Investigation of forward markets for hedging in the Danish electricity market
## Contents

1. Introduction  
2. Executive summary  
3. The Danish electricity market  
4. EEX and Nasdaq  
4.1 Turnover at EEX and Nasdaq  
4.2 Trading horizons  
5. The German power market  
6. Hedging models  
6.1 Nasdaq’s System Price model  
6.2 EEX’s Location Spread model  
7. Analysis of forward markets for hedging in Denmark  
7.1 Correlation between prices  
7.2 Other correlation coefficients  
7.3 Spot prices and hedging prices – risk premium  
7.4 Student’s t test for the quarter contracts  
7.5 Student’s t test for the annual contracts  
7.6 The risk premiums in course of time – the annual contracts  
7.7 The risk premiums in course of time – the quarter contracts  
7.8 Other calculations  
7.9 Liquidity  
7.9.1 Volume indicators of liquidity  
7.9.2 Spreads  
7.9.3 The spreads in course of time  
7.10 Conclusion from the analysis  
8. Interviews with market players  
9. Potential remedies  
9.1 Stimulation of the forward markets  
9.2 LTTR auctions  
9.3 The split liquidity argument  

Appendix 1 Terms and abbreviations  
Appendix 2 The Baltic-Nordic bidding zones  
Appendix 3 The Nordic System Price  
Appendix 4 Open Interest  
Appendix 5 Price volatility at the new and the old power market  
Appendix 6 Questionnaire no. 1  
Appendix 7 Questionnaire no. 2  
Appendix 8 References  
Appendix 9 LTTR auctions and power derivatives  
Appendix 10 Open Interest, exchange turnover, spreads, auction data and consumption
1. 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.

2. Executive summary
The liquidity of Nasdaq’s Danish EPAD contracts is low. Further, measured as a percentage of the consumption, the exchange turnover and the Open Interest is declining. So is Nasdaq’s turnover of Nordic power derivatives.

The consumers’ risk premium is high.
Correspondingly, for the interconnectors linking Sweden/Norway and Denmark, both FSE and the majority of the energy companies interviewed to this report support introduction of PTR/FTR auctions\(^1\).

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.

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).

### 3. The Danish electricity market

In 2015, the consumption was about 20 TWh in Western Denmark and 13 TWh in Eastern Denmark\(^2\).

<table>
<thead>
<tr>
<th></th>
<th>Consumption 2015 in TWh(^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>521</td>
</tr>
<tr>
<td>Sweden + Norway</td>
<td>264</td>
</tr>
<tr>
<td>Nordic (Sweden+Norway+Finland+Denmark)</td>
<td>379</td>
</tr>
</tbody>
</table>

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.

\(^1\) FSE is the Danish federation of energy consumers (the big users of electricity and gas). Please refer to appendix 1.

\(^2\) Source: www.ens.dk.

\(^3\) Source: ENTSO-E.
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 contracts. 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.

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

Table 3.2 Interconnector capacities and average consumption 2016 for DK1 and DK2. All values in MW.

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

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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 3.1, 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.

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 Nasdaq. For both EEX and Nasdaq, the figure illustrates the cleared volume: (contracts traded off-exchange and subsequently cleared) + (contracts traded at the exchange).

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6 Sources: EEX press releases, Nasdaq press releases and Nasdaq/Nord Pool annual reports.
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. 4.3.
6. Hedging models
Currently, we have (at least) two European models for hedging and trading power derivatives.

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

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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.
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. 3.1, 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 liquidity.8

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. 4.3.

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 turnover 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.

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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.
<table>
<thead>
<tr>
<th>Country</th>
<th>Consumption 2015 in TWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>70</td>
</tr>
<tr>
<td>Belgium</td>
<td>85</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>63</td>
</tr>
<tr>
<td>Denmark</td>
<td>32</td>
</tr>
<tr>
<td>France</td>
<td>475</td>
</tr>
<tr>
<td>Luxemburg</td>
<td>6</td>
</tr>
<tr>
<td>Netherlands</td>
<td>113</td>
</tr>
<tr>
<td>Poland</td>
<td>151</td>
</tr>
<tr>
<td>Switzerland</td>
<td>63</td>
</tr>
</tbody>
</table>

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 also analyses of Germany and SE4.

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 investigation shows the liquidity for this system is small and the risk premium is high.

In this case, proxy hedging is an option. Instead of using 

\[(\text{System Price}) + \text{EPAD}\]

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

In the Nordic area, the obvious alternative to \((\text{System Price}) + \text{EPAD}\) 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.

As illustrated by the example in appendix 5, it’s the correlation between the hourly prices, which must be high. For sake of completeness, the correlations between monthly averages and annual averages are displayed in chapter 7.2, though.

As can be seen from table 7.1: 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.
## Correlation between hourly prices

<table>
<thead>
<tr>
<th>Year</th>
<th>DK1 System Price</th>
<th>DK1 Germany</th>
<th>DK2 System Price</th>
<th>DK2 Germany</th>
<th>SE4 System Price</th>
<th>SE4 Germany</th>
<th>Germany System Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>0.49</td>
<td>0.71</td>
<td>0.51</td>
<td>0.68</td>
<td>-</td>
<td>-</td>
<td>0.51</td>
</tr>
<tr>
<td>2008</td>
<td>0.65</td>
<td>0.76</td>
<td>0.67</td>
<td>0.74</td>
<td>-</td>
<td>-</td>
<td>0.58</td>
</tr>
<tr>
<td>2009</td>
<td>0.68</td>
<td>0.67</td>
<td>0.53</td>
<td>0.33</td>
<td>-</td>
<td>-</td>
<td>0.55</td>
</tr>
<tr>
<td>2010</td>
<td>0.54</td>
<td>0.87</td>
<td>0.65</td>
<td>0.27</td>
<td>-</td>
<td>-</td>
<td>0.47</td>
</tr>
<tr>
<td>2011</td>
<td>0.53</td>
<td>0.81</td>
<td>0.48</td>
<td>0.83</td>
<td>-</td>
<td>-</td>
<td>0.33</td>
</tr>
<tr>
<td>2012</td>
<td>0.61</td>
<td>0.79</td>
<td>0.68</td>
<td>0.77</td>
<td>0.88</td>
<td>0.52</td>
<td>0.45</td>
</tr>
<tr>
<td>2013</td>
<td>0.21</td>
<td>0.20</td>
<td>0.72</td>
<td>0.77</td>
<td>0.83</td>
<td>0.67</td>
<td>0.58</td>
</tr>
<tr>
<td>2014</td>
<td>0.62</td>
<td>0.73</td>
<td>0.68</td>
<td>0.70</td>
<td>0.77</td>
<td>0.58</td>
<td>0.56</td>
</tr>
<tr>
<td>2015</td>
<td>0.67</td>
<td>0.59</td>
<td>0.67</td>
<td>0.55</td>
<td>0.84</td>
<td>0.44</td>
<td>0.34</td>
</tr>
<tr>
<td>2016</td>
<td>0.75</td>
<td>0.81</td>
<td>0.84</td>
<td>0.70</td>
<td>0.88</td>
<td>0.64</td>
<td>0.66</td>
</tr>
<tr>
<td><strong>2007-2016</strong></td>
<td><strong>0.53</strong></td>
<td><strong>0.61</strong></td>
<td><strong>0.65</strong></td>
<td><strong>0.55</strong></td>
<td><strong>0.88</strong></td>
<td><strong>0.56</strong></td>
<td><strong>0.53</strong></td>
</tr>
</tbody>
</table>

Table 7.1 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.

For comparison, for the years 2013–2016, table 7.2 gives the correlation between the System Prices and the spot prices of the Baltic-Nordic bidding zones.

---

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

For proxy hedging, as shown in the example in appendix 5, it’s the correlation between the hourly prices that matters. However, for sake of completeness, this chapter shows the correlation between the monthly average prices and the annual average prices.

### Correlation between average annual prices for the ten years 2007-2016

<table>
<thead>
<tr>
<th>Danish bidding zone</th>
<th>System Price</th>
<th>Germany</th>
</tr>
</thead>
<tbody>
<tr>
<td>DK1</td>
<td>0.90</td>
<td>0.94</td>
</tr>
<tr>
<td>DK2</td>
<td>0.96</td>
<td>0.85</td>
</tr>
</tbody>
</table>

Table 7.3 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.
<table>
<thead>
<tr>
<th>Year</th>
<th>DK1</th>
<th>DK2</th>
<th>SE4</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>0.86</td>
<td>0.87</td>
<td>-</td>
</tr>
<tr>
<td>2008</td>
<td>0.66</td>
<td>0.73</td>
<td>-</td>
</tr>
<tr>
<td>2009</td>
<td>0.82</td>
<td>0.53</td>
<td>-</td>
</tr>
<tr>
<td>2010</td>
<td>0.62</td>
<td>0.94</td>
<td>-</td>
</tr>
<tr>
<td>2011</td>
<td>0.76</td>
<td>0.70</td>
<td>-</td>
</tr>
<tr>
<td>2012</td>
<td>0.73</td>
<td>0.75</td>
<td>0.95</td>
</tr>
<tr>
<td>2013</td>
<td>0.34</td>
<td>0.69</td>
<td>0.80</td>
</tr>
<tr>
<td>2014</td>
<td>0.39</td>
<td>0.47</td>
<td>0.59</td>
</tr>
<tr>
<td>2015</td>
<td>0.88</td>
<td>0.85</td>
<td>0.96</td>
</tr>
<tr>
<td>2016</td>
<td>0.90</td>
<td>0.91</td>
<td>0.94</td>
</tr>
</tbody>
</table>

Table 7.4 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.

7.3 **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:

\[
P_{\text{spot}} \quad \text{Spot price for the bidding zone in question.}
\]

\[
P_{\text{system}} \quad \text{System Price.}
\]

\[
P_{\text{SYS}} \quad \text{Hedging price of System Price contract.}
\]

\[
P_{\text{EPAD}} \quad \text{Hedging price of EPAD contract for the bidding zone in question.}
\]

\[
R \quad \text{Ex-post risk premium. In this document, the following is the definition of the ex-post risk premium (“risk premium” in short version of the term)}
\]

\[
R = P_{\text{spot}} - (P_{\text{SYS}} + P_{\text{EPAD}}).
\]
Hence, a negative value is “negative” for consumers.

\[ R_{SYS} \text{ System Price contract’s contribution to ex-post risk premium } \]
\[ R_{SYS} = P_{system} - P_{SYS}. \]

\[ R_{EPAD} \text{ EPAD contract’s contribution to ex-post risk premium } \]
\[ R_{EPAD} = (P_{spot} - P_{system}) - P_{EPAD}. \]

\[ R = P_{spot} - (P_{SYS} + P_{EPAD}) \]
\[ = P_{system} - P_{system} + P_{spot} - P_{SYS} - P_{EPAD} \]
\[ = (P_{system} - P_{SYS}) + (P_{spot} - P_{system}) - P_{EPAD} \]
\[ = R_{SYS} + R_{EPAD}. \]

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.

The report *Methods for evaluation of the Nordic forward market for electricity* 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, the problem is that 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).

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, 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.
<table>
<thead>
<tr>
<th></th>
<th>DK1</th>
<th>DK2</th>
<th>SE4</th>
<th>Contribution from System Price contracts</th>
<th>Germany</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quarter contracts</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The 44 quarters Q1-2006 – Q4-2016</td>
<td>-5.03</td>
<td>-4.40</td>
<td>-3.56</td>
<td>-2.51</td>
<td>-</td>
</tr>
<tr>
<td>Annual contracts</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The 15 years 2002 – 2016</td>
<td>-3.60</td>
<td>-3.11</td>
<td>-7.21</td>
<td>-1.66</td>
<td>-3.45</td>
</tr>
</tbody>
</table>

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 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.

As can be seen from table 7.5: 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 a number of years, where EEX’s turnover 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.

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10 For SE4, the calculation uses the 5 years 2012-2016 and the 20 quarters Q1-2012 – Q4-2016.
11 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.
7.4 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:

\[ \text{MEAN}_{\text{forward}} \]
the mean of the quarters’ forward prices.
Here, for each quarter, the forward price is calculated as in table 7.5.

\[ \text{MEAN}_{\text{spot}} \]
the mean of the quarters’ spot prices.
This is almost the same as the as the mean of the hourly spot prices. It’s not exactly the same as the mean of the spot prices, because the quarters do not have the same number of hours.

**Hypothesis H:** \[ \text{MEAN}_{\text{forward}} \leq \text{MEAN}_{\text{spot}} \]

The hypothesis H can be rejected with the confidence indicated in table 7.6.

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

<table>
<thead>
<tr>
<th>Quarter contract</th>
<th>DK1</th>
<th>DK2</th>
<th>SE4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reject H with confidence more than</td>
<td>99.5%</td>
<td>99.0%</td>
<td>97.5%</td>
</tr>
</tbody>
</table>

Table 7.6

**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.

7.5 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.
7.6 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.

![Diagram showing annual contracts DK1](image)

Fig. 7.1 The risk premium for DK1 annual contracts. The forward price is calculated as indicated in table 7.5.
Fig. 7.2 The risk premium for DK2 annual contracts. The forward price is calculated as indicated in table 7.5.

Fig. 7.3 The risk premium for SE4 annual contracts. The forward price is calculated as indicated in table 7.5.
Fig. 7.4 The System Price contracts’ contribution to the annual contracts’ risk premium. The forward price is calculated as indicated in table 7.5.

Fig. 7.5 The risk premium for German annual contracts. The forward price is calculated as indicated in table 7.5.
7.7 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 7.5.
Fig. 7.7 The risk premium for DK2 quarter contracts. The forward price is calculated as indicated in table 7.5.

Average: -4.4 €/MWh
Ex-post risk premium: (spot price) – (forward price)
Linear regression
Quarter contracts DK2
Quarter number (from Q1-2006 to Q4-2016)

Fig. 7.8 The risk premium for SE4 quarter contracts. The forward price is calculated as indicated in table 7.5.

Average: -3.6 €/MWh
Ex-post risk premium: (spot price) – (forward price)
Linear regression
Quarter contracts SE4
Quarter number (from Q1-2012 to Q4-2016)
Fig. 7.9 The System Price contracts’ contribution to the quarter contracts’ risk premium. The forward price is calculated as indicated in table 7.5.

7.8 Other calculations
The regulation requires an investigation of hedging (ref. 2). To model hedging, the analysis must use the average of the forward prices’ closing prices (where the averaging is done over a period reflecting how hedging is done).

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.
### Table 7.7

<table>
<thead>
<tr>
<th></th>
<th>DK1</th>
<th>DK2</th>
<th>SE4(^{12})</th>
<th>Contribution from System Price contracts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quarter contracts</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The 44 quarters Q1-2006 – Q4-2016</td>
<td>-3.4</td>
<td>-3.6</td>
<td>-1.9</td>
<td>-1.6</td>
</tr>
<tr>
<td>Annual contracts</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The 15 years 2002 – 2016</td>
<td>-3.3</td>
<td>-3.2</td>
<td>-5.1</td>
<td>-1.6</td>
</tr>
</tbody>
</table>

Table 7.7 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.

### 7.9 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.

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\(^{12}\) For SE4, the calculation uses the 5 years 2012-2016 and the 20 quarters Q1-2012 – Q4-2016.

\(^{13}\) Ref. 5.
### 7.9.1 Volume indicators of liquidity

Concerning hedging: as can be seen from table 7.2, 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 chapter 7.1, 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 questionnaire, 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. 3). As can be seen from the figures in this chapter and from the tables in appendix 10, 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 10: 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 10.

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 10.
7.9.2 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.

<table>
<thead>
<tr>
<th></th>
<th>DK2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before introduction of PTR on the Kontek interconnector</td>
<td>0.60 €</td>
</tr>
<tr>
<td>After introduction of PTR on the Kontek interconnector</td>
<td>0.60 €</td>
</tr>
</tbody>
</table>

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 if 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.

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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.
<table>
<thead>
<tr>
<th>Average spreads of Nasdaq’s quarterly EPADs for DK1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before introduction of PTR on the Kontek interconnector(^{16})</td>
</tr>
<tr>
<td>After introduction of PTR on the Kontek interconnector(^{17})</td>
</tr>
</tbody>
</table>

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 offered\(^{18}\).

Also for DK1, the majority if 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 10 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 deteriorate 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.

### 7.9.3 The spreads in course of time

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

![Average spreads Nasdaq’s quarter contracts](image)

**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 the 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 the System Price contracts, the averaging runs over the last three quarters before the start of the delivery period.
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).

7.10 Conclusion from the analysis
The liquidity of Nasdaq’s Danish EPAD contracts is low. Further, measured as a percentage of the consumption, the exchange turnover and the Open Interest is declining. So is Nasdaq’s turnover of Nordic power derivatives.

The consumers’ risk premium is high.

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

\[ R = R_{SYS} + R_{EPAD}. \]

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.

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.

Appendix 6 and appendix 7 contain the answers to the questionnaires.

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. Presumably, due to such departments, the TSOs would be subject 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.

A 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 SE4. January 2013, the consultant published the report “Analys av möjliga åtgärder för att minska prisområdesproblematiken i Sydsverige”. One of the report’s proposals was that the Swedish TSO should offer Nasdaq’s EPAD contracts.

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 försvagas.

Later in March 2013, the proposal was also rejected by the Swedish Energy Agency, the Swedish Energy Markets Inspectorate and the Swedish TSO.

September 2013, the Swedish government rejected the proposal.

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 transaction costs originating from JAO registration, if JAO starts operating LTTR auctions on the SE/NO-DK interconnectors.

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19 Source: Montel Power News 1 November 2012.
21 Source: www.konkurrensverket.se/nyheter/konkurrensverket-avvisar-elomradesforslag
LTTR auctions provide liquidity to power derivatives, as explained in appendix 9. 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 9.

### 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 9 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.

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 The Liberalized Electricity Market. At www.houmollerconsulting.dk, you can download the article from the sub-page Facts and findings.

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](http://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](http://www.houmollerconsulting.dk), you can download the article from the sub-page Facts and findings.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>German contract</td>
<td>In this document, this is a power derivative having the German spot price as the underlying reference.</td>
</tr>
<tr>
<td>German spot price</td>
<td>See Phelix.</td>
</tr>
<tr>
<td>Grid parity</td>
<td>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.</td>
</tr>
<tr>
<td>IAS 39</td>
<td>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.</td>
</tr>
<tr>
<td>Implicit auction</td>
<td>The common term for market coupling and market splitting.</td>
</tr>
<tr>
<td>Interconnector</td>
<td>In this document, an interconnector is a power line connecting two bidding zones.</td>
</tr>
<tr>
<td>JAO</td>
<td>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. See <a href="http://www.jao.eu">www.jao.eu</a>.</td>
</tr>
</tbody>
</table>
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](http://www.nasdaqomx.com/commodities)

Nordic area

In this document, the term refers to the countries Denmark, Finland, Norway and Sweden.

OI

Open Interest.

Open Interest

For a given financial product, this is the net hedging done by means of the product. The sum of a financial product's exchange turnover and bilateral turnover 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 cleared volume (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 marked 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 *The Liberalized Electricity Market*. At [www.houmollerconsulting.dk](http://www.houmollerconsulting.dk), you can download the article from the sub-page Facts and findings.

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 deriviate, 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.

UIOASI

Use-It-Or-Sell-It. This applies to PTR auctions. With the UIOASI 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 contracts.

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.

<table>
<thead>
<tr>
<th>EPAD contract (hedging in Western Denmark)</th>
<th>EPAD contract’s hedging period</th>
<th>Open Interest for this contract noted at this point in time</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYARHYR-16</td>
<td>Calendar year 2016</td>
<td>End of December 2015</td>
</tr>
<tr>
<td>SYARHQ1-16</td>
<td>Q1-2016</td>
<td>End of December 2015</td>
</tr>
<tr>
<td>SYARHQ2-16</td>
<td>Q2-2016</td>
<td>End of March 2016</td>
</tr>
<tr>
<td>SYARHQ3-16</td>
<td>Q3-2016</td>
<td>End of June 2016</td>
</tr>
<tr>
<td>SYARHQ4-16</td>
<td>Q4-2016</td>
<td>End of September 2016</td>
</tr>
</tbody>
</table>

Table A4.1

---

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).
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.

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 side.\(^{25}\)

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 market’s hourly price volatility. Some market players have speculated that slicing

---

\(^{25}\) 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.
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:

\[
300 \text{ MWh} \times 3,000 \text{ €/MWh} = 900,000 \text{ €}.
\]

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

\[
300 \times 40 \text{ €/MWh} = 12,000 \text{ €}.
\]

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

Aa 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.

----------------------------------------------

General

1. Do you want to answer this questionnaire anonymously?  Yes ☐ No ☐  
   Answers Yes 3 No 2  
   (one interviewee wanted anonymity for some answers)

EPAD contracts

2. Does your company use EPAD contracts?  Yes ☐ No ☐  
   Answers Yes 6 No 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 that 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?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

Answers (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 is a correlation between increasing interest in EPADs in those periods in which there has been held 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 turnover 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 turnover 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
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 today 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?

<table>
<thead>
<tr>
<th>Prefer PTR auctions ☐</th>
<th>Prefer FTR auctions ☐</th>
</tr>
</thead>
<tbody>
<tr>
<td>Answers</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>(one interviewee was indifferent)</td>
</tr>
<tr>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

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 indifferentere om det bliver den ene eller anden løsning.
Other comments
Please feel free to give further comments to the investigation

-------------

There is no 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.

---------------------------------

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 pricedependent 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 inked 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 the immedeitatly (often) change. If you hit on a price (buy or sell), market will move the full spread. So then you don’t/cant get your volume done. I Sweden the show weekly EPADs. Financial market day ahead, weeks would help.

----------

The more products introduced, the less liquidity in each product, hense 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
References

Ref. 1
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
Appendix 9
LTTR auctions and power derivatives

Fig. A9.1  A case.

A9.1 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. A9.1. 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 $T = 24 \text{ h/day} \times 30 \text{ day} = 720 \text{ h}$.

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.
A9.2 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.

\[\Delta P_1 = P_1 - P_{system}.\]

\[\Delta P_2 = P_2 - P_{system}.\]

T  The duration of the LTTR contract. Normally, T is either one month or one year.

A9.3 No power derivative

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

P_2 > P_1

In this case, the LTTR contract gives a positive cash flow. The size of the difference (P_2 – P_1) determines if the player has a profit.

\[\text{Profit} = C \times T \times (P_2 - P_1) - C \times T \times P_{LTTR}.\]

\[\frac{\text{Profit}}{C \times T} = (P_2 - P_1) - P_{LTTR}.\]
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:

\[ 100 \text{ MW} \times 30 \text{ day} \times 24 \text{ h/day} = 100 \text{ MW} \times 720 \text{ h}. \]

Assume

\[
\begin{align*}
P_{\text{LTTR}} &= 1.25 \text{ €/MW} \\
P_2 &= 3.00 \text{ €/MWh} \\
P_1 &= 1.00 \text{ €/MWh}
\end{align*}
\]

The player’s profit is

\[
(3 - 1) \text{ €/MWh} \times 100 \text{ MW} \times 720 \text{ h} - 1.25 \text{ €/MWh} \times 100 \text{ MW} \times 720 \text{ h}.
\]

The player’s profit per MWh is

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

If \( P_2 \leq P_1 \),

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

\[
\text{Profit} = - C \times T \times P_{\text{LTTR}}.
\]

\[
\frac{\text{Profit}}{(C \times T)} = - P_{\text{LTTR}}.
\]

A9.4 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:

\[
\begin{align*}
P_{\text{EPAD1}} &= 1 \text{ €/MWh}. \\
P_{\text{EPAD2}} &= 4 \text{ €/MWh}.
\end{align*}
\]

The player enters into a bid position in a BZ1 EPAD contract. The size of the contract is \( C \times T \).

The player enters into an ask position in a BZ2 EPAD contract. The size of the contract is \( C \times T \).

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.

Cash flow from BZ1 contract: \((\Delta P_1 - P_{\text{EPAD1}}) \times C \times T\).

The player has bid position. Therefore, the player has a positive cash flow from the BZ1 EPAD, if \( \Delta P_1 \) turns out high.
Cash flow from BZ\textsubscript{2} contract: \((P_{\text{EPAD}2} - \Delta P_{2}) \ast C \ast T\).
The player has ask position. Therefore, the player has a positive cash flow from the BZ\textsubscript{2} EPAD, if \(\Delta P_2\) turns out low.

Sum of cash flows from EPAD contracts:
\[
\left[ (\Delta P_1 - \Delta P_2) + (P_{\text{EPAD}2} - P_{\text{EPAD}1}) \right] \ast C \ast T = [(P_1 - P_2) + (P_{\text{EPAD}2} - P_{\text{EPAD}1})] \ast C \ast T
\]

\(P_2 > P_1\)
Profit \(\frac{\text{}}{(C \ast T)}\) = \((P_1 - P_2) + (P_{\text{EPAD}2} - P_{\text{EPAD}1}) + (P_2 - P_1) - P_{\text{LTTR}}\)

\[
= (P_{\text{EPAD}2} - P_{\text{EPAD}1}) - P_{\text{LTTR}}.
\]

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

In the case, we have for the player’s EPAD contracts
\((P_{\text{EPAD}2} - P_{\text{EPAD}1}) = 4 \, \text{€/MWh} - 1 \, \text{€/MWh} > P_{\text{LTTR}}\).

\(P_2 \leq P_1\)
Profit \(\frac{\text{}}{(C \ast T)}\) = \((P_1 - P_2) + (P_{\text{EPAD}2} - P_{\text{EPAD}1}) - P_{\text{LTTR}}\).

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
\((P_{\text{EPAD}2} - P_{\text{EPAD}1}) - P_{\text{LTTR}}\).

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.
A9.5 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 10
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.
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**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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## Consumption and EPAD data

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<td>2 938</td>
<td>11%</td>
<td>190</td>
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<td>16%</td>
<td>0.57</td>
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<td>3 442</td>
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<td>3 645</td>
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<td>480</td>
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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.