the price zones DK1 and DK2

Concerning the definition of "efficiency" in this context: please refer to paragraph 4b in *COMMISSION REGULATION (EU) 2016/1719* (please see the appendix to this questionnaire)

3.1 For DK1: do you find the present products or combination of products offered on forward markets are efficient? **Yes** ☐ **No** ☐

Answers

2

4

3.2 For DK2: do you find the present products or combination of products offered on forward markets are efficient? **Yes** ☐ **No** ☐

Answers

2

4

3.3 Please feel free to elaborate on your answers to the questions 3.1 and 3.2

This yes is due to Nasdaq and PTR to Germany.

- Typically there is a demand from end-consumers and end-producers to hedge positions in the forward market to manage risks of fluctuating operational cost and revenue levels related to the Danish power prices. This typically yields a pull for short to medium term hedging (1-2 years). Furthermore, investors will seek to protect the value of their investments in the forward market. Currently, the forward market for DK1 and DK2 is not efficient based on any of the mentioned parameters. Allocating additional cross border capacities will benefit all parameters, creating natural interest in
 - o Trading the maturities allocated in the forward market
 - o Reducing the involved bid-offer spreads
 - o Increasing the churn rate or share of overall consumption traded in the forward markets, as well as diversifying the motivation for trading by expanding it to also cover cross border trading
 - o Increasing open interest on both sides of the allocated capacity

See question 2

The market is very illiquid, which makes it hard/expensive to hedge your positions.

Ad 3.1 & 3.2]

Price spreads are too wide. If you place your own interest somewhere in the spread, price will immediately (often) change. If you hit on a price (buy or sell), market will move the full spread. So then you don't/can't get your volume done. In Sweden they show weekly EPADs. Financial market day ahead, weeks would help.

The more products introduced, the less liquidity in each product, hence as few products as possible gives better spreads and better liquidity.

4. Other comments

Please feel free to give further comments to the investigation

(No comments in this field)

Appendix to questionnaire no. 2

Quotations from Article 30 in *COMMISSION REGULATION (EU) 2016/1719 of 26 September 2016 establishing a guideline on forward capacity allocation*

Options for cross-zonal transmission risk hedging

Article 30

Decision on cross-zonal risk hedging opportunities

1. TSOs on a bidding zone border shall issue long-term transmission rights unless the competent regulatory authorities of the bidding zone border have adopted coordinated decisions not to issue long-term transmission rights on the bidding zone border. When adopting their decisions, the competent regulatory authorities of the bidding zone border shall consult the regulatory authorities of the relevant capacity calculation region and take due account of their opinions.

2. Where long-term transmission rights do not exist on a bidding zone border at the entry into force of this Regulation, the competent regulatory authorities of the bidding zone border shall adopt coordinated decisions on the introduction of long-term transmission rights no later than six months after the entry into force of this Regulation.
3. The decisions pursuant to paragraphs 1 and 2 shall be based on an assessment, which shall identify whether the electricity forward market provides sufficient hedging opportunities in the concerned bidding zones. The assessment shall be carried out in a coordinated manner by the competent regulatory authorities of the bidding zone border and shall include at least:
 - (a) a consultation with market participants about their needs for cross-zonal risk hedging opportunities on the concerned bidding zone borders;
 - (b) an evaluation.
4. The evaluation referred to in paragraph 3(b) shall investigate the functioning of wholesale electricity markets and shall be based on transparent criteria which include at least:
 - (a) an analysis of whether the products or combination of products offered on forward markets represent a hedge against the volatility of the day-ahead price of the concerned bidding zone. Such product or combination of products shall be considered as an appropriate hedge against the risk of change of the day-ahead price of the concerned bidding zone where there is a sufficient correlation between the day-ahead price of the concerned bidding zone and the underlying price against which the product or combination of products are settled;
 - (b) an analysis of whether the products or combination of products offered on forward markets are efficient. For this purpose, at least the following indicators shall be assessed:
 - (i) trading horizon;
 - (ii) bid-ask spread;
 - (iii) traded volumes in relation to physical consumption;
 - (iv) open interest in relation to physical consumption.

Appendix 8 Questionnaire no. 3

As a part of this investigation, six Danish energy companies were interviewed by means of questionnaires.

Some of the interviewees wanted to be anonymous. In order to fulfil this requirement, for those questions where the interviewees were asked to write answers, the sequence of the answers are not the same in the following (i.e., for each question, the first answer is **not** always from the same company).

In the following, for the third questionnaire, you'll find the questions and the corresponding answers. For each question, the broken lines separate answers from different companies.

The third questionnaire was sent out 2 March 2017.

General

1. Do you want to answer this questionnaire anonymously?

Yes ☐

No ☐

Answers

2

4

2. Hedging against spot price volatility in the price zones DK1 and DK2

2.1 Do you find a System Price contract gives sufficient hedging against the spot price in DK1?

Yes ☐

No ☐

Answers

0

6

2.2 Do you find a System Price contract gives sufficient hedging against the spot price in DK2?

Yes ☐

No ☐

Answers

0

6

2.3 Please feel free to elaborate on your answers to the questions 2.1 and 2.2

As for both connections there is a need for EPADs as well.

Hedging a Danish contract with just a systemprice contract is like comparing tomatoes with bananas. This is not a hedge, quite opposite infact. If you by mistake think this is a hedge one instead takes on more risk. The Danish prices are correlated to much more that just a theoretical system-price.

The systemprice would in some cases make a decent hedge for the dk1 and dk2 prices but in most cases it will on hedge a part of it, because the price-diffence between dk1/dk2 and system can be quite high and change a lot over time.

- The delivered spot-price differential between the System Price and the two Danish area prices is high and volatile;
 - For 2016-2017 the delivered differential for DK1 is 2,91 EUR/MWh with an absolute standard deviation of 5,86 EUR/MWh
 - For 2016-2017 the delivered differential for DK2 is 3,69 EUR/MWh with an absolute standard deviation of 6,94 EUR/MWh
 - This means that a system price hedge would lead to a very high variation of the final delivered DK1 or DK2 price even with a System Price hedge of up to 23% (average DK2 price in 2016-2017 is 29,95 EUR/MWh with a deviation of up to 6,94 EUR/MWh)
-

The system price is not a good hedge, as Denmark are connected to NO2, SE3 and SE4. Norway and Swedens pricecurves weigh differently on the System-price.

Systemprice has a complete pricecurve from Tzero- $\rightarrow\infty$ (2027). DK1 & DK2 has Frontmonth- $\rightarrow$ 2 month, 3 Quarters, 3 years. When a monthly contract enters delivery month, you almost cannot hedge it, not even with the new futures. The correlation is also high against Germany, so if the System price is high or low, to hedge the Danish area you also need some german contracts. If there is a period with many bottlenecks, the systemprice is no hedge at all.

Event 7th. Juni 2013

Dato	Hours	DKK/MWh		
		SYS	DK1	DK2
07-06-2013	00 - 01	287,11	287,18	287,18
07-06-2013	01 - 02	281,52	281,67	281,67
07-06-2013	02 - 03	276,45	276,52	276,52
07-06-2013	03 - 04	271,23	271,45	271,45
07-06-2013	04 - 05	277,56	277,64	277,64
07-06-2013	05 - 06	286,06	285,39	285,39
07-06-2013	06 - 07	299,63	377,24	300,75
07-06-2013	07 - 08	332,73	14175,10	370,53
07-06-2013	08 - 09	343,25	14175,70	352,79
07-06-2013	09 - 10	332,88	14910,80	318,20
07-06-2013	10 - 11	324,76	14910,80	313,80
07-06-2013	11 - 12	321,48	14175,40	315,51
07-06-2013	12 - 13	314,25	401,92	309,25
07-06-2013	13 - 14	307,98	379,55	307,24
07-06-2013	14 - 15	297,69	300,83	300,83
07-06-2013	15 - 16	293,44	295,68	295,68
07-06-2013	16 - 17	291,43	290,91	290,91
07-06-2013	17 - 18	290,84	290,69	290,69
07-06-2013	18 - 19	290,16	290,02	290,02
07-06-2013	19 - 20	290,61	292,33	292,33
07-06-2013	20 - 21	289,57	290,02	290,02
07-06-2013	21 - 22	284,57	284,35	284,35
07-06-2013	22 - 23	282,56	282,19	282,19
07-06-2013	23 - 00	268,84	268,25	268,25
Middel		297,36	3252,98	298,05
I Euro/7,45		39,91	436,64	40,01

Comment

The questions 2.2 and 2.3 ask if you have a sufficient hedge, if you have a System Price contract only (and no supplementing EPAD contract).

Terminology

In this questionnaire, a "System Price contract" is a power derivative having the Nordic System Price as the underlying reference.

Examples

Currently, some of Nasdaq's System Price contracts are

<u>Ticker code</u>	<u>Underlying reference</u>
ENOAFUTBLMAPR-17	System Price during the month April 2017
ENOFUTBLQ2-17	System Price during second quarter of 2017
ENOFUTBLYR-18	System Price during the year 2018

Appendix 9 References

Ref. 1

Li, Y., & Fortenbery, T. (2013). *Do Speculators in Futures Markets Make Cash Markets More Volatile?* Selected paper prepared for presentation at the Agricultural & Applied Economics Association's 2013 AAEA & CAES Joint Annual Meeting, Washington, DC, August 4-6, 2013.

The paper's summary reads: *This paper investigates the extent to which speculative trade in futures markets contributes to volatility in cash markets. By analyzing coffee, crude oil and wheat we find that futures and cash prices are cointegrated in levels and exhibit bi-directional causality in variance. Thus, factors causing higher futures price volatility will also cause higher cash price volatility. Results suggest increases in speculative activity are associated with decreases in futures price volatility, thus cash price volatility. On balance it appears that policies which limit speculative trade contribute to de-stabilizing cash prices, rather than reducing volatility as intended.*

Ref. 2

COMMISSION REGULATION (EU) 2016/1719 of 26 September 2016 establishing a guideline on forward capacity allocation.

Ref. 3

Liquidity in the GB wholesale energy markets. Discussion Paper published by the British regulator Ofgem 8 June 2009.

Ref. 4

Methods for evaluation of the Nordic forward market for electricity, EC Group, 25 November 2016. Report written by the consultancy EC Group for the Norwegian energy regulator NVE in cooperation with the energy regulators in Denmark, Finland and Sweden.

Ref. 5

The evolution of European traded gas hubs, Oxford Institute for Energy Studies, 2015. On page 45, in a discussion of the Spanish gas market, you find the statement *the churn rate quoted is a very poor 1.77 on the total volumes.*

Ref. 6

Evaluering af fysiske transmissionsrettigheder på Storebæltsforbindelsen. Report 26 June 2015 from the Danish TSO Energinet.dk.

Ref. 7

Wholesale Energy Markets in 2015. Ofgem report 9 September 2015.

Appendix 10 LTTR auctions and power derivatives

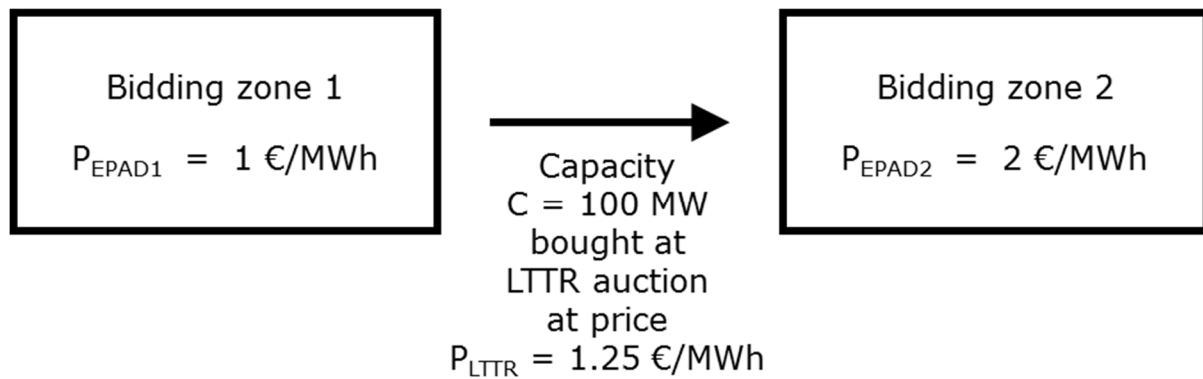


Fig. A10.1 A case.

A10.1 Introduction

The case discussed in this appendix illustrates how the LTTR auctions provide liquidity to Nasdaq's EPAD contracts.

The appendix uses the case from fig. A10.1. In this case, the prices 1 €/MWh and 2 €/MWh are the EPAD contracts' hedging prices at the point in time, where the player buys the LTTR capacity.

The LTTR contract is an April contract. Therefore, the duration T of the LTTR contract is $T = 24 \text{ h/day} * 30 \text{ day} = 720 \text{ h}$.

In the case, both the player and the market expect bidding zone 2 will have the highest spot price.

At the outset, it looks as if the player will have a loss: the EPAD contracts forecast a price difference of 1 €/MWh between the two bidding zones. Nevertheless, the player pays 1.25 €/MWh for the LTTR capacity.

However, as the following calculations will show, in a market with high price volatility, there's a fair chance the LTTR contract will be profitable, even if the EPAD contracts' forecast turn out to be right.

This case discusses two Nordic bidding zones. Hence, the power derivatives are Nasdaq's EPAD contracts.

However, you can make a similar case with one zone being a Nordic bidding zone and the other zone being Germany.

A10.2 Terminology

BZ ₁	Bidding zone 1.
BZ ₂	Bidding zone 2.
C	Capacity bought at LTTR auction in direction from bidding zone 1 to bidding zone 2.
P _{EPAD1}	Hedging price of EPAD contract for bidding zone 1.
P _{EPAD2}	Hedging price of EPAD contract for bidding zone 2.
P ₁	Spot price of bidding zone 1. P ₁ is an average price, where the averaging is done over the duration of the LTTR contract.
P ₂	Spot price of bidding zone 2. P ₂ is an average price, where the averaging is done over the duration of the LTTR contract.
P _{system}	System Price. P _{system} is an average price, where the averaging is done over the duration of the LTTR contract.
ΔP ₁	$\Delta P_1 = P_1 - P_{\text{system}}$.
ΔP ₂	$\Delta P_2 = P_2 - P_{\text{system}}$.
T	The duration of the LTTR contract. Normally, T is either one month or one year.

A10.3 No power derivative

The following calculations give the player's profit, if the player does **not** enter into an EPAD contract.

P₂ > P₁

In this case, the LTTR contract gives a positive cash flow. The size of the difference (P₂ - P₁) determines if the player has a profit.

$$\text{Profit} = C * T * (P_2 - P_1) - C * T * P_{\text{LTTR}}.$$

$$\text{Profit} / (C * T) = (P_2 - P_1) - P_{\text{LTTR}}.$$

Example: PTR for the month of April

If the player bought 100 MW, the player has bought the right to ship this amount of energy from BZ₁ to BZ₂:

$$100 \text{ MW} * 30 \text{ day} * 24 \text{ h/day} = 100 \text{ MW} * 720 \text{ h.}$$

Assume

$$P_{\text{LTTR}} = 1.25 \text{ €/MWh}$$

$$P_2 = 3.00 \text{ €/MWh}$$

$$P_1 = 1.00 \text{ €/MWh}$$

The player's profit is

$$(3 - 1) \text{ €/MWh} * 100 \text{ MW} * 720 \text{ h} - 1.25 \text{ €/MWh} * 100 \text{ MW} * 720 \text{ h.}$$

The player's profit per MWh is

$$(3 - 1) \text{ €/MWh} - 1.25 \text{ €/MWh.}$$

 $P_2 \leq P_1$

In this case, there's no cash flow from the LTTR contract. The player has a negative profit.

$$\text{Profit} = - C * T * P_{\text{LTTR.}}$$

$$\text{Profit} / (C * T) = - P_{\text{LTTR.}}$$

A10.4 The player enters into an EPAD contract

At the outset, the hedging prices of the EPAD contracts predict the player will have a loss. This is because the EPAD contracts predict a price difference of 1 €/MWh between the two price zones, and the player paid 1.25 €/MWh at the LTTR auction.

However, assume we get the following hedging prices at a point in time, which is after the purchase of the LTTR capacity, but before the start of the delivery period. Further, assume the player enters into EPAD contracts as indicated:

$$P_{\text{EPAD1}} = 1 \text{ €/MWh.}$$

The player enters into a bid position in a BZ₁ EPAD contract. The size of the contract is $C * T$.

$$P_{\text{EPAD2}} = 4 \text{ €/MWh.}$$

The player enters into an ask position in a BZ₂ EPAD contract. The size of the contract is $C * T$.

The following calculations give the player's profit. The contribution from the LTTR contract is the same as in the calculations above. However, now we must factor in the cash flows from the two EPAD contracts.

$$\text{Cash flow from BZ}_1 \text{ contract: } (\Delta P_1 - P_{\text{EPAD1}}) * C * T.$$

The player has bid position. Therefore, the player has a positive cash flow from the BZ₁ EPAD, if ΔP_1 turns out high.

Cash flow from BZ₂ contract: $(P_{EPAD2} - \Delta P_2) * C * T$.

The player has ask position. Therefore, the player has a positive cash flow from the BZ₂ EPAD, if ΔP_2 turns out low.

Sum of cash flows from EPAD contracts:

$$[(\Delta P_1 - \Delta P_2) + (P_{EPAD2} - P_{EPAD1})] * C * T = [(P_1 - P_2) + (P_{EPAD2} - P_{EPAD1})] * C * T$$

$P_2 > P_1$

$$\text{Profit} / (C * T) = (P_1 - P_2) + (P_{EPAD2} - P_{EPAD1}) + (P_2 - P_1) - P_{LTTR}$$

$$= (P_{EPAD2} - P_{EPAD1}) - P_{LTTR}.$$

The profit is independent of the spot prices P_1 and P_2 .

In the case, we have for the player's EPAD contracts

$$(P_{EPAD2} - P_{EPAD1}) = 4 \text{ €/MWh} - 1 \text{ €/MWh} > P_{LTTR}.$$

$P_2 \leq P_1$

$$\text{Profit} / (C * T) = (P_1 - P_2) + (P_{EPAD2} - P_{EPAD1}) - P_{LTTR}.$$

Note that $(P_1 - P_2) \geq 0$.

The spot price difference gives the player an extra profit, if the market's and the player's forecast of the spot price difference turns out to be wrong.

No trading of System Price contracts is needed when a player hedges the profit from an LTTR contract between two Nordic bidding zones.

Conclusion

If the player enters into EPAD contracts, the player's profit will at least be

$$(P_{EPAD2} - P_{EPAD1}) - P_{LTTR}.$$

There's an extra contribution to the profit from the spot price difference, if the forecast of the sign of $(P_1 - P_2)$ turns out to be wrong.

Hence, after having bought an LTTR contract, the player can lock in the future profit by using Nasdaq's EPAD contracts.

Nasdaq's EPAD contracts can be used to hedge the profit from the LTTR contract

Further, this explains why the LTTR auctions provide liquidity to Nasdaq's EPAD contracts.

A10.5 If the market has high price volatility

Note the prices in the case: at the outset, Nasdaq's EPAD contracts forecast the player will have a loss.

However, at the LTTR auctions, players will be willing to pay a price higher than the EPAD contracts' difference, if the market is very volatile. With a volatile market, there's a chance that you can lock in a positive profit after having bought the LTTR capacity.

Naturally, you may turn the timing around: you may enter into the EPAD contracts before buying the LTTR capacity, if you have a forecast indicating the combination of the EPAD hedging prices and the price at the future LTTR auction will be profitable.

Appendix 11 Open Interest, exchange turnover, spreads, auction data and consumption

The Kontek interconnector linking DK2 and Germany

PTR auctions with UIOSI were introduced 1 January 2014 (i.e. the first PTR auctions took place at the end of 2013).

In the following tables, the red numbers are from the period before 1 January 2014, whereas the green number are from the period after this date.

The Great Belt interconnector linking DK1 and DK2

Monthly PTR auctions were introduced on the Great Belt interconnector 1 July 2014. The first auction took place 24 June 2014.

The average spreads

For each of the first four tables, the numbers in first column labelled *Average spread* indicate the average of the spreads during the trading period.

The numbers in the second column labelled *Average spread* indicate the average of the red and the green spreads, respectively.

Note that the contract Q1-2014 was mainly traded before the start of PTR auctions on the Kontek interconnector. Therefore, the mean of this contract's spreads is included in the averaging of the spreads before the introduction of the PTR auctions.

Data

The sources for the data in this appendix are:

- * The Danish Energy Agency (data on consumption).
- * Syspower (data on Open Interest, spreads, Nasdaq's exchange turnover of EPADs).

Unless otherwise noted, in this report, Syspower is the source of all these data. Further, Syspower is the source of data on closing prices/last fix for Nasdaq's power derivatives.

The source of data on the German contracts' settlement prices is www.eex.de.

- * Energinet.dk (data on the LTTR auctions).

This investigation uses data from Syspower, because getting reliable historical data from Nasdaq was a problem.

2 April 2017

DK1	Consumption and EPAD data ²⁶								Auction data ²⁷							
	OI and consumption			Exchange turnover ²⁸		Ex-change turnover /Consumption	Average spread	Average spread	Average volume per hour during quarter				Sum		Average	
	OI ²⁹	Consumption ³⁰	OI/Consumption	Quarter	Annual				DK1→DE	DE→DK1	DK2→DE	DE→DK2	DK1↔DE	DK2↔DE	DK1↔DE	DK2↔DE
Contract	GWh	GWh	Pct.	GWh	GWh	pct.	EUR	EUR	MWh/h							
2012-Q1	1 698	5 433	31%	908	1 085	37%	0.49	0.45	337	337	0	0	675	0	577	0
2012-Q2	1 621	4 641	35%	880	1 085	42%	0.55		329	329	0	0	658	0		
2012-Q3	1 146	4 572	25%	678	1 097	39%	0.51		203	312	0	0	515	0		
2012-Q4	1 507	5 317	28%	831	1 097	36%	0.44		278	349	0	0	627	0		
2013-Q1	1 162	5 421	21%	732	678	26%	0.30		222	437	0	0	660	0		
2013-Q2	1 441	4 675	31%	793	686	32%	0.59		172	359	0	0	531	0		
2013-Q3	936	4 621	20%	631	693	29%	0.47		202	338	0	0	540	0		
2013-Q4	1 016	5 172	20%	749	693	28%	0.38		143	267	0	0	410	0		

²⁶ Source to EPAD data: Syspower.

²⁷ The sum of capacity sold via annual and monthly auctions. Source: www.energinet.dk. The data from Energinet.dk and www.jao.eu do not agree.

²⁸ The column "Quarter" contains the exchange turnover for the EPAD quarter contracts. The column "Annual" contains the contribution from the EPAD annual contracts. For example, for Q1, in a non-leap year, the contribution from the annual contract is (turnover annual contract)*90/365.

²⁹ Open Interest for the EPAD quarter contract one of the last three trading days before delivery. Due to the cascading of the annual contracts, this contains the contribution from both annual and quarter contracts.

³⁰ Source: www.ens.dk. The numbers indicate the consumption excl. losses in the transmission grid. The consumption for 2016-Q4 is estimated using the numbers from the previous quarters.

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DK1	Consumption and EPAD data								Auction data							
	OI and consumption			Exchange turnover		Ex-change turnover /Con-sumption	Aver-age spread	Aver-age spread	Average volume per hour during quarter				Sum		Average	
Con-tract	OI	Con-sumption	OI/Con-sumption	Quar-ter	An-nual				DK1→DE	DE→DK1	DK2→DE	DE→DK2	DK1↔DE	DK2↔DE	DK1↔DE	DK2↔DE
	GWh	GWh	Pct.	GWh	GWh	pct.	EUR	EUR	MWh/h							
2014-Q1	967	5 278	18%	816	410	23%	0.35	0.50	123	450	237	237	573	475	295	450
2014-Q2	642	4 649	14%	756	415	25%	0.39		107	298	195	195	405	390		
2014-Q3	563	4 602	12%	455	420	19%	0.57		33	174	240	240	207	480		
2014-Q4	937	5 171	18%	767	420	23%	0.38		0	203	240	240	203	480		
2015-Q1	844	5 270	16%	609	266	17%	0.38		0	0	240	240	0	480		
2015-Q2	867	4 621	19%	428	269	15%	0.42		0	73	202	202	73	404		
2015-Q3	437	4 686	9%	384	272	14%	0.53		0	117	240	240	117	480		
2015-Q4	550	5 285	10%	524	272	15%	0.44		0	265	198	237	265	436		
2016-Q1	681	5 421	13%	227	199	8%	0.47		0	446	240	240	446	480		
2016-Q2	782	4 720	17%	162	199	8%	0.76		0	437	199	177	437	376		
2016-Q3	537	4 590	12%	179	201	8%	0.62		0	450	243	242	450	486		
2016-Q4	718	5 178	14%	349	201	11%	0.50		0	361	214	214	361	428		

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DK2	Consumption and EPAD data								Auction data							
	OI and consumption			Exchange turnover		Ex-change turnover /Con-sumption	Aver-age spread	Aver-age spread	Average volume per hour during quarter				Sum		Average	
	OI	Con-sump-tion	OI/Con-sumption	Quar-ter	An-nual				DK1→DE	DE→DK1	DK2→DE	DE→DK2	DK1↔DE	DK2↔DE	DK1↔DE	DK2↔DE
Con-tract	GWh	GWh	Pct.	GWh	GWh	pct.	EUR	EUR	MWh/h							
2012-Q1	297	3 739	8%	520	181	19%	0.84	0.60	337	337	0	0	675	0	577	0
2012-Q2	284	3 074	9%	301	181	16%	0.66		329	329	0	0	658	0		
2012-Q3	623	2 996	21%	631	183	27%	0.65		203	312	0	0	515	0		
2012-Q4	585	3 628	16%	554	183	20%	0.85		278	349	0	0	627	0		
2013-Q1	514	3 792	14%	576	281	23%	0.63		222	437	0	0	660	0		
2013-Q2	797	3 088	26%	448	284	24%	0.52		172	359	0	0	531	0		
2013-Q3	1 199	2 984	40%	636	287	31%	0.45		202	338	0	0	540	0		
2013-Q4	636	3 479	18%	477	287	22%	0.43		143	267	0	0	410	0		

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DK2	Consumption and EPAD data								Auction data							
	OI and consumption			Exchange turnover		Ex-change turnover /Con-sumption	Aver-age spread	Aver-age spread	Average volume per hour during quarter				Sum		Average	
	OI	Con-sumption	OI/Con-sumption	Quar-ter	An-nual				DK1→DE	DE→DK1	DK2→DE	DE→DK2	DK1↔DE	DK2↔DE	DK1↔DE	DK2↔DE
Con-tract	GWh	GWh	Pct.	GWh	GWh	pct.	EUR	EUR	MWh/h							
2014-Q1	497	3 564	14%	516	238	21%	0.38	0.60	123	450	237	237	573	475	295	450
2014-Q2	751	3 000	25%	454	240	23%	0.48		107	298	195	195	405	390		
2014-Q3	607	2 978	20%	446	243	23%	0.59		33	174	240	240	207	480		
2014-Q4	431	3 456	12%	241	243	14%	0.55		0	203	240	240	203	480		
2015-Q1	427	3 560	12%	237	274	14%	0.44		0	0	240	240	0	480		
2015-Q2	616	3 008	20%	146	277	14%	0.52		0	73	202	202	73	404		
2015-Q3	325	2 938	11%	190	280	16%	0.57		0	117	240	240	117	480		
2015-Q4	654	3 442	19%	141	280	12%	0.59		0	265	198	237	265	436		
2016-Q1	644	3 645	18%	63	310	10%	0.68		0	446	240	240	446	480		
2016-Q2	358	3 014	12%	122	310	14%	0.80		0	437	199	177	437	376		
2016-Q3	433	2 939	15%	126	314	15%	0.73		0	450	243	242	450	486		
2016-Q4	592	3 444	17%	199	314	15%	0.65		0	361	214	214	361	428		

Average spreads of the annual EPAD contracts				
Contract	DK1		DK2	
	Contract's average spread	Average of red and green spreads, respectively	Contract's average spread	Average of red and green numbers, respectively
	€	€	€	€
2012	0.57	0.44	0.73	0.48
2013	0.41		0.34	
2014	0.33		0.39	
2015	0.37	0.37	0.49	0.50
2016	0.37		0.50	

The average spreads of the annual EPAD contracts.

For each contract, this is the average of the spreads during the last year before delivery.
For the 2012 contract, it's the average from 28 April 2011 to 23 December 2011, though.

Note that the contract 2014 was mainly traded before the start of PTR auctions on the Kontek interconnector.