Outdated calculations of electricity production costs

The green transition has stalled in Denmark

Most Danish politicians see it as a fact that renewable energy is the cheapest form of electricity production in Denmark. This is stated on the Danish Energy Agency's website in a report from 2015. Much has happened since 2015, and there are clear indications that the policy based on the conclusions from 2015 is now reaching a dead end, making it necessary to reassess the options for further development.

Among the signs of the problems of the green transition in Denmark are significant delays in the expansion of offshore wind turbines, energy islands, flexible consumption (PtX) and transmission networks. Perhaps more critical is that the large growth of solar energy has changed the price profiles in the electricity market to the detriment of wind and solar energy.

The Danish Energy Agency's cost calculation from 2015

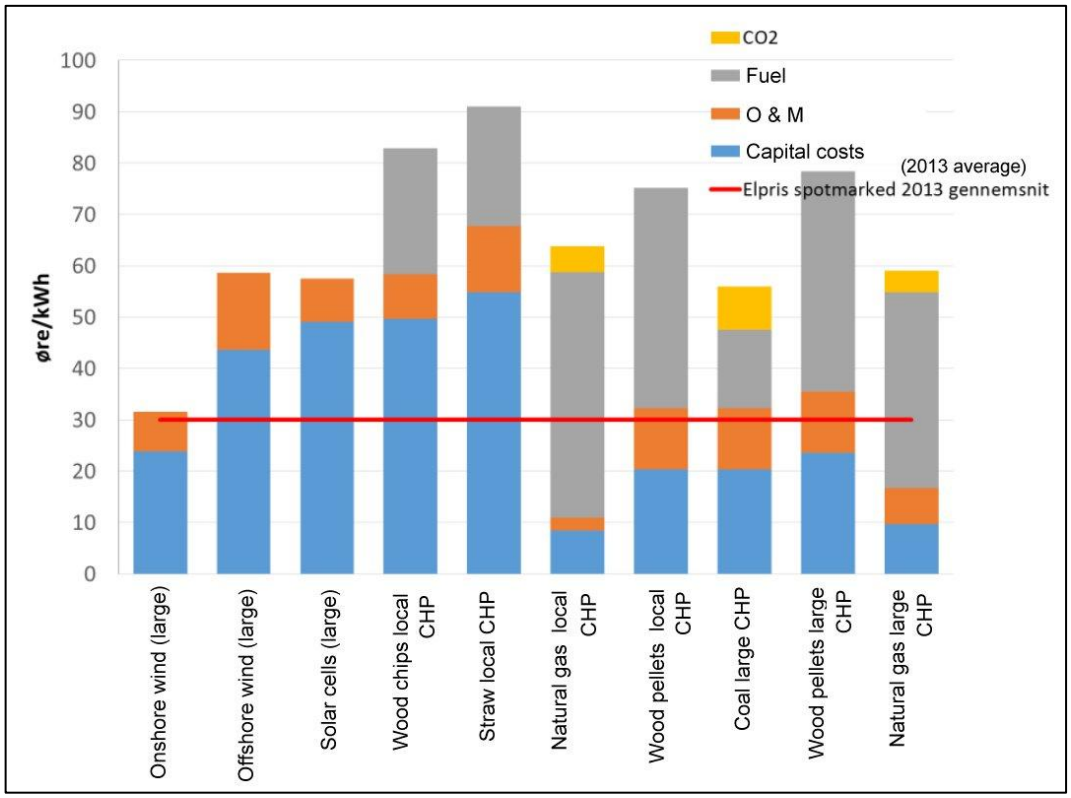

Fig. 1 - Production costs in 2014 prices. Chart by Danish Energy Agency (my translations).

The report from 2015[1] presents onshore wind as the cheapest source of electricity in Denmark. However, in the current plans (AF24), offshore wind and solar cells are to provide the majority of the expansion of Danish electricity supply towards 2050, and their prices are no lower than the cheapest fossil alternatives (fig. 1).

There are two main reasons to reassess the comparison:

- The trade value in the electricity market is not the same for all types of production. The cost per kWh produced is therefore not a fair measure.

[1] Elproduktionsomkostninger for 10 udvalgte teknologier - Danish Energy Agency - March 2015

- It requires more installed capacity to produce a certain amount of energy with fluctuating production than with controllable production and thus correspondingly more infrastructure. Infrastructure construction is currently a decisive bottleneck.

Wind and solar power have changed the European electricity market

Electricity consumers in Denmark know that they can make money by charging their cars and washing clothes when the price is low in the electricity spot market. Customers can therefore adjust their consumption profile so that the total consumption is cheaper.

Similarly, producers with controllable plants can adjust production to make the most profit. Producers of wind and solar energy do not have the same opportunities, which gives them lower average prices per MWh in the spot market.

Average trade values for the individual production types can be calculated based on the hourly prices of the spot market. The long-term trends have been more or less visible for several years.

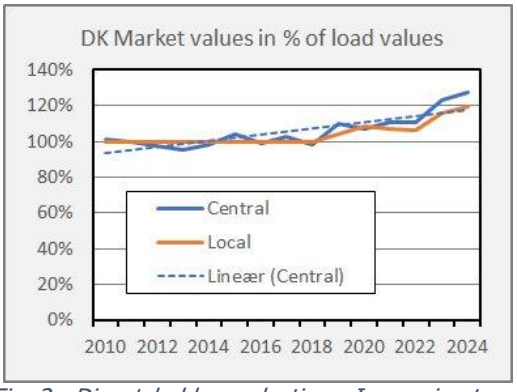

Fig. 2 - Dispatchable production - Increasing trend since 2018

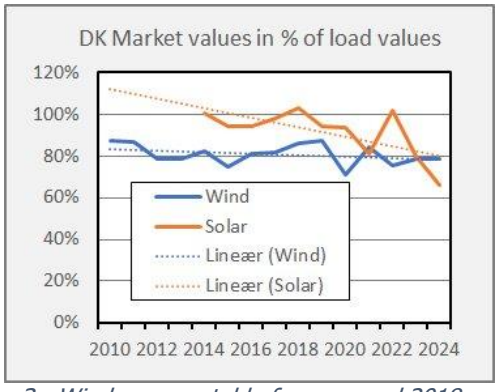

Fig. 3 - Wind energy stable from around 2018, solar energy sharply declining since 2022

The curves in Fig. 2 and 3 are normalized with the market value of electricity consumption as 100%. The big question is if these trends will continue. Of course, this depends on the sensitive balances between supply, demand and transmission, both in Denmark and in neighbouring countries.

By all accounts, expansion of fluctuating production will continue. The flexible demand, which is supposed to smooth the fluctuations, is delayed and the transmission capacity is insufficient. It is strange that authorities and investors are not making preparations to stabilize the development.

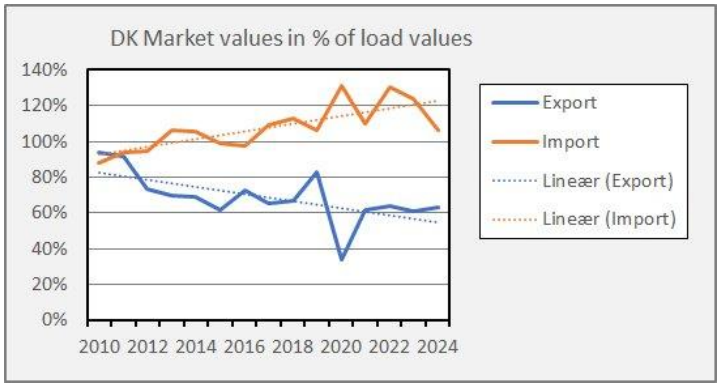

Fig. 4 - Trends in import and export prices have made it an expensive option for Denmark to assume smoothing via neighboring countries

Fig. 4 suggests that most of Europe is moving in the same direction as Denmark, as many need to import or export at the same time. It is difficult to imagine a continuation of the

trends shown. On the other hand, one or more countries must make significant changes in course to break the trends.

> The current situation is, roughly speaking, that the commercial value of wind energy is around ⅔ of the commercial value of dispatchable production, while the value of solar energy is even lower. Such differences completely turn the perceptions based on fig. 1 upside down.

Difficult to estimate the additional infrastructure costs of solar cells

The transmission grid is planned as a whole to meet an overall need for transmission and supply. The individual plants are not usually linked to specific needs. Therefore, it is rarely possible to calculate individual infrastructure costs for individual customers' new needs.

According to the Danish Energy Agency's "Analysis assumptions for Energinet 2024" (AF24), the capacity of Danish wind and solar plants is to grow from 10,954 MW at the beginning of 2024 to 42,876 MW at the beginning of 2031, i.e. almost a fourfold increase. In comparison, the largest Danish hourly consumption of electricity was approximately 9,000 MW in 2024.

In any case, it is a huge undertaking to expand a network that is primarily built to serve a consumption of up to 9,000 MW to serve a production of over 40,000 MW in just 7 years. Solar cells account for 66% of the power increase, but deliver a much smaller fraction of the energy increase. Therefore, it can be reasonably assumed that the expansion with solar cells costs more infrastructure than any other expansion on land.

> These findings should be sufficient reason for a reassessment of the optimal expansion of Denmark's electricity production capacity for the coming years.

Solar cells have become a dominant factor in the electricity market

It takes a greater power capacity of solar cells per unit of energy produced in Denmark than in more southern countries. In relation to dispatchable production, the ratio in Denmark is approximately five to one. The large capacity means, firstly, a greater need for grid capacity, and secondly, a strong impact on spot prices in the electricity market.

A comparison of Danish spot prices for an average day in 2018 with an average price in 2024 shows the influence of solar power (fig. 5).

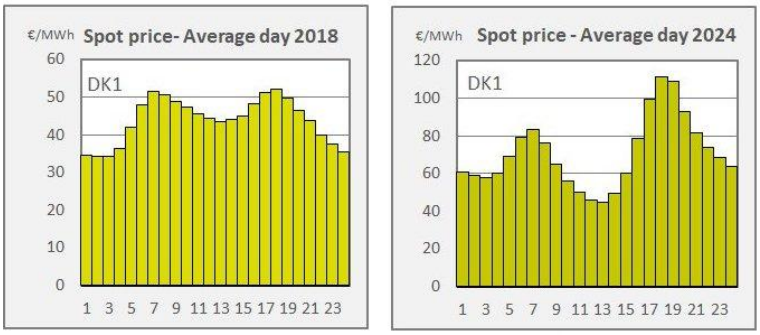

Fig. 5 - Daily spot price minimum moved from night to day

The change moves a lot of money. It is especially the sellers of solar energy who lose money. This has shown in practice in Denmark as financial difficulties for the developers of solar energy.

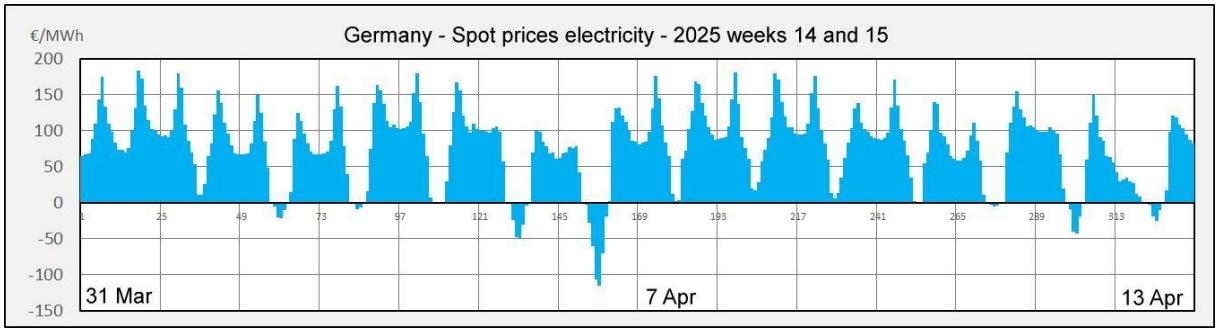

Fig. 6 - Danish spot prices are strongly influenced by the electricity market in Germany

The influence of solar energy on the electricity market is noticeable in most of Europe (fig. 6). This means that it will be bad business to install more solar cells unless it is fully compensated by smoothing the production, for example in the form of batteries.

Spread of weekly commercial values in 2025

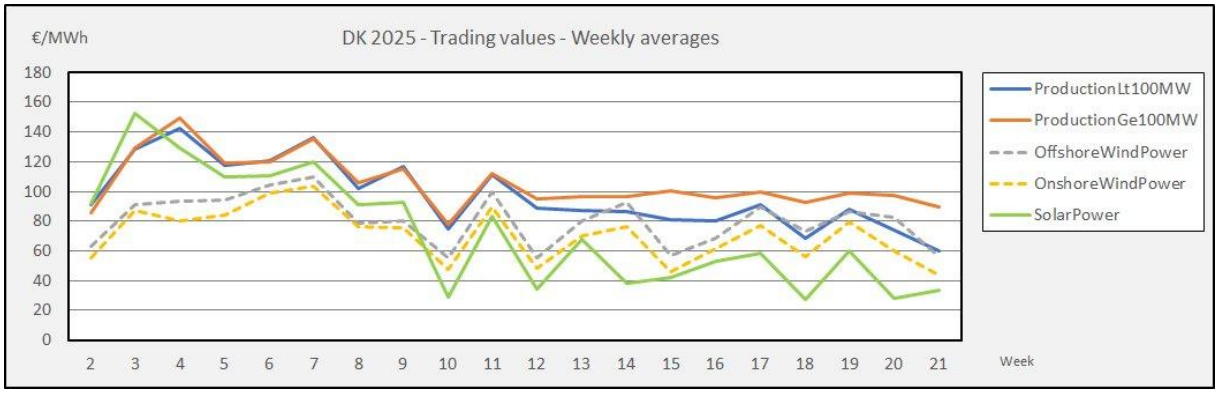

Fig. 7 - Trade values in the spot market fluctuate from week to week

From week 2 of 2025, the commercial values per week are calculated for the following categories:

- CHP plants < 100 MW
- CHP plants >= 100 MW
- Offshore wind
- Onshore wind
- Solar power

There was a high price level at the beginning of the year, also for solar energy. The influence of solar power caused prices to fall, most significantly for solar energy, which has both the highest and the lowest weekly values recorded in 2025. Depending on settlement agreements, price variations can have a major economic impact on providers in the electricity market.

Elements for a Danish strategy

If we assume a continuation of the market trends shown, it may become expensive for Denmark to be so dependent on exchanges with neighbouring countries.

Denmark should therefore establish an ample capacity of flexible resources on both the demand and supply sides. This should increase commercial resilience and make it possible to operate profitable in counterphase with the needs of the larger neighbouring countries.

It will be a major challenge to develop sufficient flexible resources to ensure Denmark the necessary freedom of action in parallel with the planned expansion of wind and solar energy. But what is the alternative?