

Wind Energy is not Always Cheapest

Offshore wind and biomass are the most expensive technologies.

Two years ago, the Danish Energy Agency (DEA) calculated the cost of electricity from selected new facilities. Minor adjustments were made in 2015, but the ranking was the same: Onshore wind was the cheapest among electricity production technologies.



Fig. 1 – DEA announcement of 18 July 2014: “New analysis: Wind is cheapest”

The analysis was made when fuel costs were at the highest level ever. Fuel prices were supposed to increase further, but at a moderate rate.

Fuel price forecasts are published annually by DEA and by the Danish transmission system operator, Energinet.dk. This note will use the forecasts published in 2014, 2015 and 2016 for an estimation of the influence of the new forecasts on the electricity cost for selected production technologies. Fig. 2 shows an overview of the results.

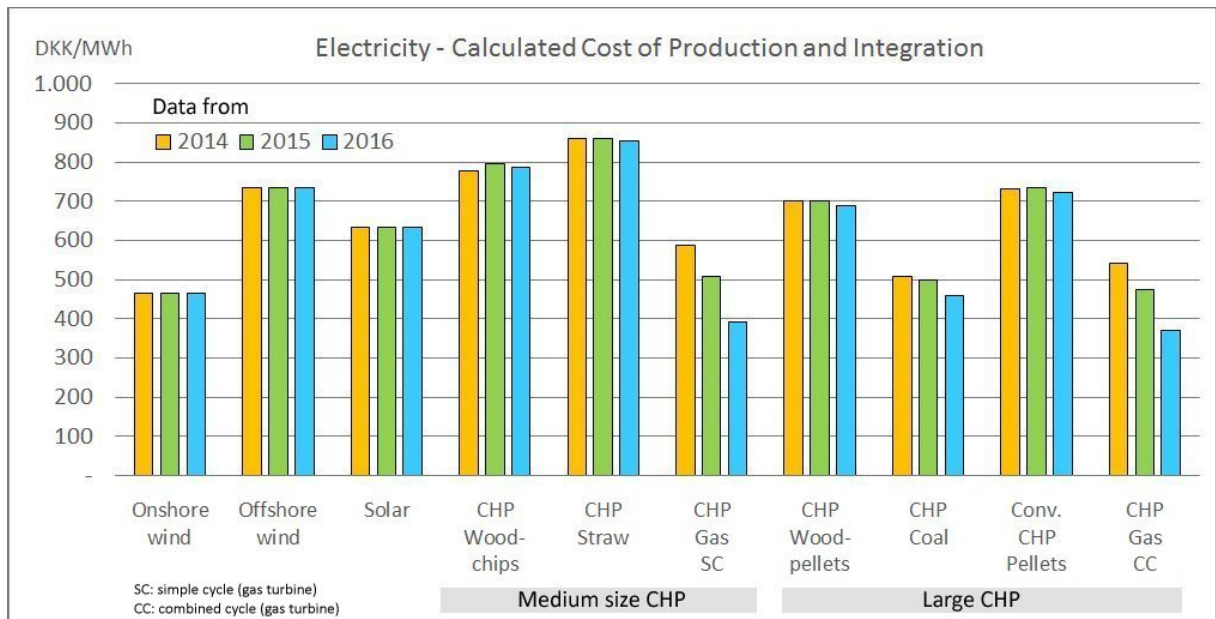


Fig. 2 – Biomass and offshore wind are the most expensive technologies in all three projections.

It is not surprising that the production costs for technologies using gas or coal are sensitive to fuel price variations, but it is interesting that the prices of biomass products seem to be rather robust to variations in the international fuel market.

Obviously, offshore wind is an expensive technology (in line with biomass technologies). Therefore, *nearshore wind parks* are being considered as a cheaper alternative.

The calculations were based on DEA's model¹ and data published by DEA and Energinet.dk. Integration costs are from EA Energy Analyses. Apart from fuel prices, no change of data was made, and no evaluation of data quality was made.

¹ <http://www.ens.dk/info/tal-kort/fremskrivninger-analyser-modeller/beregning-elproduktionsomkostning>

Fuel Price Development

The prices of fossil fuels have been volatile with long waves and large variations.

Oil and gas markets are responsive to political events, such as the Arab oil embargo in 1973, the revolution in Iran 1979, the financial crisis with lack of investments in the 2000s and the Arab spring in 2011.

There seems to be a stable 30 \$ level during calm periods with 100 to 120 \$ peaks during crises. Political crises are inevitable, but impossible to predict. Therefore, fuel price forecasts are so unreliable.

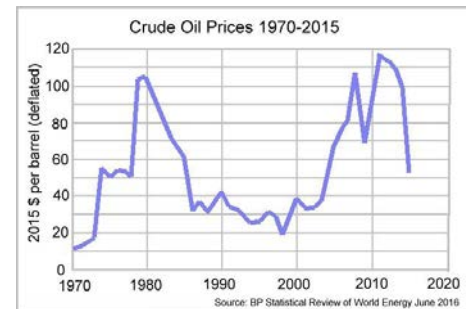


Fig. 3 - The crude oil price can stabilize anywhere between 30 and 110 \$ per barrel

Most Danish fuel price forecasts start at the actual level followed by a steady increase. The falling oil prices from 2014 to 2016 make the fuel price forecasts for these three years very different.

The 2015 forecast seems to expect another crisis about 2020, while the 2016 forecast seems to predict a calm period until the late 2020s.

The Danish forecasts are based on IEA projections, but for the first years, the 2016 forecast also considers prices from the forward markets.

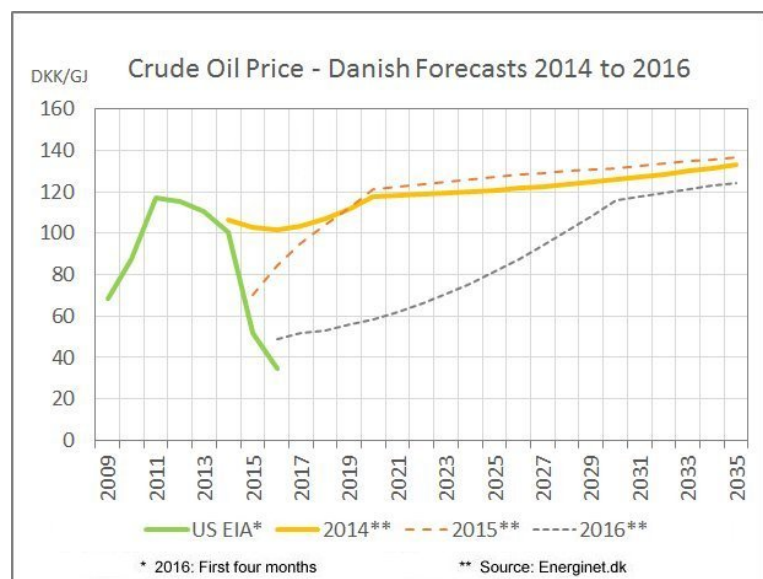


Fig. 4 - Three different futures

Cost Calculation

DEA has published its model for calculation of electricity production costs as a complex spreadsheet. Several sensitivity analyses have been made, but all DEA calculations use the 2014 fuel price forecast.

Fuel costs are calculated for 20 years from 2016 to 2035. The annual discount rate is 4%.

The model does not include integration costs.

DEA has selected 10 technologies for comparisons:

- Three non-CHP technologies: onshore wind, offshore wind and solar power
- Three medium size CHP technologies
- Four large CHP technologies

The limits between small, medium size and large CHP units are not clear.

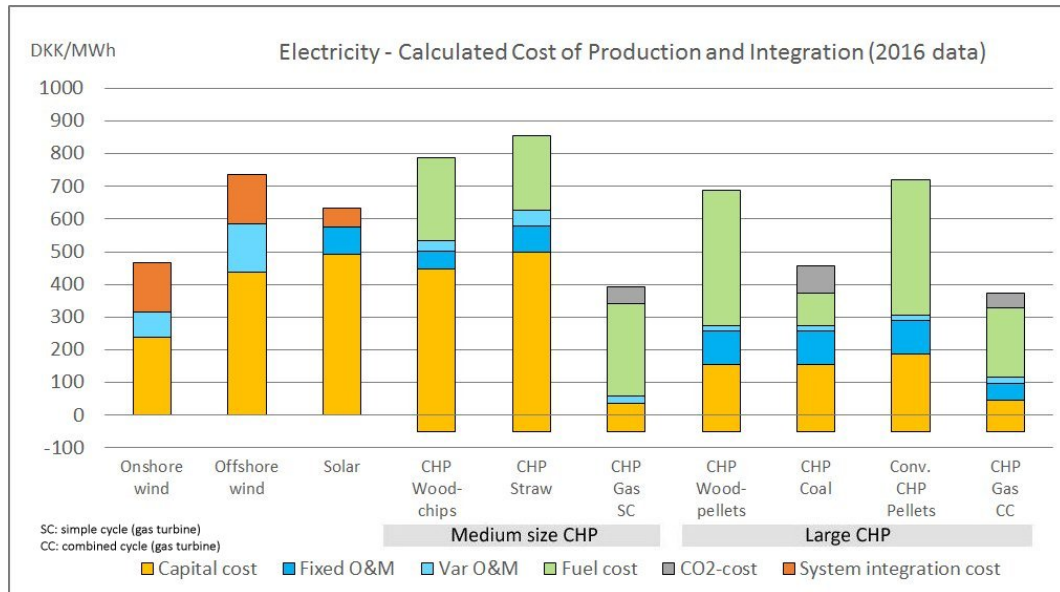


Fig. 5 - The cost composition reveals very different properties

In fig. 5, integration costs (provided by EA Energy Analyses²) are added to the model results for non-dispatchable units. For dispatchable units an integration value has been subtracted.

The cost of CO₂ quota is hard to find in the spreadsheet. The report from EA Energy Analyses says (p. 24): 44 DKK/ton in 2020 and 237 DKK/ton in 2035.

Missing "Fixed O&M" for medium size "CHP Gas SC" must be an error in the DEA model.

	Capacity factor
Onshore wind	34%
Offshore wind	47%
Solar power	13%
Medium size CHP	46%
Large CHP	57%

Table 1- Assumed capacity factors

Independent of fuel price level, two groups of technologies can be identified:

- Cheap technologies: onshore wind, CHP Coal and CHP Gas (SC and CC).
- Expensive technologies: offshore wind and all CHP technologies based on biomass.

Solar power is somewhere in-between.

The results raise the question if offshore wind and biomass are too expensive technologies.

Stranded Investments

Economy is not a main objective in Danish energy policy. It is a main goal to transform electricity production and eliminate emission of greenhouse gases. In the long term, clean electricity is supposed to play an increasing role in reducing emissions from the heating and transport sectors.

The calculated cost per MWh for new installations is not useful for planning. The purpose of presenting wind energy as the cheapest could be to justify the Danish energy policy.

² EA Energianalyse: Vindintegration i Danmark, 2014 (in Danish)

From an economic point of view, it is not only a question of choosing technology for new power plants. A fair comparison should also include the continued operation of existing units, which have not come to the end of their technical or economic lifetime.

New capacity may have so much better properties that it can be justified to replace obsolete units by new. When the improvements are environmental, it is necessary to include the cost of pollution in the economic comparison as an *external cost*. The problem is that setting the cost of externalities may include subjective elements, so it is possible to “create” the wanted outcome.

Capital costs are essential parts of the total cost of supplying electricity. The need for reserve capacity is the traditional criterion for decisions on new capacity. However, due to the political goals new production facilities are being installed irrespective of the need for reserve capacity.

Wind and solar facilities are subsidized, not only in Denmark, but also in our neighbouring countries. The result is decreasing wholesale prices followed by mothballing or decommissioning of thermal units.

The cost of decommissioning power plants before the end of their technical and economic lifetime is called “sunk money” or “stranded investments”. This loss will indirectly be paid by the consumers as strategic reserves or capacity markets, which are being prepared in several countries.

The trend is unmistakable in Europe. While the wholesale prices are decreasing, consumer prices have a steady growth.

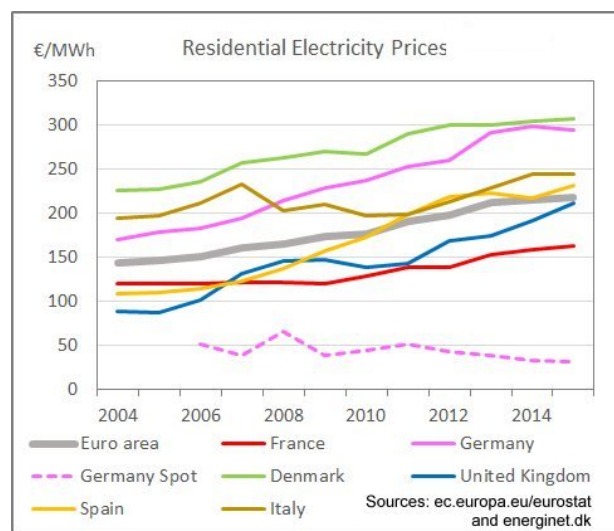


Fig. 6 - Consumer prices and wholesale prices are moving apart

Nearshore Wind Parks

Offshore wind is among the expensive technologies, while onshore wind is cheap. However, it is difficult to find sufficient onshore sites for new wind turbines. Therefore, a political agreement from 2012 included 500 MW nearshore wind parks.

In 2015, a preliminary tender for six nearshore wind parks with a total capacity up to 350 MW was issued and with a price ceiling at 700 DKK/MWh.

The distances from shore are in most cases 4 km, but in one case 8 km. The sea depth varies from 5 to 25 m.

Table 2 shows scaling factors for investments for various distances and depths with 4 km and 15 m as a reference point. The table suggests that sea depth is more important than distance to the shore.



Fig. 7 - Locations for Danish nearshore wind farms

Distance from shore	4 km	8 km	10 km	12 km	15 km	20 km	25 km
Water depth							
5m 10m	0.967	0.974	0.978	0.982	0.988	0.998	1.008
15m	1.000	1.008	1.012	1.016	1.022	1.033	1.043
20m	1.034	1.042	1.046	1.050	1.056	1.067	1.078
25m	1.067	1.075	1.080	1.084	1.090	1.102	1.113
30m	1.124	1.133	1.137	1.141	1.148	1.160	1.172
35m	1.237	1.247	1.252	1.257	1.264	1.277	1.290

Source: Henrik Klinge Jacobsen, Pablo Hevia-Koch and Christoph Wolter: Nearshore Versus Offshore: Comparative Cost and Competitive Advantages, IAEE Energy Forum, Bergen Special 2016

Table 2 - Investment cost scaling factors used for DK comparison

In 2016, the Danish government is considering a postponement of the nearshore projects and the Krieger's Flak wind park in order to limit the cost to the taxpayers. The government assures that the long-term targets are unchanged.

The idea of nearshore windfarms has caused some resistance among local residents and in the tourist business. They see the wind farms as disturbing the otherwise unspoilt nature in the Danish coastal areas.

The Danish PSO Problem

Subsidies for renewable energy in Denmark are financed by the PSO system (Public Service Obligations), in several countries known as PSC (Policy Support Cost).

The EU Commission has raised doubt about the PSO system because the payment of PSO charge is to be based on all electricity consumed in Denmark, whereas only domestically produced electricity has access to the support.

In 2014, a temporary solution covering 2015-2016 was approved. Denmark must find another solution for the following years.

When taxpayers are charged instead of electricity consumers, the government will have a stronger interest in limiting subsidies.

The total PSO cost for wind energy was about DKK 2.2 billion in 2012 and about DKK 4.1 billion in 2015. Without postponement of the offshore projects, the cost of subsidies would increase further.

The big question is if the subsidies and the spot markets will find a stable balance in the long term. Otherwise, the electricity markets might collapse, and the national governments will control the development of the electricity systems through subsidies. The EU Commission may be concerned about this perspective.

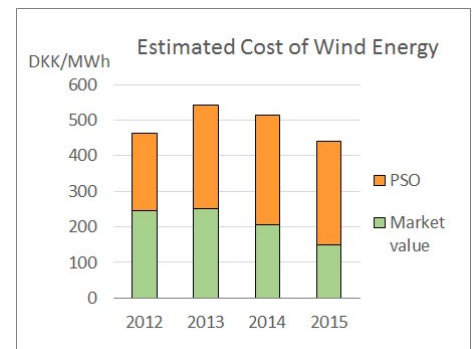


Fig. 8 - PSO has increased from 47% to 66% of the cost of wind energy