Have Electricity Spot Prices hit the Bottom?

The wholesale price of energy has been decreasing since the end if the financial crisis. The leading price forecasts have predicted increasing energy prices every year since then. So far, they all failed, but eventually the tide must turn.

It is impossible to predict the future energy prices. Nevertheless, official forecasts are regularly published and carefully studied by energy planners. Energy planners need forecasts with steadily increasing prices for justifying their plans for new green energy solutions. The expensive solutions depend on a future with high cost of energy. Energy investments based on wishful thinking can be a dangerous game.

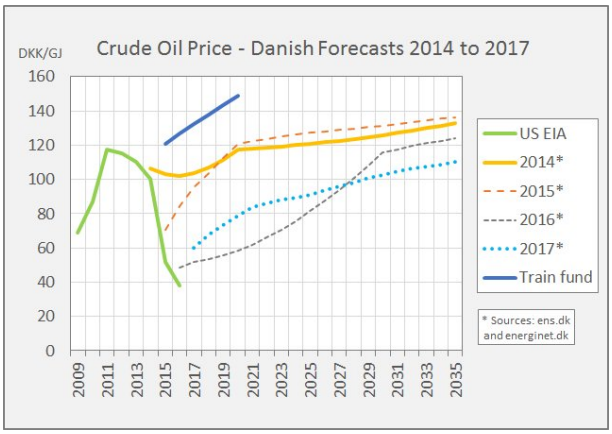

Fig. 1 - Danish forecasts refer to the International Energy Agency (IEA)

The Danish train fund is a striking example. In order to satisfy everybody in a negotiation, virtual money for the financing of a necessary renovation of Danish railway infrastructure was found in a new energy tax on North Sea oil based on unrealistic expecttions.

The wholesale market for electricity

The annual market values[1] of Danish electricity demand for the years 2010 to 2016 are used as reference values for comparisons. Fig. 2 shows the load value related to the crude oil prices in fig. 1. The correlation is positive. The correlation coefficient is 0.64.

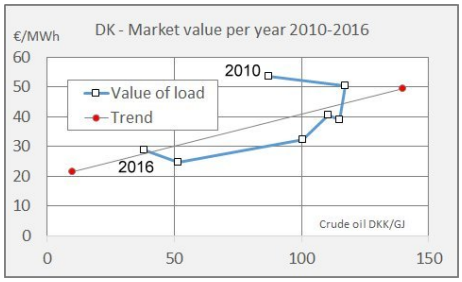

Fig. 2 - Crude oil price and Danish market value of electricity

It is not surprising that high electricity prices follow high fuel prices. Fossil fuels still play an essential role in electricity production.

The penetration of wind energy is another possible leading variable. Wind power has been added to the power system as a surplus capacity. The competition drives the spot prices of electricity down to thermal marginal costs, first for condensing units and later for CPH[2] units.

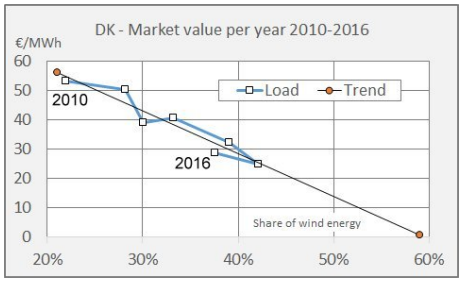

Fig. 3 - Share of wind energy in Denmark and market value of electricity

The correlation is negative (fig. 3). The correlation coefficient is - 0.96.

It would be a natural idea to use the sum of wind and solar energy for the comparison, but the available Danish data for solar power was not sufficient for the purpose.

[1] Annual market values are hourly spot prices weighted (in this case) with hourly electricity demand
[2] CHP: combined heat and power

Danish spot prices are set abroad

Fig. 3 seems to suggest that decreasing electricity market prices are results of increasing wind power penetration. However, the electricity market depends on several other factors.

Denmark has two price zones in the Nordic spot market, NordPool, and interconnections to three price zones in Norway and Sweden and to Germany. Spot prices are set hour by hour. In most hours, Danish spot prices are determined in the larger neighbouring countries.

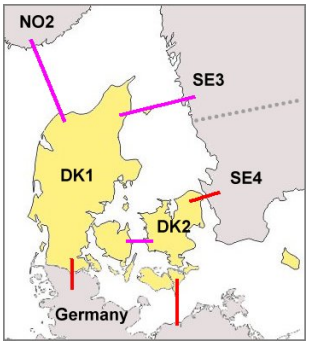

Fig. 4 - NordPool price zones

Hours in 2016	DK1	DK2
Same price as DE and NO/SE	17%	17%
Same price as NO or SE	46%	58%
Same price as Germany (DE)	20%	10%
Separate Danish prices	17%	15%

Table 1 – Price setting dominated by Norway and Sweden (simplified)

The electricity transit between the Nordic countries and Germany causes bottlenecks in the grid most of the hours. The locations of bottlenecks are decisive to the spot prices in the two Danish price zones.

Frequent limitations on the interconnections to Germany and a different German market design are main reasons for the distribution of the hours in table 1. The Danish price zones only had their own spot price 17% and 15% of the hours in 2016. This means that spot prices were set elsewhere in 83% and 85% of the hours.

The German influence

The electricity spot prices are volatile, particularly in Germany. Wind and solar power do have considerable influence on the hourly spot prices and therefore also on the annual averages.

Surplus of power creates low prices and export of electricity. The export via Denmark also affects Danish spot prices.

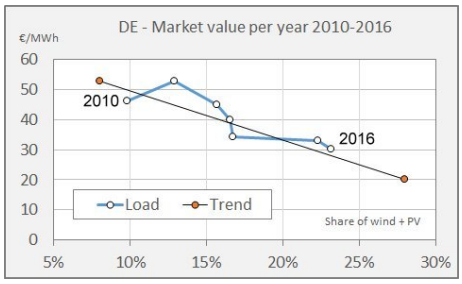

Fig. 5 - German market values and shares of wind plus solar energy

The correlation between the share of wind plus solar energy and market values is less convincing than on fig. 3, but still significant. The correlation coefficient is - 0.86.

In fig. 6, the Danish and German trends from fig. 3 and 5 are shown in the same chart.

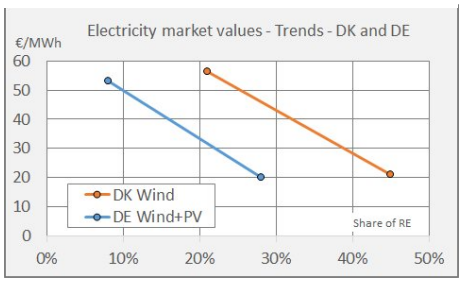

Fig. 6 - Danish and German trends

There is no evidence that the trends can be extrapolated to higher penetrations of fluctuating energy sources, but there might be good reasons for a careful consideration of the possible market response to more spot price volatility and to less production volumes for dispatchable power plants.

Some theoretical studies have been made for Germany[3], but the mentioned papers do not analyse extreme limits for RE penetration.

Influence of wind power on market values in Denmark

The energy production from wind and solar power is still a small fraction of the total energy consumption in Europe. Therefore, other factors must have caused most of the fall in energy prices since 2010.

On the other hand, it is obvious that the injection of wind power into the Danish electricity market has changed the market values of different energy products since 2010 (fig. 7).

Fig. 7 – Reference (100%) is the annual market value of Danish electricity demand

The value of dispatchable power (from central and local CHP units) was slightly higher than the demand value (between 100% and 110%) for all years.

Net import is also dispatchable. Its value has been increasing because wind power output and net export have similar variations (fig. 8). The import hours are usually the same as the hours with low wind and high spot prices.

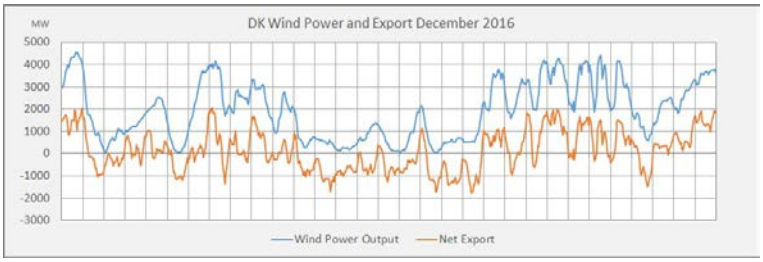

Fig. 8 - Danish wind power output and net export in December 2016

There are no Danish time series for solar power (or PV) before 2014. The market value starts slightly above 100% because solar production is limited to daytime, but the value decreases with increasing production.

The value of wind energy was between 80% and 90%. The trend is slightly decreasing.

Import and export had approximately the same market values in 2011, but have since then moved apart. From 2013 to 2016, the gap was about 35% (fig. 7). The wind power variations are mainly absorbed abroad. The gap is an indicator of the cost of adjusting the wind power profile to fit the demand of consumers.

Simulations with 40% wind and solar energy in Germany

The interesting question is how the market will behave when wind power penetration in Germany has reached for instance the present Danish level about 40%. I used my own model, PWSIM, for a few simulations of the German power system with shares of wind and solar energy between 20% and 40%.

In the first simulation (fig. 9) all nuclear power was gradually phased out, while the share of renewables increased from 20% to 40%. Increasing penetration of wind and solar power will push the average spot price in Germany and Denmark downwards, while decommissioned

[3] [1], [2] and [3]

traditional power stations will push the price upwards. The effect of new wind and solar energy for the market value of the electricity demand was approximately counterbalanced by the closure of the nuclear power plants.

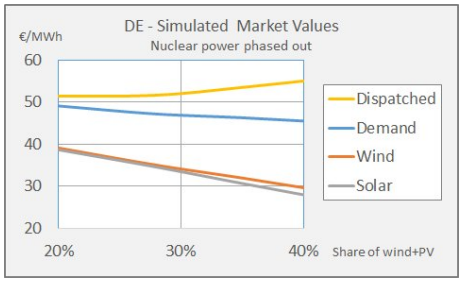

Fig. 9 - Market values moving apart

While the market values of electricity demand seem to be rather robust, the market values of energy from dispatchable sources and non-dispatchable sources move significantly apart corresponding to the development already observed in Denmark (fig. 7).

The gaps left by wind and solar power (the residual load) will not be an attractive market for thermal power plants. Some thermal power plants will probably have to close.

In fig. 10, also 10 GW coal fired capacity and 10 GW gas fired capacity have been phased out. The effect on market values is significant. The value of energy from dispatchable plants goes up from 55 €/MWh to 80 €/MWh.

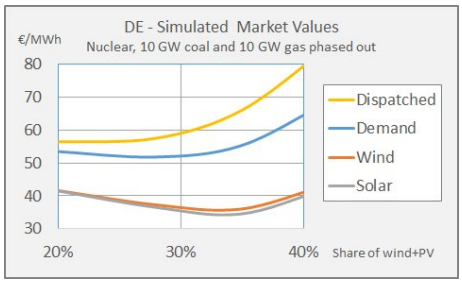

Fig. 10 - Effect of additional removal of 20 GW dispatchable power

This result is not realistic. There will be hours with up to 25 GW necessary import. If the increasing value of dispatchable power cannot encourage owners of power plants to maintain sufficient service, shortage of electricity will call for political intervention.

The experiments demonstrate the important role of dispatchable resources. Flexible demand has been the standard answer for decades. The future will need much more flexibility than it has been possible to activate so far.

Discussion

This note has presented observations of the electricity markets in Germany and Denmark for the period 2010 to 2016. During these years, economy has recovered from the financial crisis, and the penetration of wind and solar power has increased considerably in both countries.

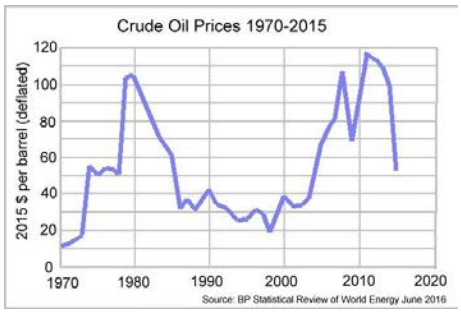

Fig. 11 - A low crude oil price can be stable for many years - until the next international crisis

The economic recovery is probably a main reason for the decreasing energy price level. Energy prices will probably stabilize at the present level if the international conditions remain stable.

According to the simulations, the removal one TWh of dispatchable energy has a stronger effect on electricity spot prices than adding one TWh of non-dispatchable energy. Therefore, the resulting spot price development will depend on the capacity of remaining thermal power stations.

Fossil-fired power plants will be price setting in most hours several years ahead, and the general fuel price level will set a basic level for the electricity spot markets. An increased share of wind and solar power will cause a higher spot price volatility.

It is difficult to predict if the relative market value of the *electricity demand* will be higher or lower than set by the fuel prices, but there is good reason to expect increasing relative market values of energy from traditional power plants and decreasing relative market values for wind and solar energy.

References

1. Lion Hirth: The market value of variable renewables. The effect of solar wind power variability on their relative price. Energy Economics 38 (2013) 218-236
2. Falko Ueckerdt, Lion Hirth, Gunnar Luderer, Ottmar Edenhofer: System LCOE: What are the costs of variable renewables? Potsdam Institute for Climate Impact Research, June 2013
3. Hirth, Lion (2016): “The benefits of flexibility: The value of wind energy with hydropower”, Applied Energy 181, 210-223. doi:10.1016/j.apenergy.2016.07.039