A General Election on Climate

The climate change was the main issue during the recent election campaign in Denmark. Eleven of thirteen parties declared to have the most ambitious climate policy. On the night after the European election, a former chairperson of a Danish right-wing party referred to "the climate-fools". But majority of the voters were really concerned about the climate. In the succeeding Danish election, her party lost more than half its seats in the Danish parliament, and the majority changed from the blue parties to the red parties.

The 70% target is a moral matter

After the Danish election, four left-wing parties negotiated a common understanding for a new government. They have reached an agreement on emissions of greenhouse gas (GHG): they must be reduced by 70% from 1990 to 2030 instead of 60% (the previous target).

The percentage has become the main indicator in a bidding process. However, very little has been written about the rules of the game in the international comparisons.

In a discussion on TV on June 24th, it was stated several times, that the GHG reduction is a moral matter. It is well known that changes in Danish emissions will not have any effect on the global climate, but an ambitious climate policy will make us feel better and Denmark will get a leading role in the development of new climate friendly products.

"Emission inventories" is a favourable method for Denmark

A year ago, the Danish prime minister announced in large newspaper ads that Denmark is one of the world's best climate nations. This is a rude exaggeration. Therefore, I collected some facts in a brief note[1].

Fig. 1 – "World's best" is an exaggeration

According to Eurostat, emission values can be calculated in three ways:

1. *Air emissions accounts* by Eurostat: GHG emissions classified by economic activities.
2. *GHG emission inventories* by UN: GHG emissions classified by technical processes.
3. *Footprints*: GHG emissions classified by final use of products. Modelling results published by Eurostat.

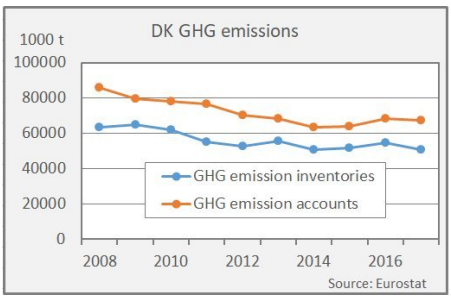

Fig. 2 – Emission accounts include Danish economic activities abroad

In most comparisons, the Danish results are slightly worse than the EU average, but the Danish reduction rate is above average.

The emission inventories are published by the Danish Energy Agency and used for international comparisons. This is a favourable choice from a Danish point of view because it has the lowest Danish emissions. It excludes

[1] http://pfbach.dk/firma_pfb/references/pfb_green_competition_2018_05_05.pdf

for instance electricity import and fuel for Danish ships and aircrafts when bunkered outside Denmark.

Greenhouse gases are not only carbon dioxide (CO2), but also methane (CH_4), nitrous oxide (N_2O) and fluorine-gases (HFC, PFC and SF_6).

Danish emission reductions 1990-2017

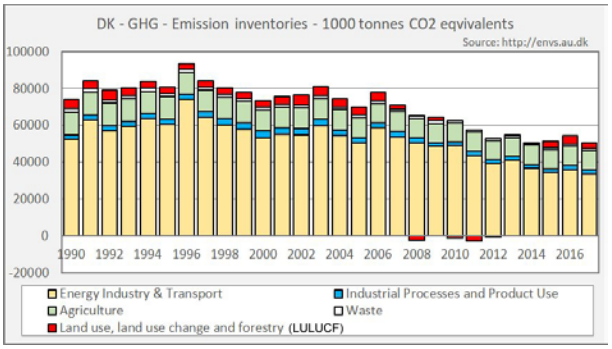

Fig. 3 - Danish GHG emissions 1990-2017

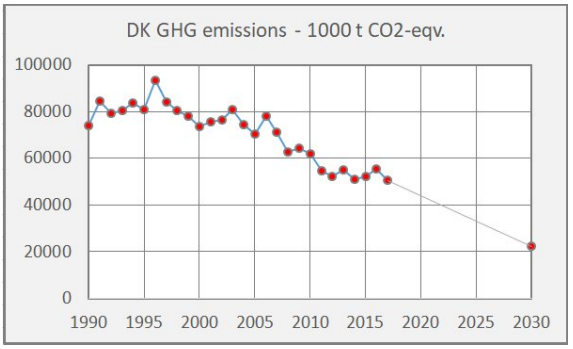

Fig. 4 - The new DK emission target in 2030

Denmark has succeeded in reducing the GHG emissions by the first 30% (fig. 4). The next 40% are probably more troublesome and more expensive.

Carbon dioxide is the most important greenhouse gas, but the effect of other gases should not be ignored. The magnitude of their emission is about 15 million tons CO_2 equivalent per year in Denmark (fig. 5).

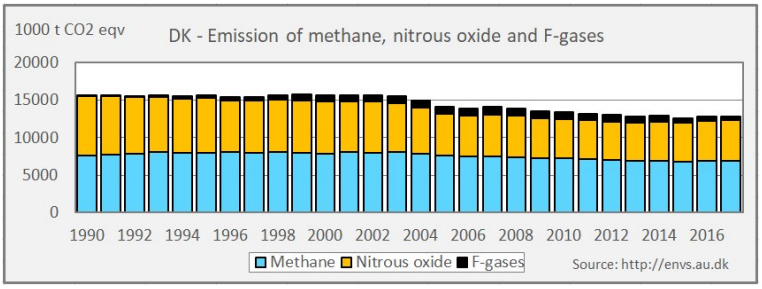

Fig. 5 - About 15 mill tons emission of other GHG gases than CO_2

Statistics from the Danish Energy Agency (ens.dk) have a specification of the main components of the **CO_2 emission** (fig. 6). The chart does not include methane, nitrous oxide and F-gases. Therefore, the totals are different in fig. 3 and 6.

The chart reveals that the electricity sector has reduced its emission of CO_2 more than other sectors.

How should a Danish GHG reduction of 27 million tons per year be possible in just 11 years?

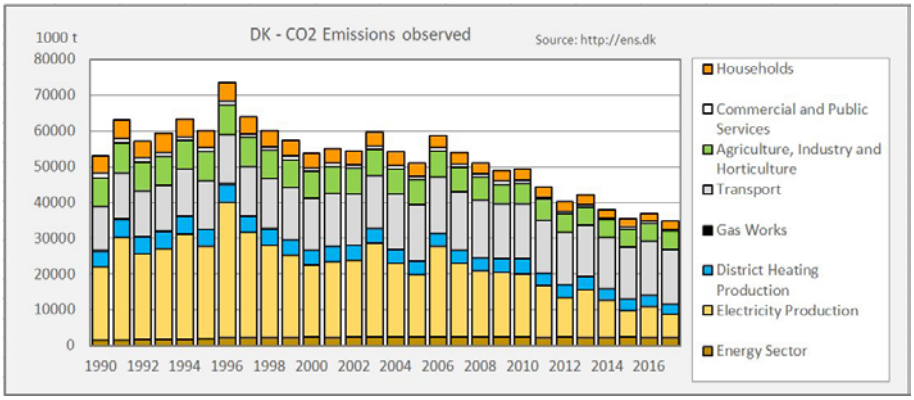

Fig. 6 - Heat and electricity have done their part already

It will be far from sufficient to remove all GHG emission from the electricity sector.

Table 1 assumes that all kinds of GHG emission should be reduced by 70% from 1990 to 2030.

The transport sector had the wrong trend from 1990 to 2017 and it is the largest GHG emitter in 2017. It will take a complete revolution of Danish transport to meet the new 2030 target. It is doubtful if we have the time for such changes.

DK - All greenhouse gases	1990	2017	2030
CO2 Energy Sector	1401	2201	420
CO2 Electricity Production	20561	6647	6168
CO2 District Heating Production	4473	2754	1342
CO2 Gas Works	101	31	30
CO2 Transport	12420	15226	3726
CO2 Agriculture, Industry and Horticulture	7785	5092	2335
CO2 Commercial and Public Services	1406	648	422
CO2 Households	4922	2106	1477
Methane All sectors	7595	6885	2279
Nitrous gases All sectors	7966	5450	2390
F-gasses All sectors	42	482	13
Total - 1000 t CO2 eqv	68672	47522	20602
Total - % of 1990		69%	30%

Table 1 - A hypothetical reduction scenario

The role of electricity and wind energy

Production of electricity and CHP heat cause about a third of the CO_2 emissions in fig. 6. Some characteristics of this sector are shown in fig. 7:

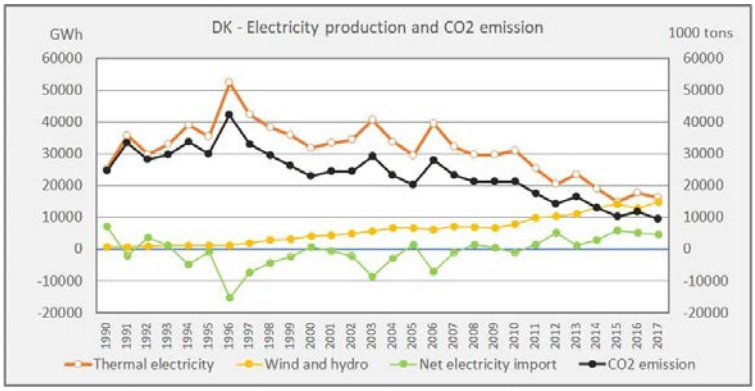

Fig. 7 - Emissions include electricity and CHP heat

- The emission of CO2 clearly follows the thermal production.
- The emission per kWh thermal electricity falls from 1017 g in 1990 to 318 g in 2017. The reduction reflects among other things increasing use of gas and biomass.
- The electricity sector can contribute to the continued emission reduction by phasing out remaining use of fossil fuel. The potential reduction would be another 10 mill tons CO_2.
- Wind energy production has reached a level of about 15 TWh per year.

Electricity import is the easy solution

Electricity import is a less noticed contribution to GHG reduction. The net import has reached a level about five TWh per year. Imported electricity is formally carbon-free because it is included in the emission inventories of the producing country.

The electricity import will probably increase because several Danish power plants will be decommissioned within the next few years. The large power plants, which were built before 2000, will be at the end of their economic lifetime before 2030. It is doubtful if they will be replaced by new power stations. The GHG emissions will fall correspondingly.

The typical idea is that new wind power combined with the batteries in a large fleet of electric cars will be an essential contribution to the green transition in Denmark. However, charging of electric cars cannot be limited to windy periods.

Denmark does not have backup capacity for the wind power. Therefore, electricity import is vital for maintaining a high level of security of supply (fig. 8). Besides, the import is carbon free by definition.

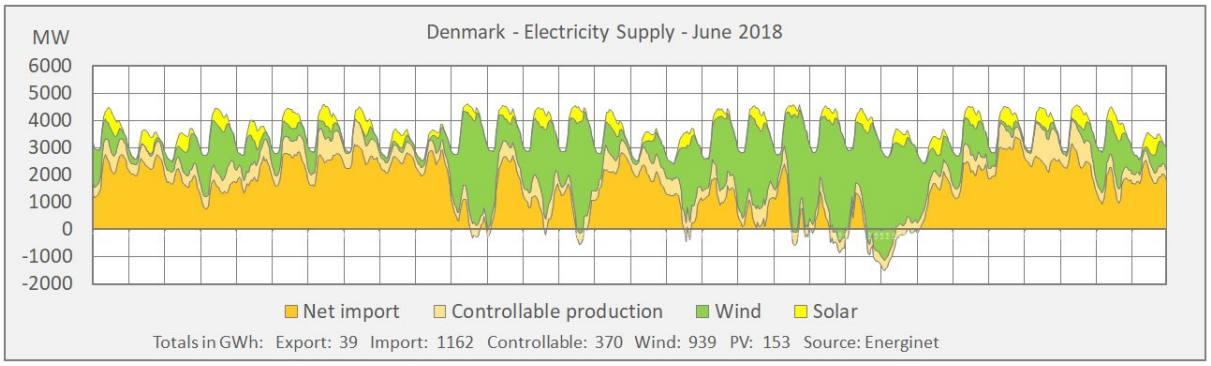

Fig. 8 - Electricity import guarantees security of Danish electricity supply

New wind farms have no direct effect on the emission inventory

In 2018, Danish wind farms produced 13.9 TWh, thermal power stations produced 14.1 TWh and the net import was 5.2 TWh.

As an experiment, we can assume that all thermal production were closed down before 2018. The necessary import would have been 19.5 TWh and overflow from existing wind power only 0.2 TWh. The formal carbon emission in 2018 would be zero.

Import of more than half the electricity consumption may be too unreliable or too expensive.

The import could be reduced by increasing the Danish wind power output by for instance 3.5 TWh (25%). The necessary import would then go down by 2.7 TWh and the wind power overflow would go up by 0.8 TWh. The carbon emission would still be zero.

Maybe we want an even lower dependence on imported power and double the wind power output by adding 13.9 TWh instead of 3.5 TWh. This would reduce the necessary import by 7.6 TWh and increase the wind power overflow by 6.3 TWh. The incremental overflow is 68% for the last per cent. The carbon emission would still be zero.

This is only a numerical example in order to show that wind power alone can neither solve emission problems nor supply problems.

New wind power has the indirect effect that it pushes thermal power plants out of the market, but there might be other ways to limit the thermal production. Lower thermal production saves carbon emission.

During the recent Danish general election campaign, plans for new offshore wind farms in the North Sea with a total capacity of 10 GW were mentioned. It will take several new large transmission lines to handle a 10 GW inflow into the Danish power grids.

In 2015 the European Grid Vision[2], e-Highway2050, identified the power potential of the North Sea. The report explains that it would be a long way round to land an electricity production of this magnitude in Denmark. Whether landed in Denmark or elsewhere, an increasing part of the additional wind energy would go abroad, unless electricity storage or other types of flexible demand have been implemented in large scale in Denmark.

It will take a much broader range of measures than wind power and electric cars to make an efficient and successful green energy transition in Denmark.

The moral dilemma

The reduction of GHG emissions had high priority in the recent Danish election campaign. The new government has defined a target of 70% reduction from 1990 to 2030. There is still a long and troublesome way to go.

Wind power is a technology of national importance in Denmark. Therefore, it is natural to see wind power as a core element of the green transition. Wind power has pushed thermal power plants out the market, but fluctuating wind power cannot replace dispatchable production. Backup capacity is needed. Electricity import is the backup for Danish wind power. The traditional production has been replaced by a combination of wind energy and electricity import.

The 70% reduction by 2030 is probably a more ambitious target than any other country has set. Due to the rules of the emission inventories, Denmark moves its emission problems on to its neighbours by relying on foreign backup for the wind power. This strategy will make the Danish emission inventory look better at the cost of emission inventories in other countries. It may be commercially reasonable, but Denmark cannot claim to have behaved more morally than others have.

Some people will argue that the initial support for wind power has shown that it has paid off to be a front-runner, but the difference is that it is still uncertain which technologies will be usable for flexible power-to-x systems. Denmark has the chance to take the international lead, but also the risk of choosing a false trail.

Statistical sources:

- Danish Energy Agency, Annual and monthly statistics (https://ens.dk/en/our-services/statistics-data-key-figures-and-energy-maps/annual-and-monthly-statistics)

- Eurostat (https://ec.europa.eu/eurostat/data/database)

- Aarhus University, Department of Environmental Science, Emission inventory (http://envs.au.dk/videnudveksling/luft/emissioner/emissioninventory/)

- Energinet, Energy Data Service (https://www.energidataservice.dk/en/)

[2] My introduction: http://pfbach.dk/firma_pfb/pfb_ehighway2050_2016_01_07.pdf