What Can Fill the Wind Power Gaps in 2020?

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It is a Danish political target to cover 50% of the electricity consumption by wind energy by 2020. Besides, solar cells are expected to cover about 4%. On the other hand there was so far remarkably poor interest for discussing the type of capacity which will be necessary for producing the remaining 46%.

It has not been considered as a problem. We already have sufficient power station capacity. Besides, Denmark has strong interconnections, still being extended.

Nevertheless, there are reasons to consider the ways to make the future electricity supply in Denmark both optimal and climate neutral.

A balancing act

Several dilemmas are beginning to appear, both in Denmark and in other European countries.

First, a certain reserve of dispatchable capacity must be ready for balancing the natural variations in wind power and for the prevention of cascading grid faults. In the northern part of Europe several consecutive days with very little wind occur. Most countries are planning so-called capacity arrangements (typically capacity markets) in order to secure the presence of sufficient dispatchable capacity while Denmark prefers to wait and see.

Secondly, several modern power plants have been closed down or mothballed in Denmark and in Germany. It is expensive to keep a power plant ready for operation. It is natural for the owners of the power plants to adjust the capacity when the electricity demand is decreasing. However, the capacity reduction will not solve the economic problems because filling wind power gaps will permit only rather low power plant capacity factors. Therefore considerable decommissions of power plants must be anticipated unless maintaining the capacity is paid for separately.

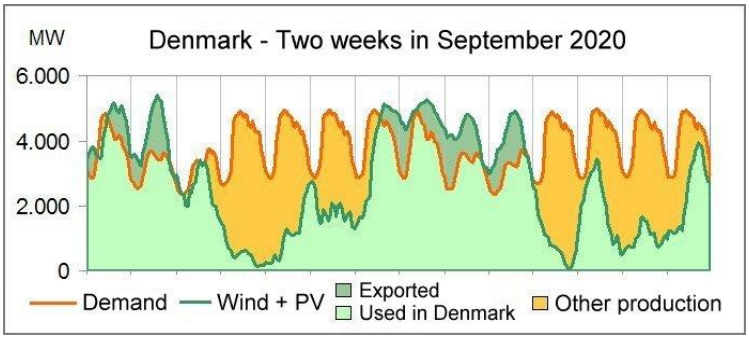
Thirdly, the combined production of heat and power (CHP) has been an essential element of Danish energy policy since the 1980s. The CHP principle implies a considerable reduction in fuel consumption. CHP has covered up to half the demand for space heating in Denmark, but the production has been steadily decreasing for some years. In addition to saved energy an efficient interaction between wind power and CHP has considerable synergy effects.

Fourth, it is necessary to keep certain thermal units connected to the grid in order to maintain grid stability, even when wind and PV could cover all electricity demand. The Danish transmission system operator, Energinet.dk, decides the amount and pays the cost. Besides, certain types of power plants, such as waste-burning units, must operate continuously.

So far the future role of CHP in Denmark is unknown. It is also unknown to which degree Danish generation is supposed to fill the wind power gaps.

The Residual Market

The CHP systems depend on the electricity market which will be left over from wind power and solar cells. It is called the residual market. It is demonstrated on the chart below which has been simulated for a couple of weeks in September 2020.



The yellow areas show what has been left over for the CHP units. The chart ignores the unavoidable production from waste-burning plants and from units which are necessary for the grid stability. The amount of forced thermal production in 2020 is unknown.

The residual market which will be available to the CHP units will under all circumstances be very much different from the electricity consumption. The energy volume will be strongly reduced, but the needed capacity will be practically unchanged, and much larger diurnal regulations must be done. From an economic viewpoint energy and capacity are two different products. The CHP plants are losing money when the revenue from production of electricity depends only on sale of electric energy.

The reason is that several neighbouring countries are preparing arrangements for capacity payment. The result will be that the electricity spot price, even in the future, will reflect only variable costs without any contribution for replacement of the power stations.

CHP opportunities

Great efforts are being made in order to develop energy storages for absorbing the wind power variations.

The Danish CHP stations have about 180 TJ hot water storages (or about 50 GWh). They can store heat from the CHP production during hours with low wind power output. The storages can also absorb electricity overflow by using electric heaters and heat pumps for the conversion of electricity to heat.

The conversion of electricity to hot water for the district heating systems is exactly that flexible electricity consumption which can contribute to an efficient use of solar and wind energy. For the time being no other technology can support solar cells and wind turbines as efficiently as CHP.

Simulations have shown that the perfect interaction with PV and wind power will require a certain overcapacity of CHP plants, hot water storages, electric heaters and heat pumps.

At the end of the 1990s the CHP systems produced about 100 PJ heat per year. Now the production has decreased to about 80 PJ. Depending on the conditions the CHP production in 2020 is estimated to be somewhere between 40 and 75 PJ.

Reserve Capacity is not Free of Charge

Under the present market conditions the most likely outcome in 2020 will be at the low end of the interval. In this scenario the CHP flexibility will be insignificant. During calm periods it will be necessary to import electricity up to 4,000 MW. During windy periods a considerable electricity overflow must be exported or curtailed.

Both electricity and heat from CHP can be climate neutral by the conversion of the large CHP units to burning biomass. It is uncertain if the best distribution in the long term will be 50% wind, 4% PV and 46% CHP or something else. According to expectations the wind energy after 2020 will be extended to more than 50% with a view to convert electricity for use for heating and transport. In that case the dependence on the flexibility which CHP systems can provide will be correspondingly greater.

There is no reason to believe that buying capacity from foreign capacity markets will be cheaper or more climate-friendly.

It is understandable that there is a reluctance to add a capacity payment to the energy payment of the present electricity market. It will imply an additional cost for electricity consumers compared to the present arrangements. However, it can be difficult to avoid the capacity payment if the wind power gaps of the future are supposed to be covered by a suitable capacity of Danish CHP units.