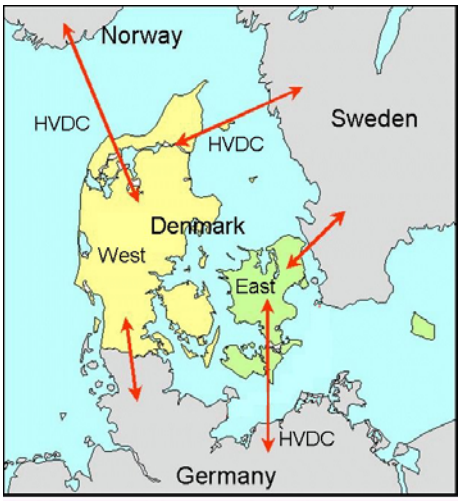
Danish Wind Power and Electricity Export in 2007

Denmark is considered to be a frontrunner in the use of wind power. In 2007 the generation of wind energy in west Denmark was 5.6 TWh or 26 % of the electricity consumption. In east Denmark 1.6 TWh wind energy was generated, which is 11 % of the electricity consumption.



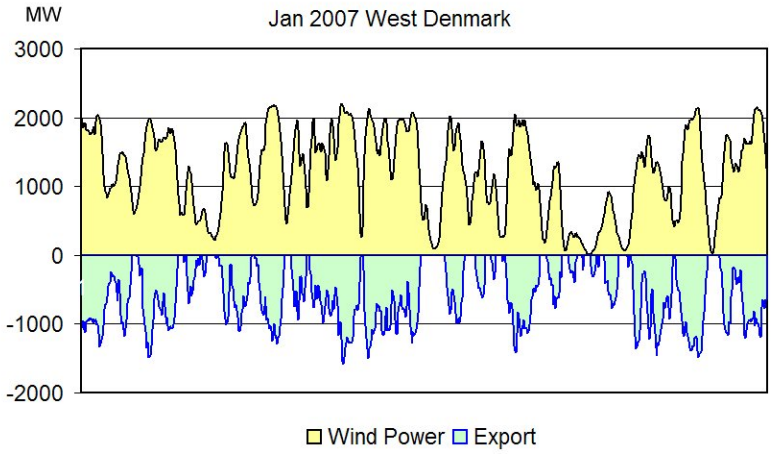
Denmark is interconnected with Norway, Sweden and Germany. An HVDC link between west and east in under construction.

The normal interpretation is that 20 % of the electricity demand in Denmark was covered by clean wind energy in 2007. However, some people claim that this is an idealization, and that most of the wind energy was exported at prices much below the real cost of wind energy.

This paper is a presentation of some facts on Danish wind power and electricity export in 2007 extracted from the web site of the Danish Transmission System Operator, Energinet.dk. Some comparisons are made, but the final destination of the wind energy will always be a matter of political interpretation.

1. Wind Power Characteristics

Some wind power characteristics are demonstrated on the graphic presentation of the hourly West Danish wind power generation in January 2007, particular the intermittent and irregular nature.



The wind power profile is completely different from the daily load profile.

When the hourly net export of electricity is shown on the same diagram as the wind power a certain synchronism appears. The diagram supports the view that a considerable part of the wind energy has been exported for use abroad.

A statistical correlation can be demonstrated, but we must still discuss if there is a real causal connection.

2. International Exchange of Electricity

The electricity exchange with Denmark's neighboring countries depends on different market arrangements.

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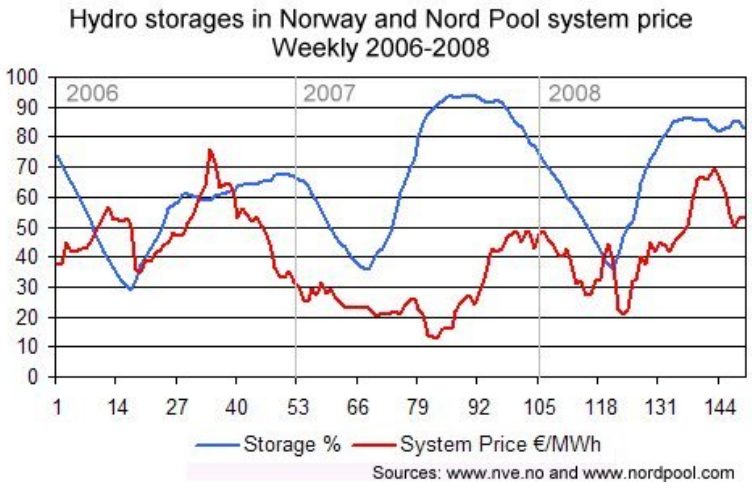
Denmark has joined the Nordic power exchange, Nord Pool. Nord Pool Spot is a day-ahead-market with gate closure for bidding every day at 12:00. Nord Pool can dispose of all available transfer capability on interconnectors between the Nordic countries for an optimization based on supply and demand bids for the next day. This procedure is called an *implicit auction* leading to a *market coupling* between the Nordic countries. The result is an optimal utilization of the interconnectors.

The transfer capability between the Nordic area and Germany is distributed between market players by an *explicit auction* prior to gate closure of the German and Nordic spot markets. The market players must bid for transfer capability based on their guess on subsequent spot market prices. The procedure can lead to idle interconnectors in case of wrong guessing. An attempt to arrange a market coupling between Nord Pool and Germany was made recently. The arrangement is temporarily suspended because of less satisfactory results.

The Nord Pool spot price reflects the hydrological situation in Norway.

2007 was a wet year compared with 2006. The high water level of the storages in 2007 is reflected in low spot prices.

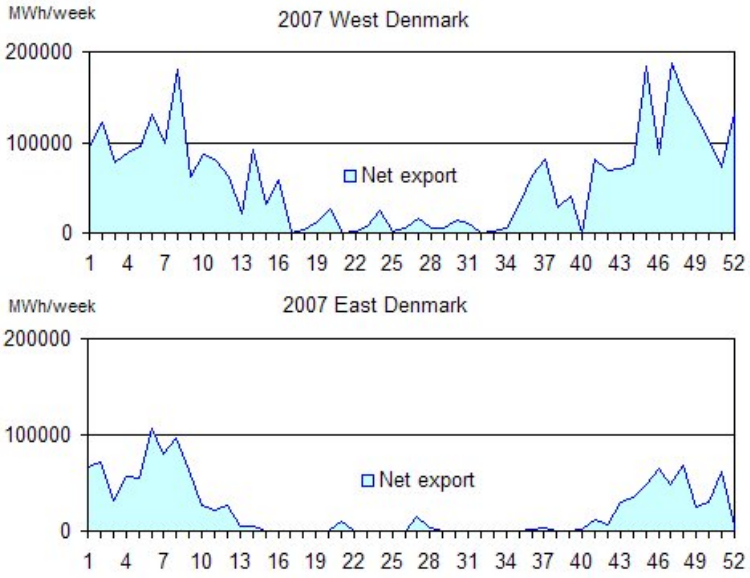
Regarding hydrology 2008 does not look much different from 2007, but the commissioning of the NorNed interconnector in May 2008 may have influenced the spot market.



The Nord Pool spot price has a strong influence on Danish import and export of electricity. The net export was 6.7 TWh in 2006 and 1.0 TWh in 2007.

Wind power and competitive generation on Danish CHP (combined heat and power) units are leading to a Danish net export of electricity, even when the spot price is low.

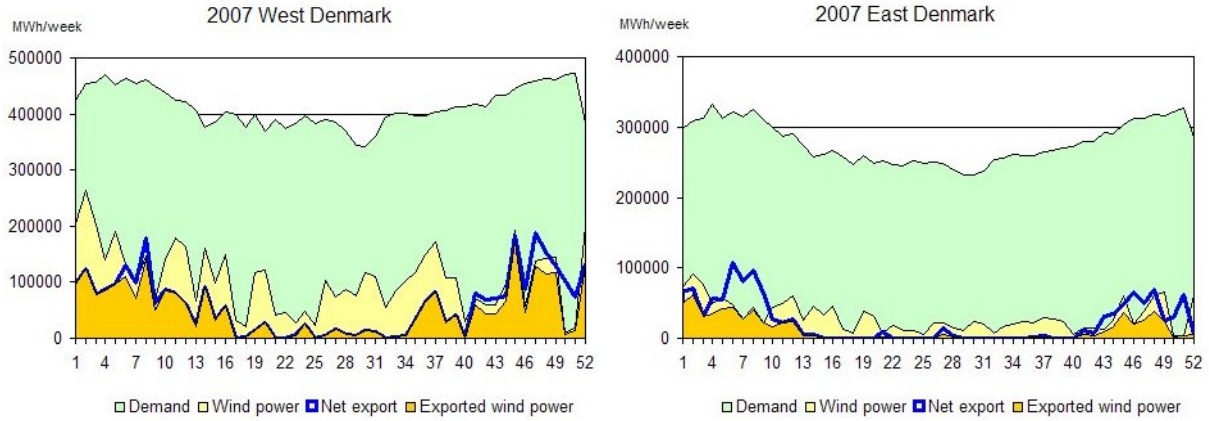
Nobody can tell if the export is caused by wind power or by CHP. In 2007 most of the export was recorded during the cold weeks when the CHP units have a high minimum generation. This observation could be an argument for blaming the CHP for the export.



However, there is no doubt that the net export of electricity would be lower without the wind generation.

3. Wind Power and Export in 2007

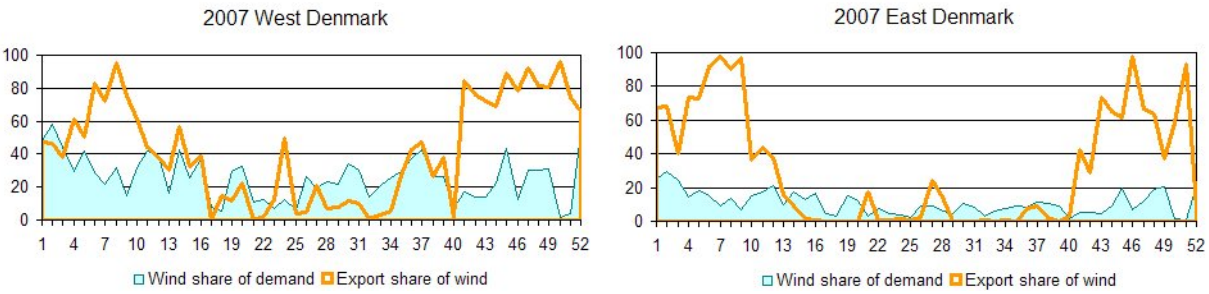
As an experiment wind power and net export have been compared hour by hour for each of the two Danish power systems in 2007. The smaller of these two numbers is called exported wind energy.



The diagram shows that in west Denmark electricity export (the dark blue curve) was smaller than wind power production for most weeks in 2007. Therefore at least some wind energy (the yellow area) was used locally. On a weekly basis the exported wind energy has been nearly identical with the net export according to this definition. In east Denmark the export exceeded the wind energy for several weeks.

Denmark 2007	Electricity consumption	Wind energy produced	Net export of electricity	Wind energy exported		B/A	D/B	D/C
	A	B	C	D				
	MWh	MWh	MWh	MWh	Hours	%	%	%
West	21.595.508	5.561.711	3.130.797	2.611.979	5048	25,8	47,0	83,4
East	14.515.894	1.610.371	1.185.385	628.719	3453	11,1	39,0	53,0
Total	36.111.401	7.172.083				19,9		

Even with this interpretation more than 50 % of the wind energy has been absorbed within Denmark. The following diagram shows how the calculated export of wind energy was distributed week by week:



The diagram suggests that nearly 100 % of the wind energy was exported during some weeks.

We do not know the price paid for the exported energy, but we can use the local spot price hour by hour as a hypothesis. The table should be seen as an indication. Some surplus electricity was traded in the regulating market and sold at prices below the spot price level.

Denmark	Wind energy exported			Average spot price
2007	MWh	Value M€	€/MWh	€/MWh
West	2.611.979	78,527	30,06	32,40
East	628.719	20,259	32,22	33,01

The table tells that even if we accept that this share of the wind energy was sold abroad, the commercial value was just slightly lower than the spot price. However, the spot price level in 2007 was considerably below the real cost of wind energy. It remains to be seen if the future spot prices will pave the way for a better business case for wind energy.

4. Lessons Learned

There seems to be a conflict between CHP and wind power during cold periods of the year. The conflict was not a serious problem so far. The strong interconnections and the international markets provided the necessary trading opportunities.

The wind power generation in Denmark will be expanded considerably. The target for 2025 is 50 % of the electricity demand. The international trading will probably not be able to absorb the increased share of wind power by 2025. It is also an open question if an acceptable utilization of the new wind power assets can be achieved by export.

Fortunately the CHP systems are not only a source of problems. They can also contribute to a solution. The hot water in the district heating systems is a large thermal storage. The CHP units can be operated in a very flexible way if surplus electricity is used for water heating.

Water heating can be direct or by heat pumps. It can guarantee a proper use of all electricity and a minimum price for surplus electricity. In the present regulating market negative prices frequently occur for downwards regulation.