Wind Power and Spot Prices in Denmark and Germany

Statistical Survey 2009

1. Preface

This text updates *Wind Power and Spot Prices: German and Danish Experience 2006-2008*[1] by adding a comprehensive data survey for the calendar year 2009, and extending the study to cover hourly wind data from all four German control areas.

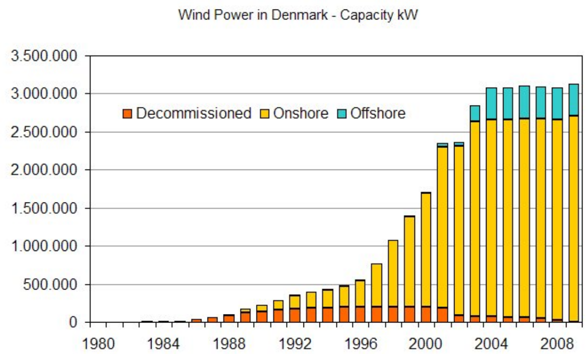
The evaluations are based on market data published by Energinet.dk, and by the four German transmission system operators, and on market reports from Energinet.dk. Evaluations are offered, though with reservations regarding the accuracy of the data.

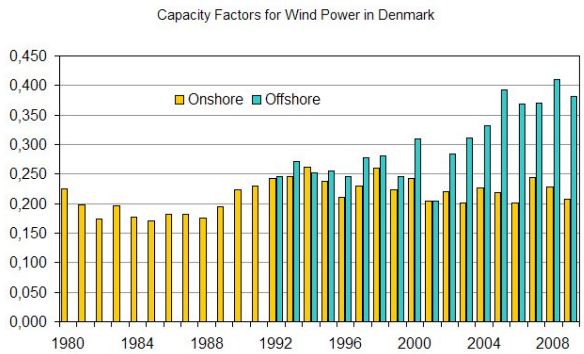
Abbreviations:

EEX	European Energy Exchange	DKE	Denmark East	DE	Germany
NP	Nord Pool	N	Norway	ENDK	Energinet.dk
DKW	Denmark West	S	Sweden		

2. Overview

Wind power performance





- In 2009 the energy content of wind in Denmark was 87.9% of the energy content in a normal wind year.[2]
- The total production of wind energy in 2009 was 6.7 TWh in Denmark and 37.7 TWh in Germany.
- The average capacity factors in Denmark were 0.21 onshore and 0.37 offshore. The corresponding duration hours were 1,820 hours onshore and 3,343 hours offshore.
- The production of wind energy was equivalent to 19.4% of the electricity demand in Denmark in 2009.
- For Denmark and Germany together the share of wind energy has been estimated as equivalent to 7.6% of the aggregated demand.

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[1] http://www.ref.org.uk/PublicationDetails/53
[2] http://www.energinet.dk/NR/rdonlyres/63304588-44E6-4576-9D03-6723E3D4E6D0/0/Milj%C3%B8deklarationer2009forellevereti%C3%98stogVestdanmark.pdf

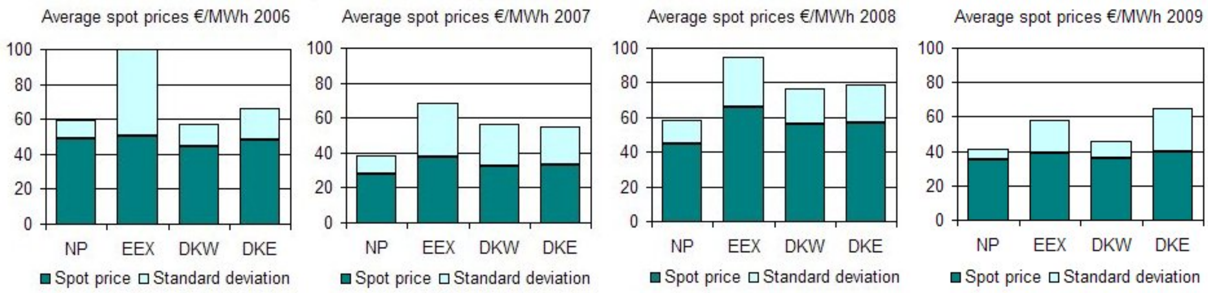
– There is a high positive correlation between German and Danish wind power energy flows.
– Calm periods with low wind power output occur simultaneously in Denmark and Germany. The minimum average wind power output during 24 consecutive hours in 2009 was 0.23% of the maximum hourly production for Denmark, and 1.61% for Denmark and Germany together.

Interconnector performance

– The Danish interconnections had low availability for trade in 2009 due to outages of interconnector equipment, and the limited capacity of adjoining transmission grids.

2009	Average availabilities of interconnections			
%	To DKW	From DKW	To DKE	From DKE
Norway	90.9	90.0		
Sweden	70.9	76.3	76.3	91.6
Germany	90.9	75.4	93.0	86.5

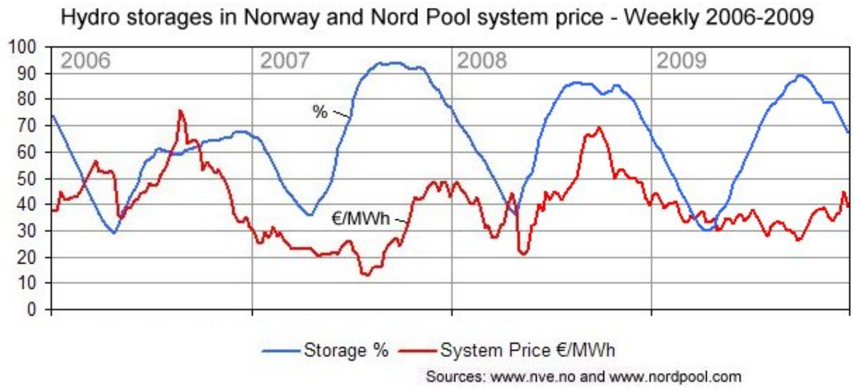
Market performance



– The average spot prices were low in 2009, with NP, EEX and the two Danish areas exhibiting similar prices.
– Low standard deviations indicate good spot price stability, but do not exclude the occurrence of extreme prices.
– The German spot market seems to respond to changing conditions with an increasing number of extreme spot prices.
– 71 hours with negative spot prices have been observed for Germany in 2009.
– Nord Pool allowed negative spot prices in Denmark from October 2009: 9 hours with negative spot prices occurred in west Denmark in December 2009.
– Periods with price spikes have been observed for east Denmark, particularly during the autumn of 2009, the main reason being limitations placed on the interconnection with Sweden (Øresund). Consequences of the Swedish congestion policy are demonstrated for selected cases.
– Regardless of causes the Nordic electricity transmission system has been insufficient to provide a reasonably functioning market in east Denmark in 2009.

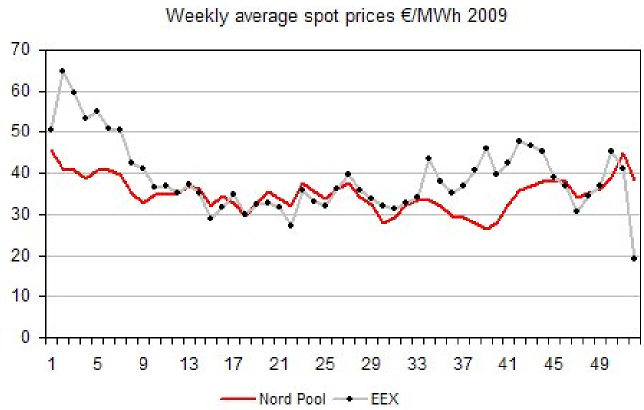
	2006	2007	2008	2009
No of hours	Spot price = 0	Spot price = 0	Spot price = 0	Spot price <= 0
West Denmark (DKW)	28	85	28	55
East Denmark (DKE)	5	30	9	4
Nord Pool system price	0	0	0	3
EEX, Germany	10	28	35	73

3. Neighbouring countries in 2009



The water storage levels in Norwegian hydro and the Nord Pool spot price indicate stability and normal conditions.

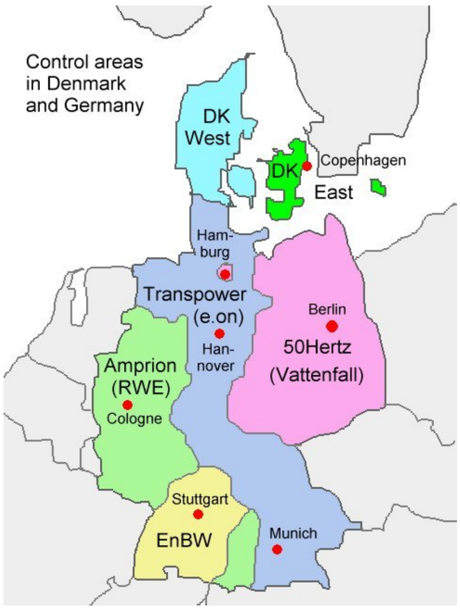
Furthermore Germany and the Nordic area have had similar average spot price levels during most weeks in 2009. Based on this observation only a limited transit of power should be expected.



Unlike previous years hourly wind power data has been downloaded for all four German control areas.

The recorded vertical German demand seems to be incomplete. Therefore this set of data had to be ignored in this report. According to IndexMundi the estimated German electricity consumption in 2009 was 549 TWh.[3]

The German system operators are: Transpower (former E.on Netz), Amprion (RWE), EnBW and 50Hertz (former Vattenfall Transmission).



[3] http://www.indexmundi.com/germany/electricity_consumption.html

4. Main characteristics of Danish power systems in 2009

4.1. Annual key figures

The following table is based on market data from Energinet.dk:

	Demand	Net exchange		Wind generation		Wind energy export		
	MWh	Export MWh	Import Mwh	MWh	% of demand	MWh	Hours	% of wind generation
DK West	20,550.012	3,171.098	982,890	5,123,249	24.9	2,476.214	5,683	48.3
DK East	14,049.905	376,231	2,898,132	1,586,727	11.3	278,179	1,972	17.5
DK (total)	34,599.917			6,709,976	19.4			

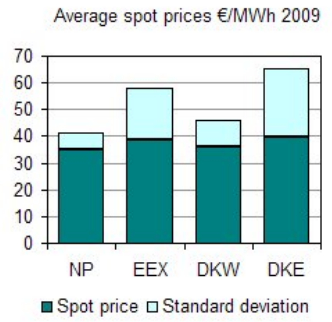
The net export has been calculated hour by hour as the total of all exchange from each of the two Danish systems. In this context the *wind energy export* has been defined for each system and for each hour as the smaller value of generated wind energy and net export.

The duration hours have been calculated as annual energy demand divided by maximum load. They tell the same story as the load factor (duration hours divided by the number of hours in the year). The year 2009 had 8,760 hours.

Demand	Max	Duration
	MW	Hours
West	3,677	5,588
East	2,614	5,374
Denmark	6,287	5,503

The average market conditions are summarized in this table:

	Area price	St.Dev.		Spot price	St.Dev.
	€/MWh	€/MWh		€/MWh	€/MWh
DK West	35.95	10.14	NP	34.90	6.26
DK East	39.76	25.50	EEX	38.78	19.40

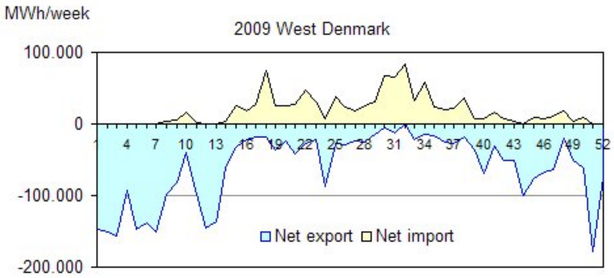


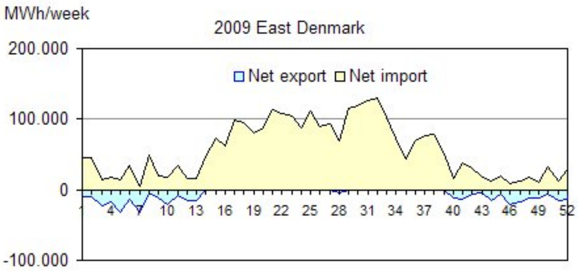
The standard deviation is an indicator of the price volatility. The possible reasons for the differences will be discussed subsequently.

The magnitude of the overflow problem due to Danish wind power can be indicated in a table with number of hours with spot prices equal to zero and downwards balancing prices equal to or below zero. When the price of balancing (or regulating) power is below 0 the system operator must pay for export of energy. Nord Pool introduced negative spot prices in October 2009.

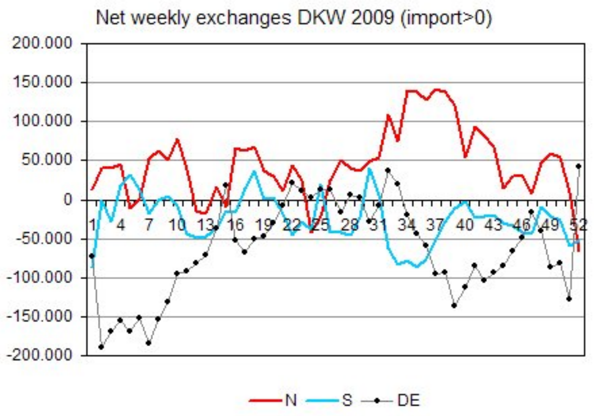
No of hours	Spot price <= 0	Spot price >100	Bal. price <= 0	Bal. price >100
DK West	55	4	159	77
DK East	4	98	30	319
Nord Pool	3	4		
EEX	73	45		

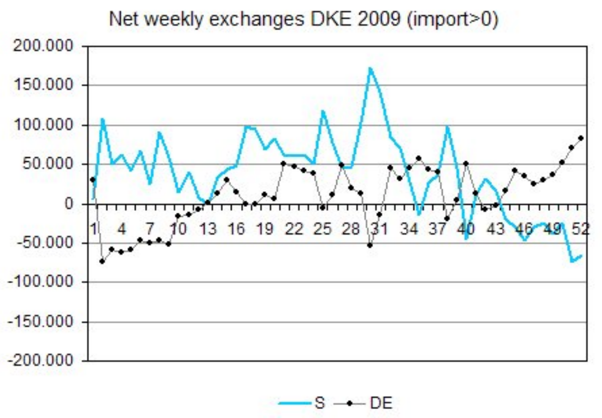
4.2. Weekly averages



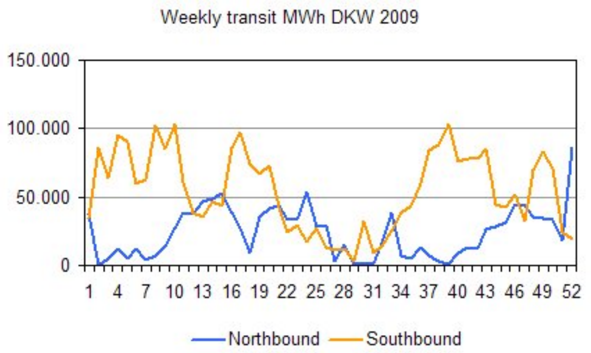


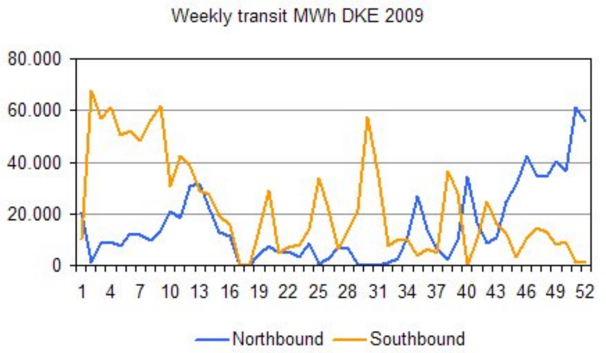
Net exchanges per hour have been accumulated for each of the two Danish control areas (above) and for each border (below). The charts show a significant surplus of electricity during the cold seasons for Western Denmark.



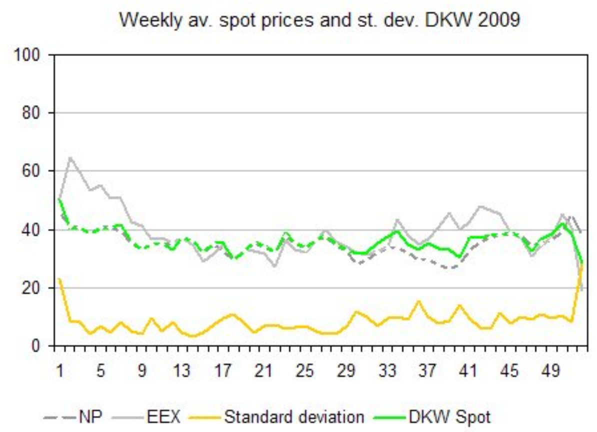


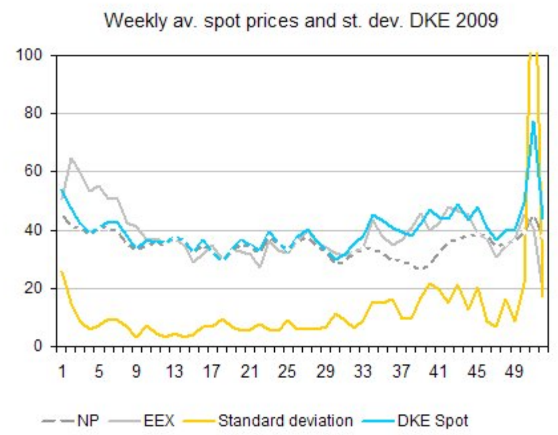
Transit has been calculated hour by hour. In accordance with the spot price profile (chapter 2) there is a mainly southbound transit during the first ten weeks, but no predominant direction during the summer.





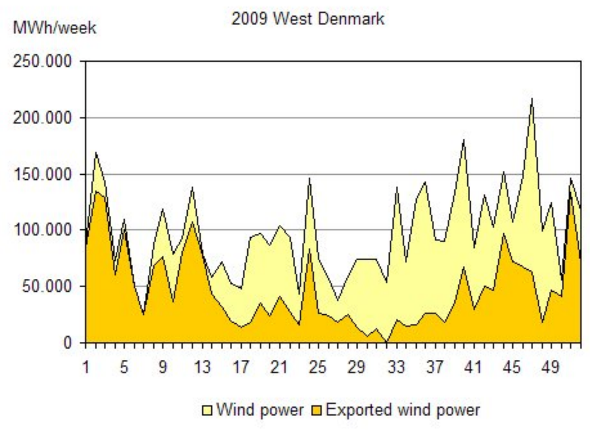
During transit periods congestion on one of the interconnectors is common. The spot prices of the two Danish systems follow either Nord Pool or EEX depending on which interconnector is congested.

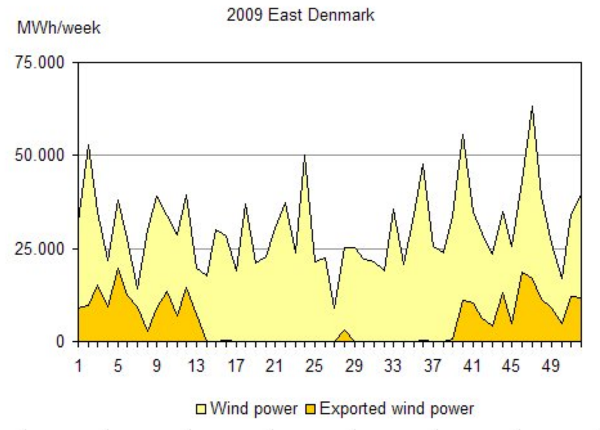




The chart suggests congestion on the borders between Denmark and Germany during the first ten weeks and congestion between Eastern Denmark and Sweden during the weeks 33 to 45. In chapter 4 we shall evaluate the situation in Eastern Denmark in week number 51.

The generation of wind energy varies considerably from week to week.



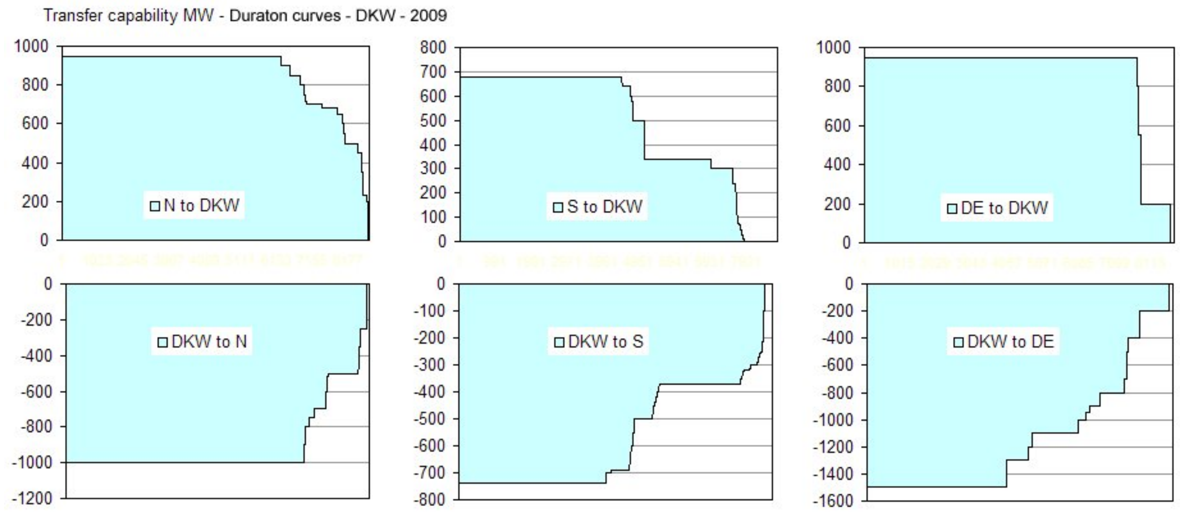


Following the definition in 3.1 the wind energy is divided into an export share (the light brown area) and a share used locally (the light yellow area). The estimate of exported wind energy is a sensitive matter because it raises doubts about the beneficiary of subsidised Danish renewable energy. The chart indicates that the share of exported wind energy is high during the cold seasons when increased demand for heat entails high electricity production from the CHP plants.

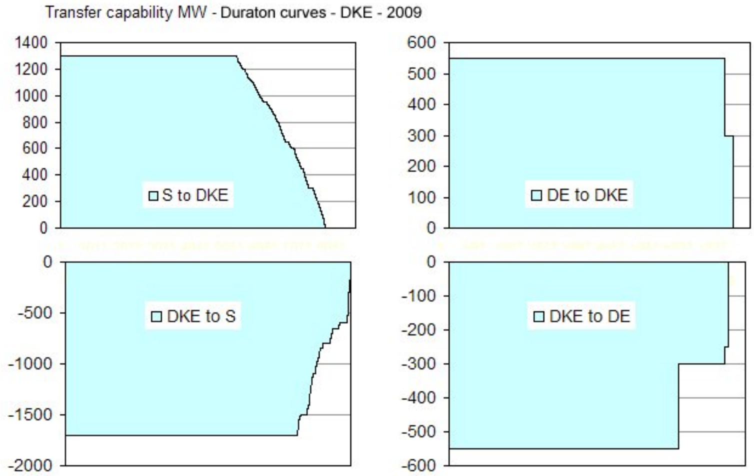
4.3. Interconnector Performance

The electricity market is the modern tool for optimizing power system operation across national borders. Sufficient transport capacity is a decisive factor for both reasonable system security and an efficient market service.

The trading capacity on the 400 kV AC interconnection between West Denmark and Germany depends on stability limits of the interconnected AC networks.



The duration curves above for West Denmark shows that the HVDC links to Norway and Sweden continued to suffer from severe hardware faults during 2009, the transfer capability from West Denmark to Germany being more or less reduced for nearly half of 2009.



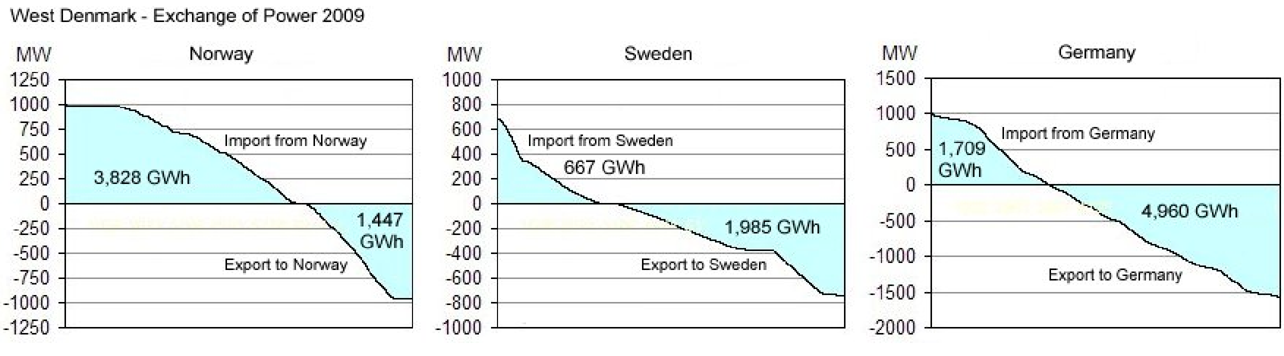
The capacity reductions on the AC interconnection between Denmark East and Sweden reflect Swedish congestion policy. The Nordic system operators use different methods for the handling of internal bottlenecks. Norway is divided into areas with different area prices in case of congestion, whereas it is the Swedish policy to maintain the same spot price for all parts of the country. Therefore internal bottlenecks are transferred into reduced trading capacity on interconnectors.

Interconnections are often supposed to have nearly 100% availability. The Danish observations from the period 2006 to 2009 demonstrate that the practical availabilities are much lower.

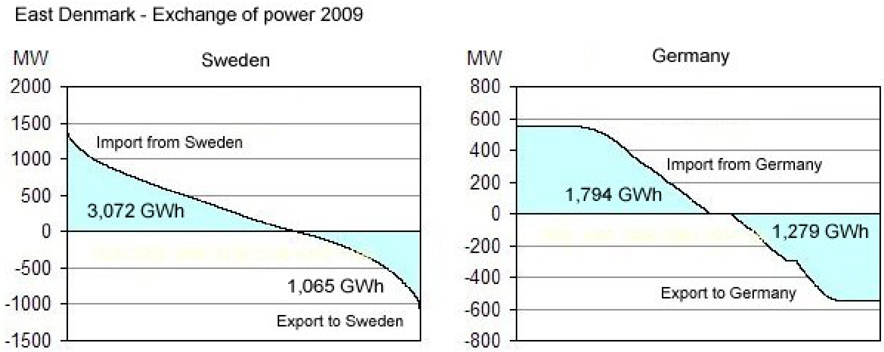
2009	Average availabilities of interconnections			
%	To DKW	From DKW	To DKE	From DKE
Norway	90.9	90.0		
Sweden	70.9	76.3	76.3	91.6
Germany	90.9	75.4	93.0	86.5

Interconnections can help smooth spot price oscillations due to intermittent generation (particularly wind power), but, obviously, this is only true if there is capacity available for this purpose.

The following charts give an impression of the amounts exchanged in 2009:



The distribution suggests a certain transit from Norway to Sweden. 1,009 GWh were transferred from Norway to Sweden via Denmark during 3,793 hours in 2009.



In the following table the number of hours with import, export and congestion is shown for each of the five interconnectors.

Hours	Export	Congest.	Import	Congest.	Total	% congest.
DKW-N	2725	11	5989	2625	8760	30,1
DKW-S	5925	927	2604	214	8760	13,0
DKW-DE	5806	2351	2952	353	8760	30,9
DKE-S	3085	32	5674	673	8760	8,0
DKE-DE	3595	1067	4696	1391	8760	28,1

4.4. Wind Power Properties

Downloading hourly wind power output for Germany allows us to study the wind power profile for a larger geographical area than Denmark. It is particularly interesting as a means of evaluating whether the smoothing effect can eliminate the occurrence of sharp peaks and times of zero production.

2009		Transpower	Amprion	EnBW	50Hertz	DE total
Wind	GWh	15,437	6,479	453	15,369	37,738
Max	MW	8,383	3,678	349	8,888	20,349
Min	MW	0	21	0	1	159
Duration	Hours	1,841	1,762	1,297	1,729	1,854
Share	%	-	-	-	-	6.9

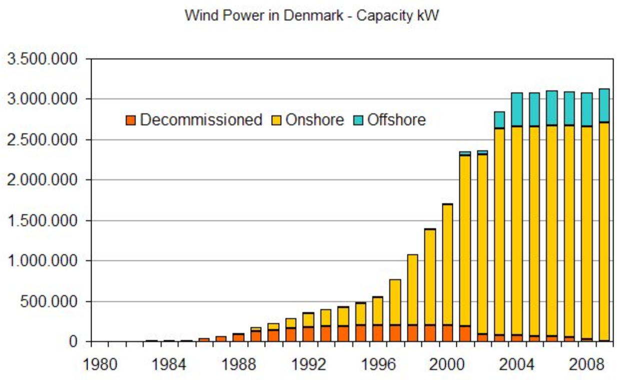
The German share of wind energy has been based on an estimated total electricity consumption of 549 TWh.

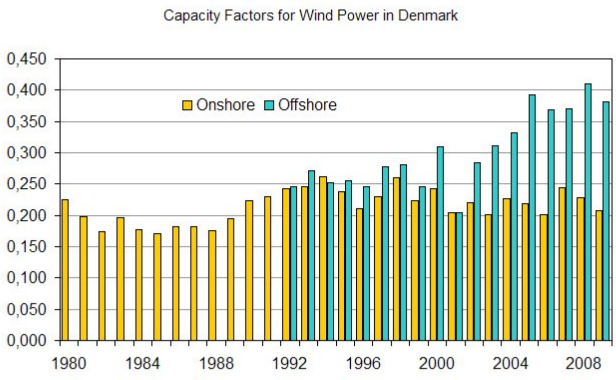
2009		DKW	DKE	DK total	DE/DK total
Wind	GWh	5,122	1,586	6,708	44,446
Max	MW	2,262	669	2,877	21,678
Min	MW	0	0	1	223
Duration	Hours	2,265	2,372	2,331	2,054
Share	%	24.9	11.3	19.4	7.6

At the end of 2008 the installed wind power capacity in Denmark was 3,085 MW of which 423 MW was offshore capacity.[4] The installed capacity in Germany at the end of 2008 was

[4] http://www.ens.dk

23,903 MW.[5] The first German offshore wind farm, Alpha Ventus (60 MW), was completed in 2009.[6]

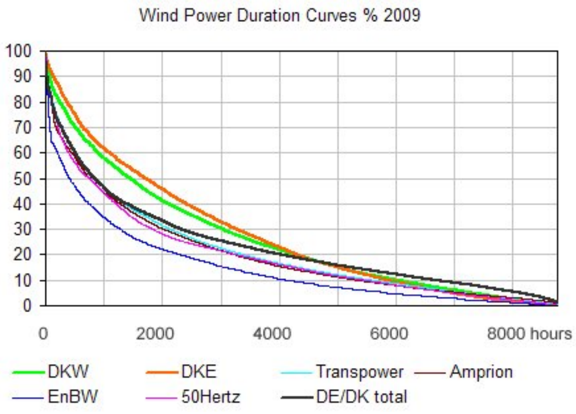


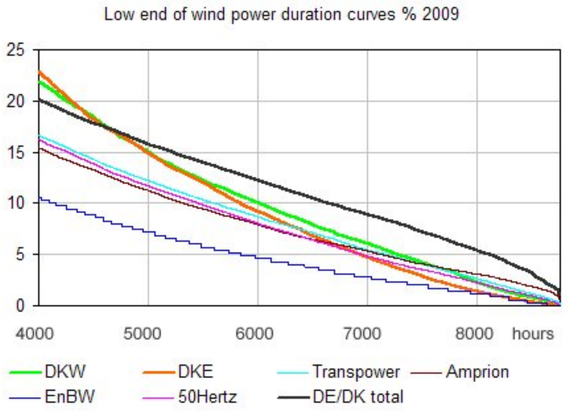


Note that these charts include only those wind turbines which have been in operation during the entire year.

The maximum simultaneous wind power production for Denmark and Germany was 21,678 MW in 2009 or 89.5% of the sum of the six local *peak* productions (24,229 MW).

The wind power duration curves have been calculated as a percentage of the annual maximum production in order to facilitate comparisons. The curves have different profiles reflecting different wind resources and different shares of offshore wind power.





The close-up on the lower end of the duration curves demonstrates the smoothing effect for periods with low wind power output. In this range the aggregated curve shows higher values than each of the six control area curves.

The maximum aggregated wind power output for the six areas is 21,678 MW or 89% of the sum of the maximum productions for each area. The total installed wind power capacity in Denmark and Germany at the beginning of 2009 was about 27,000 MW. The average installed capacity in 2009 has probably been slightly higher than 27,000 MW.

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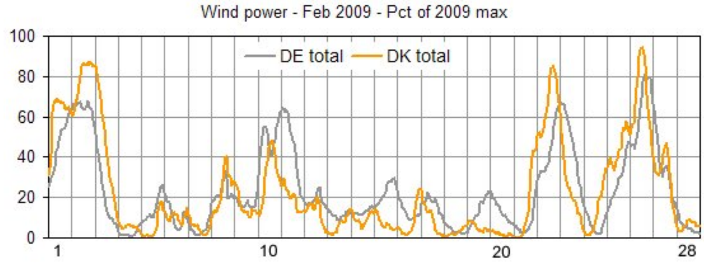
[5] http://www.wind-energie.de/de/statistiken/datenblatt-2008/

[6] http://www.monstersandcritics.com/news/business/news/article_1513628.php/Germany-completes-construction-of-first-offshore-wind-farm

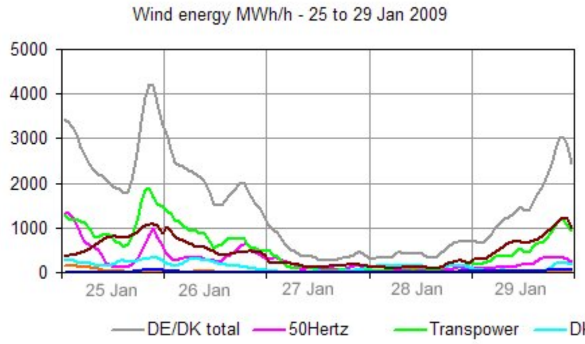
It is possible to demonstrate that the wind power variations in Denmark and Germany are quite closely synchronized, as in the following example (in percent of the year's maximum aggregated output for each of the two countries).

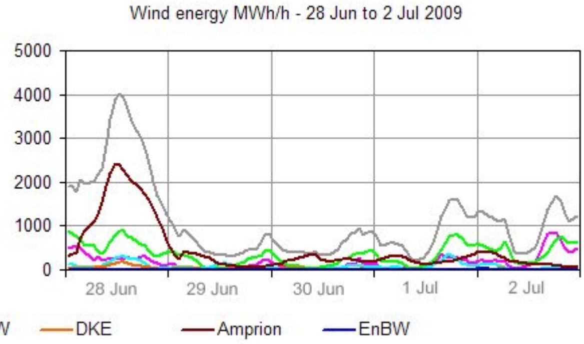


The minimum aggregated wind power output is interesting for operational purposes.

2009	Wind power minimum average sustained output in % of annual hourly maximum								
	DKW	DKE	Transpower	Amprion	EnBW	50Hertz	DK total	DE total	DE/DK total
Hours	%	%	%	%	%	%	%	%	%
1	0.00	0.00	0.00	0.57	0.00	0.01	0.04	0.78	1.03
12	0.16	0.01	0.30	1.00	0.00	0.13	0.33	1.12	1.47
24	0.23	0.10	0.71	1.37	0.25	0.58	0.39	1.28	1.61

Consecutive days with wind power output in Denmark and Germany lower than 1000 MW have been observed in January and June 2009.





A capacity credit can be calculated for a fleet of wind turbines by use of statistical methods, and capacity credits between 6 and 10% of the installed wind power capacity have been proposed.

However, it should be noted that the capacity credits for adjacent areas cannot be added. Wind power plants do not operate in a stochastically independent manner, because they all depend on a common and related source, the wind.

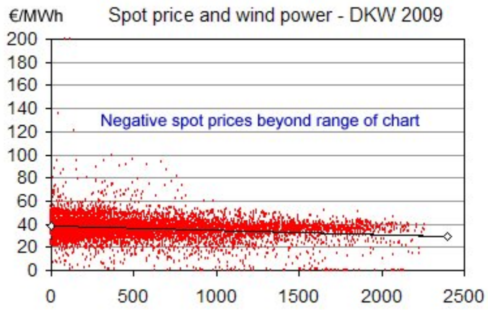
In the determination of the necessary reserve capacity for Denmark and Germany the wind power fleet should therefore be considered as one unit. The security criteria for the operation must be based on the minimum sustained capacity of the total wind fleet which seems to be less than 1% of the installed capacity for 1 hour and less than 1.5% for 24 hours.

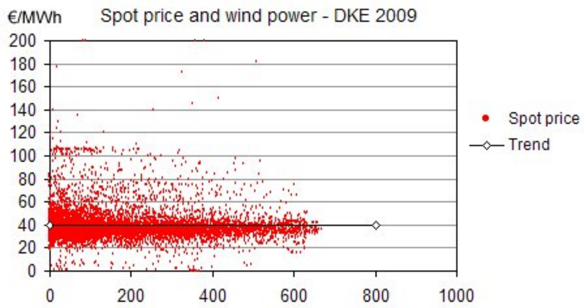
5. Wind Power and Spot Markets

Wind power has an impact on market prices in two ways:

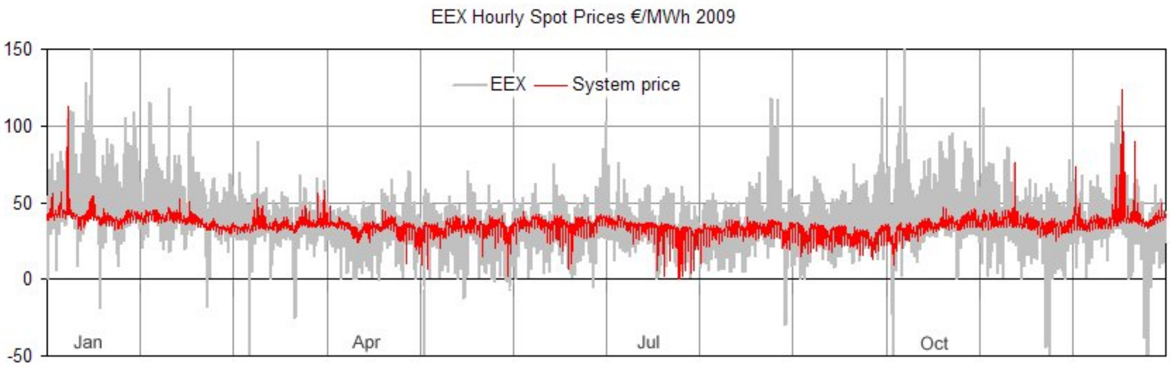
- increasing wind generation may cause reduced prices
- the volatility of wind power may cause price volatility

The following diagrams show local spot prices and wind power for the entire year 2009. The correlations are surprisingly low. Several other factors than wind power have an impact on market prices. Nord Pool allowed negative spot prices in Denmark from 1 October 2009. A few cases have been observed. The new price floor is -200 €/MWh.



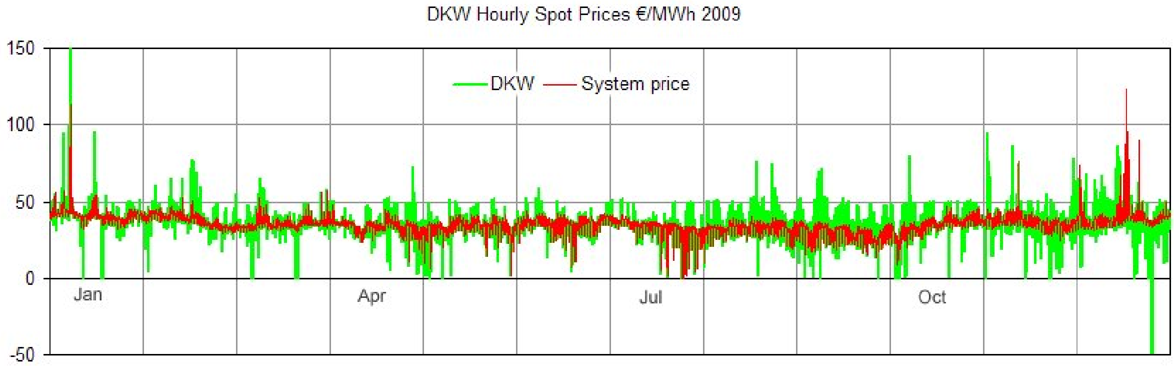


A time series with hourly spot prices can be used for the identification of some characteristic periods.

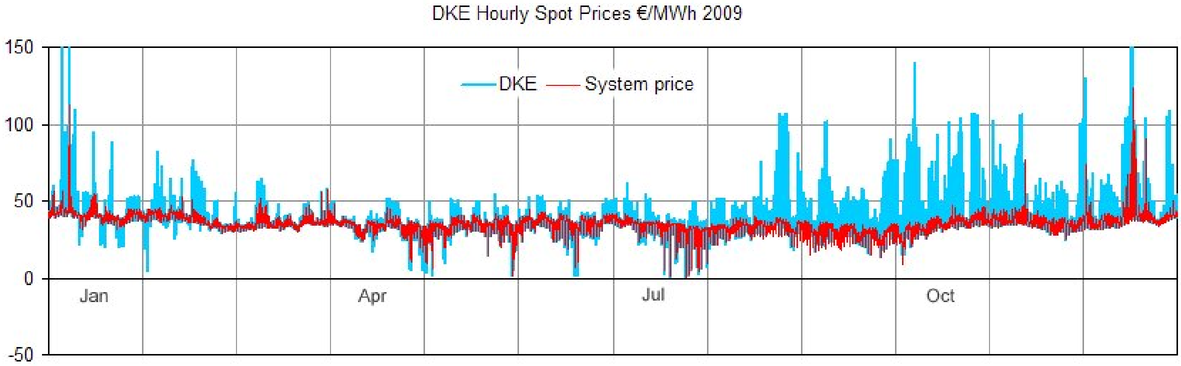


The chart above compares the EEX spot price with the Nord Pool system price. The high volatility and the negative spot prices in the German market is obvious, but even the system price has a slightly higher volatility than in previous years.

In the following chart several cases of zero spot prices in Western Denmark are visible, and the first negative spot prices are observable in December.



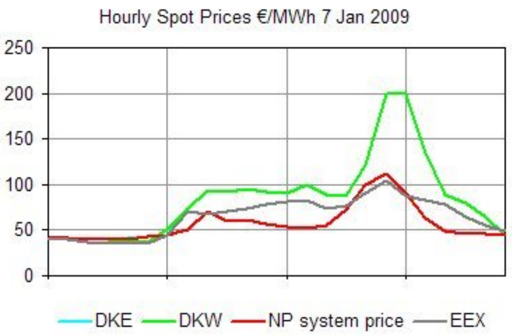
Only a few cases of zero prices have been observed in Eastern Denmark, but there has been a series of high prices during the autumn, as can be seen in the subsequent chart:

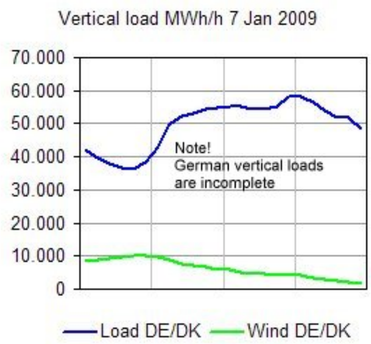


The following observations from these charts have been selected for examination:

- 4.1: Price spikes in January
- 4.2: Zero prices in all Nordic countries in July
- 4.3: "Nordic electricity prices hit rock bottom" (Energinet.dk, September)
- 4.4: Price spikes in DKE during autumn
- 4.5: Positive and negative price spikes in December

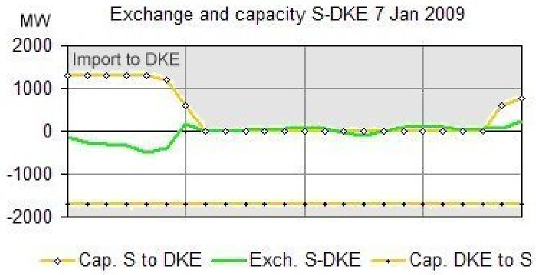
5.1. 7th January 2009: Denmark isolated from other spot markets

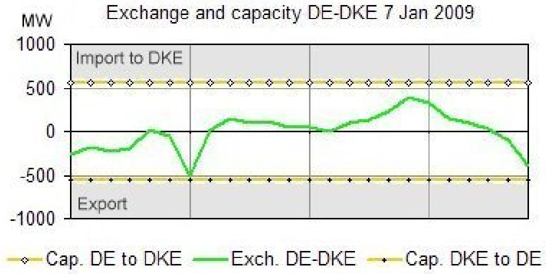




The spot price curves are interesting because the Nord Pool system price and the EEX spot price are at the same level during the evening peak, while the two Danish area prices are higher and identical throughout the day.

Price spikes in Germany and Denmark due to increasing demand and falling total wind power output during the day are not surprising, but the isolated nature of the Danish price curves call for an explanation.





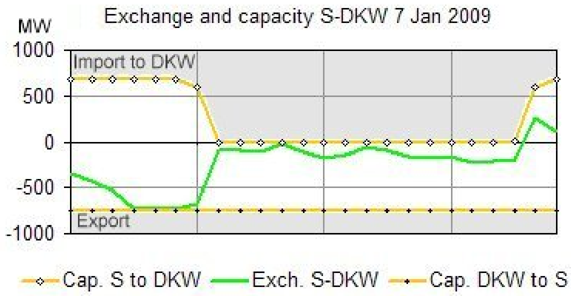
The transfer capability from Sweden to Eastern Denmark has been reduced to zero throughout the day, which explains the price difference between Eastern Denmark and Sweden.

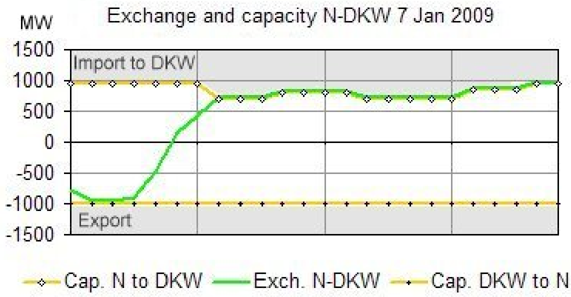
The exchange between Eastern Denmark and Germany has not been constrained. The missing market coupling between Denmark and Germany may justify the price difference.

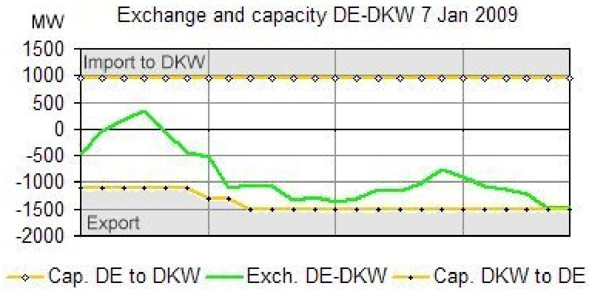
The market in Western Denmark has also been effectively isolated from the Nordic market due to grid constraints. There has been an export to Germany of about 1,000 MW throughout the day, a flow which runs against strong price signals and indicates inefficient market arrangements across the border.

Interconnectors from Norway to the Netherlands and from Sweden to Germany bypass Denmark, and they may have connected the Nordic and the continental markets and caused a consistency between the Nordic system prices and the EEX prices.

On the 7th January 2010 from 7 to 22 the spot markets in the two Danish price areas were disconnected from spot markets in the neighbouring countries. The identity of spot prices in the two Danish price areas is remarkable and suggests inefficient competition in the spot market.





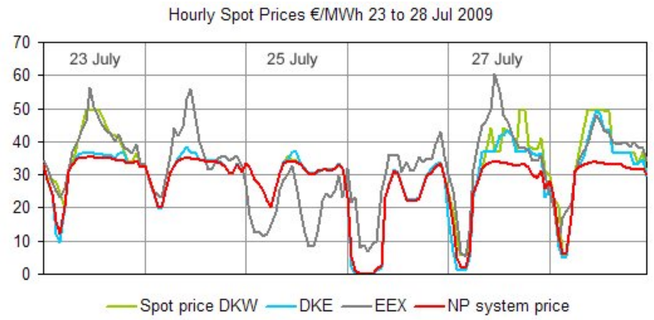


The spot price study tried to confirm a hypothesis relating to the correlation between wind power and spot prices, but found more complex explanations. In line with observations from the previous three years this case demonstrates that volatile spot prices are caused by a combination of several circumstances, such as grid congestion, inefficient market arrangements, and shortage of generation. Abuse of market power could be a contributing factor. Wind power has not yet been identified as the only reason.

5.2. 26th July 2009: Zero Prices in all Nordic Countries

In July 2009 the Nord Pool spot price was more volatile than usual, and during the night of 26th July zero spot prices are recorded for all 4 Nordic countries.

During 5 of the 6 days on the chart the EEX price was higher than the Nord Pool system price.

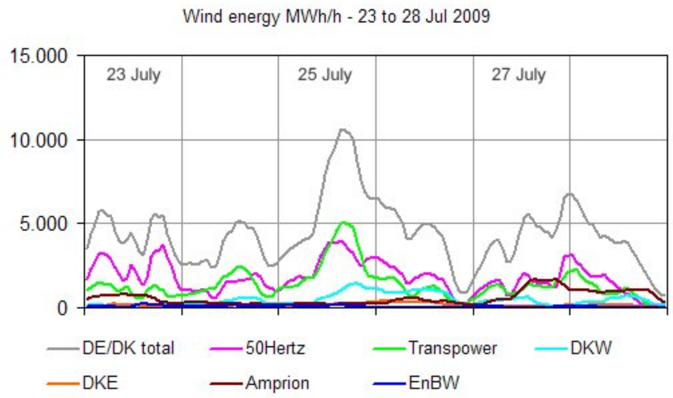


The Energinet.dk Market Report for July 2009 has the following explanations:

> In July, the water level in the Nordic hydro reservoirs started out below the norm for the time of the year, and although the water level rose during the month, it never reached normal levels.
>
> \- - -
>
> The price fall in the Nordic market was therefore mainly the result of seasonal fluctuations in the demand. Due to the small increase in the coal price, the average spot price at the EEX in Germany rose from DKK 247/MWh in June to DKK 265/MWh in July.
> The night of Sunday, 26 July 2009, zero prices were observed for four hours in all the Nordic countries except for the central and northernmost Norwegian price areas. The zero prices were caused by high wind-power generation in the Danish areas and ample water supply in the other Nordic countries. Furthermore, sales opportunities were limited because consumption in the Nordic countries had hit a record low. Both the area prices and the system price, which expresses the theoretical market price without congestion, were DKK 0/MWh - a phenomenon never seen before in the Nordic market.

Low electricity demand in July seems to have been the main reason for low spot prices, and the influence of wind power was probably limited.

The average wind power output in Germany and Denmark for the 6 days was less than 20% of the installed capacity. On 25th July there was a modest peak of wind power reflected in the EEX spot price.



The collapse of the Nordic spot prices during the night of the 26th is still surprising. Contributing reasons could be misjudgment by market participants and inefficiencies of market functions such as the missing market coupling between Nord Pool and EEX.

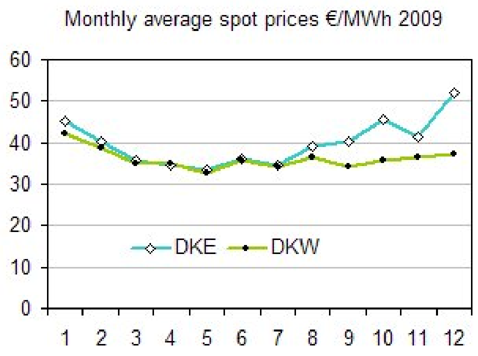
5.3. Energinet.dk: "Nordic electricity prices hit rock bottom"

According to Energinet.dk's market report for September 2010 low electricity demand and rising water level in the Nordic hydro storages caused a continuing falling level of electricity prices.

The following quotation from the market report gives a fair overview of the conditions on the Nordic electricity market:

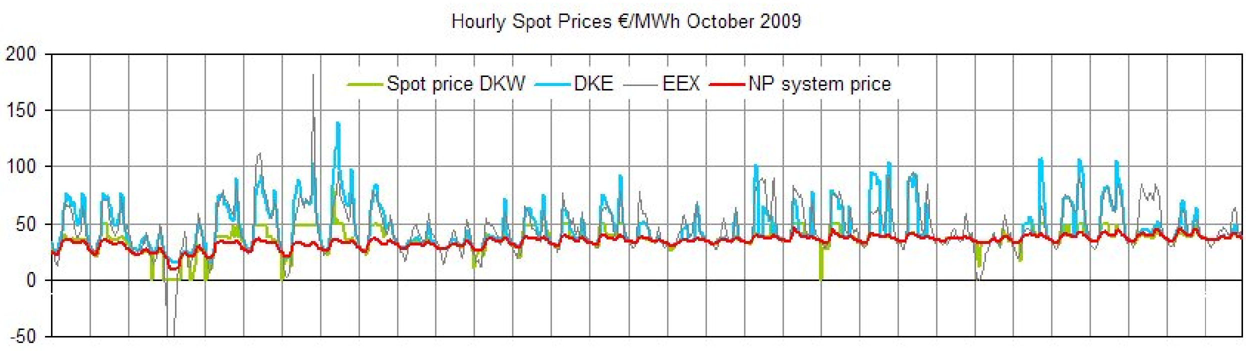
> **Nordic electricity prices hit rock bottom**
> In Western Denmark, the average electricity price dropped by almost DKK 20/MWh during September to an average of DKK 253/MWh. The largest fall in the remaining Nordic countries was seen in Southern Norway where the electricity price decreased by more than DKK 50/MWh on average per month to an average of DKK 170/MWh in September. This price fall is caused by the rising water level in the Nordic hydro reservoirs, especially in Norway where the water level is close to the norm for this time of the year.
> In Eastern Denmark, the spot price increased by almost DKK 10/MWh on average in September compared to August, and Eastern Denmark was the only price area in the Nordic countries which saw price increases. In September, the average spot price in Eastern Denmark was DKK 301/MWh. This increase was a result of Svenska Kraftnät's limitations on the Øresund Link caused by internal congestion in the transmission grid in Sweden. During the hours of Svenska Kraftnät's limitations on the Øresund Link, Eastern Denmark is in fact only connected to the remaining Nordic market through the Kontek cable to Germany.
> Despite a slightly increasing tendency in the East Danish electricity price in September, the electricity prices in both of the Danish price areas are almost half the prices of last year; and the market situation shows clear signs of the elctricity price in the Danish price areas being strongly influenced by import from the remaining Nordic countries. Furthermore, the general economic downturn and the consequent decreasing electricity consumption also put a downward pressure on the electricity price.

5.4. Price spikes in DKE during autumn

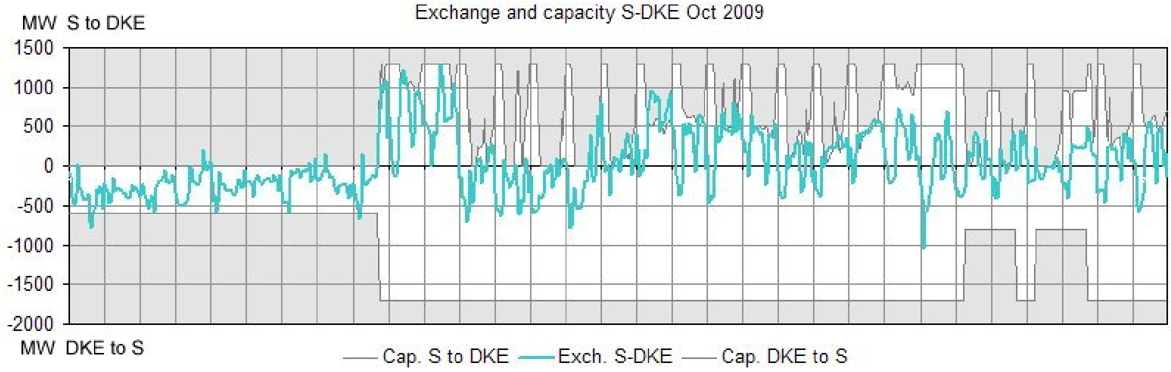


The Swedish limitations on the interconnectors between Sweden and East Denmark have caused a slightly higher price level in East Denmark than in West Denmark, particularly during the last months of the year. The average spot price in East Denmark is 27% above the price in West Denmark in October and 40% higher in December.

The spot price curves for October show how DKE spot prices as a main rule have followed the German market. The observation demonstrates a dependency on the German market and suggests serious bottlenecks between Sweden and East Denmark.



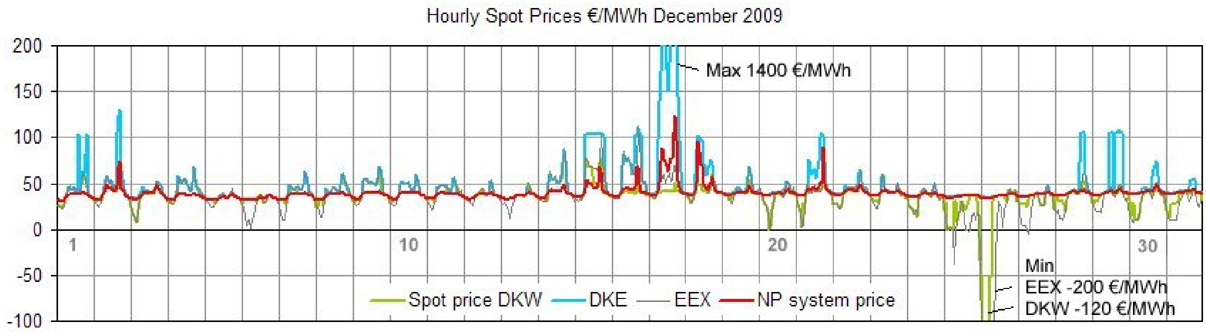
The following chart confirms this assumption, the white area showing the range which has been available for exchange:



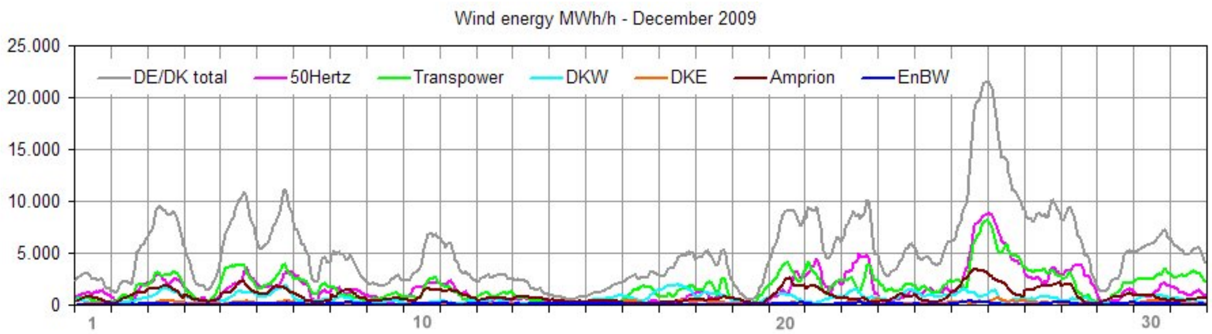
Svenska Kraftnät may have good reasons for these limitations, and the European court will decide if Swedish market participants have enjoyed protection that is in conflict with the rules of competition.

In any case it must be a fact that the Nordic electricity transmission system is insufficient for a reasonable market function. The higher spot price level in East Denmark indicates significant economic consequences of the insufficient transmission system to electricity consumers.

5.5. December 2009: Positive and negative price spikes



The most striking observations based on the spot prices in December are the very high prices on the 17th in DKE and the negative prices on the 26th in DKW. EEX had low night prices in several cases. How are these observations related to the wind power?

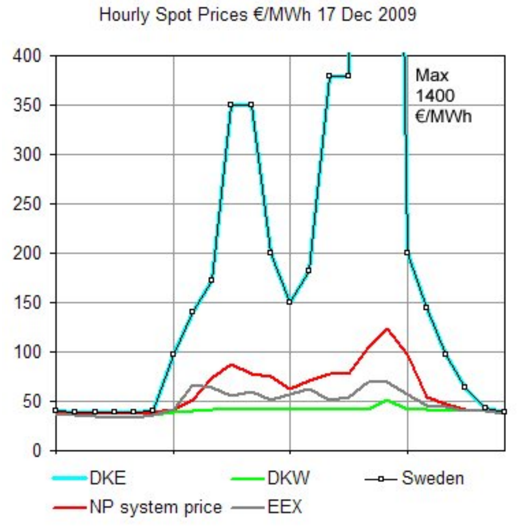


The wind power peak on the 26th December may have contributed to the negative prices at the same time. Apart from this peak the wind energy output has been rather low in December. It is an interesting observation that the wind power did not exceed 15% of the installed capacity in Germany and Denmark for a five days period in December, but this fact cannot be the only reason for the price spikes.

On the 17th December a combination of circumstances caused very high spot prices in Sweden and East Denmark. An interconnection between west and east in Denmark might have been very helpful in this case according to the spot price chart.

The DKE peak price on the 17th December was 1,400 €/MWh.

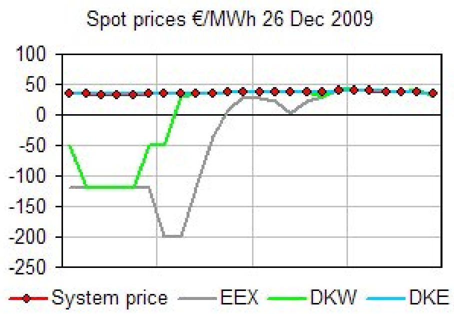
The Energinet.dk market explains the background:



On 17 December, the East Danish electricity price reached the highest level this year with DKK 10.418/MWh for two hours. The high level was caused by outage of the nuclear power plant Ringhal unit 3 in Sweden and high consumption in the Nordic countries caused by low temperatures. In Sweden and Finland, similar high price levels were recorded. Furthermore, the largest East Danish CHP, Asnæsværket unit 5, was out of operation a couple of days earlier which also contributed to the price increase. In Finland and Sweden the emergency procedure for failure to achieve clearing prices had to be activated in the spot market, and also the system operator's power reserve had to be activated.

On night of the 26th December an unfavourable combination of low electricity demand and a large inflow of wind energy created a surplus of electricity in Germany and West Denmark. Negative spot prices were recorded in Germany and West Denmark, but not in East Denmark.

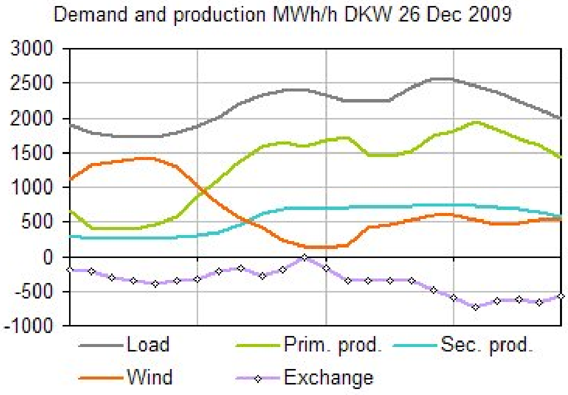
Why did the two Danish control areas behave so differently during the night?

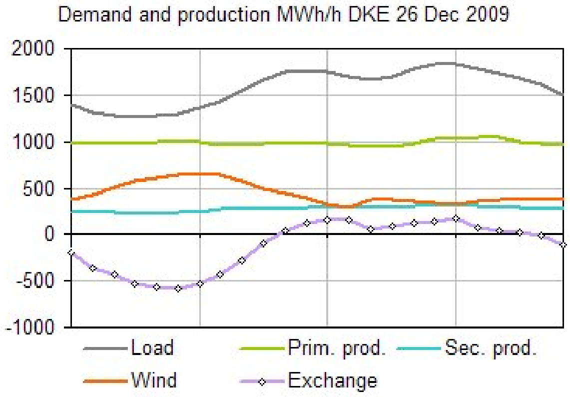


The Energinet.dk market report says:

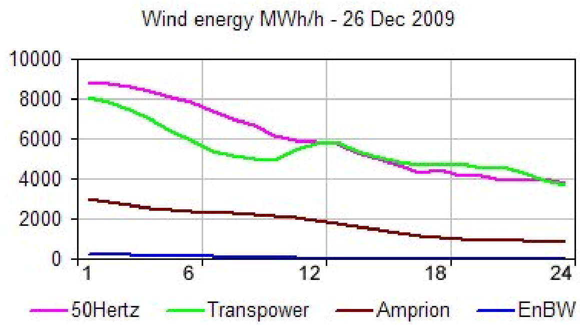
At the end of December, negative electricity prices were seen for the first time in Western Denmark. The negative electricity prices were caused by low consumption, high wind power generation in Western Denmark as well as in Germany, and low temperatures activated heat load-determined electricity production at combined heat and power plants. For a couple of hours the electricity price dropped to a level of approx. DKK -890/MWh in both Western Denmark and in Germany. In Germany, the spot price continued descending on the European Energy Exchange (EEX) and reached a level of approx. DKK - 1488/MWh for the succeeding two hours, during which full utilization of the connection to Western Denmark provided the price difference between the West Danish price area and Germany.

East Denmark had imported the maximum possible (550 MW) from Germany, but plenty of capacity was available in both directions on the Øresund interconnection to Sweden. Therefore East Denmark was able to follow the Nord Pool system price.





In West Denmark the wind power curve was like a mirror image of the electricity demand, and all three interconnectors were operated very close to capacity limits. The market had to push thermal generation downwards. The result was identical spot prices in West Denmark and Germany from 01:00 to 05:00 o'clock when falling wind power output relieved the situation in West Denmark.



The same night at 01:00 o'clock the system operator in East Germany, 50Hertz, had to deal with 4,594 MW demand and 13,841 MW production.[7] Wind power contributed with 8,776 MW and other renewables with 849 MW.

The share of wind energy in the 50Hertz control area is well above the German average. Therefore the rest of the German control areas are obliged to receive 4,650 MW, the so-called HoBA (Horizontaler Belastungsausgleich or horizontal equalisation of load).

The export to East Denmark was 550 MW.

In spite of maximum use of all available options 50Hertz had to demand that production was reduced by 1,000 MW from 01:00 to 04:00 o'clock. In such cases in Germany, the system operator is obliged to publish a report with an explanation of the reasons for the intervention. Another report was published by 50Hertz in 2009 on the conditions on the 23rd March.

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[7] Bericht der Systemführung zu Maßnahmen und Anpassungen gem. § 13 EnWG während der Starkwindperiode im Zeitraum 25.12.2009 bis 26.12.2009, 50Hertz Transmission GmbH, 14 January 2010

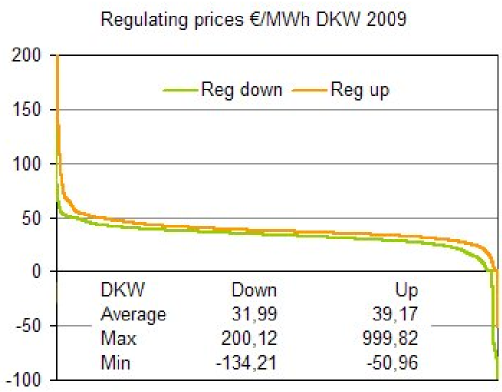
6. Regulating Power

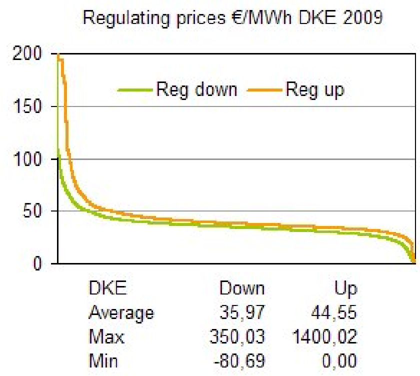
Nord Pool Spot is a wholesale market for buyers and sellers, the gate closure being for the following day at noon. Therefore its spot prices are based on expectations 24 to 36 hours before real time, and day-ahead wind power forecasts are very inaccurate.

The Nord Pool ELBAS market offers market players access to intra-day trade until 1 hour before delivery.

The Nordic system operators use the Nordic regulating power market for real time balancing. Market players are bidding in advance, and the system operators can activate the bids when needed. In Denmark there are different prices for regulating upwards and downwards.

Dispersed regulating prices are a first warning of unsatisfactory market stability.





Different rules apply for balancing within Nordel and UCTE, which is probably the reason why the need for regulating power is higher in West Denmark then in East Denmark. Negative prices for regulating power occurred in 194 hours in West Denmark and 53 hours in East Denmark.

7. Wind energy trading

One of the important traders of wind energy in Denmark is “Vindenergi Danmark Amba”, which is a co-operative of owners of wind power plants, who must sell wind energy commercially. The web site, www.vindenergi.dk, presents the following trading statistics for 2009 (with my translations):

	Jan	Feb	Mar	April	May	June
West Denmark						
Installed capacity, MW	881	889	899	907	915	932
Production, GWh	167	108	160	83	158	135
Clearing price, øre/kWh	29.3	26.8	24.4	24.9	24.7	26.3
Balancing cost., øre/kWh	0.7	1.2	1.1	2.4	0.2	0.5
East Denmark						
Installed capacity, MW	262	264	265	194	194	195
Production, GWh	43	38	42	21	30	29
Clearing price, øre/kWh	32.9	28.0	26.3	24.9	25.0	26.9
Balancing cost., øre/kWh	1.2	0.4	0.2	0.5	0.5	1.1
Total						
Installed capacity, MW	1,143	1,153	1,164	1,100	1,108	1,127
Production, GWh ,	211	146	202	104	187	165
	July	Aug	Sep	Oct	Nov	Dec
West Denmark						
Installed capacity, MW	954	967	976	991	1,030	1,060
Production, GWh	116	134	176	183	252	152
Clearing price, øre/kWh	23.8	27.2	24.4	23.9	25.3	25.2
Balancing cost., øre/kWh	1.0	0.5	0.2	1.7	0.4	4.0
East Denmark						
Installed capacity, MW	197	197	196	196	199	202
Production, GWh	21	23	31	33	43	26
Clearing price, øre/kWh	23,3	28.3	30.1	32.3	28.8	45.6
Balancing cost., øre/kWh	2.0	0.4	0.4	1.3	1.2	5.0
Total						
Installed capacity, MW	1,150	1,164	1,173	1,187	1,229	1,262
Production, GWh	137	157	207	216	295	178