Ph.D. Stine Grenaa Jensen[1]

A CO2-NEUTRAL ENERGY SYSTEM - AN EXAMPLE OF DENMARK

[1] Danish Energy Association, Rosenoerns Allé 9, DK-1970 Frederiksberg, Denmark
Phone: +45 35 300 437; E-mail : sgj@danskenergi.dk

OVERVIEW

A CO2-reduction at 20 % in the European Union by 2020 is the target set in 2007 by the European Commission (European Commission, 2007). The final Directive agreed on in December 2008 out-lined national target for each Member State for the sectors not included in the EU-ETS quota sys-tem. For the quota sectors the target was set commonly. On the long term, a target at 20 % is not enough for meeting the 2 degree target agreed on in the Copenhagen Accord in end 2009. And further measures must be taken into account to reach this target.

In the long run targets have been set on minimum 80 percent for the industrialised countries for 2050. This challenging target has to be discussed now for deciding on long term visions for the society, especially since the lifetime of energy investments often reaches 40 years.

In several countries, discussions about CO2-neutrality enter the scene. In Denmark the government is preparing a strategy for how to make Denmark independent on fossil fuels. The issue of security of supply does dominate the picture, but at the same time, economy and climate are at the same time arguments. A transition towards a CO2-neutral society with a low share of fossil fuels requires a transition of the whole energy system we have today. In general there are three ways to reduce emissions from energy:

- Use less energy
- Increased use of renewable energy
- Storage of CO2 in the ground (CCS)

The purpose of this paper is to illustrate how such a CO2-neutral vision could be formulated. For this, the goal is set to:

- Reduce emissions to zero in 2050 for Denmark
- Increase security of supply by reducing independence of imported oil and gas.

The analyses will show one scenario with descriptions of the mechanisms in use in 2025 and 2050. The scenario will show how the future could look like by the use of technologies like electric vehicles, heat pumps, biogas, and CO2-storage. Furthermore, the scenario includes massive use of energy efficiency. Together, the modelling of these technologies shows a possible path towards a CO2-netral society for Denmark.

METHODS

Technical analyses for scenarios in 2025 and 2050 are modelled in the scenario model STREAM, which includes production and consumption for the Danish energy system. In year 2025 calculations are extended to include more detailed calculations by the general equilibrium model Balmorel, which models the heat and power system in the Nordic region on hourly basis.

The scenario rests on three central assumptions. First, Denmark has committed to the renewable energy target at 30 % in 2020. Second, it is assumed that this target is continued with 1%-point each year until 2025. Finally and most central, it is the target of the model that the emissions reaches a level of zero in 2050.

The technical analyses are modelled in the model STREAM, which is a spreadsheet model developed in 2005-2007 (Teknologirådet, 2007). Consumption is described from economic

growth and savings for the sectors: Tertiary, residential and industry. Production is described from desired fuel mix and corresponding demand for production on hourly level. Emissions, power production, fuel consumption etc. are output from the model.
The energy modelling is conducted in the general equilibrium model Balmorel (www.balmorel.com), which includes some geographical considerations for the heat and power production and consumption. Focus is here especially on electric veichels, heatpumps and power use in industry processes.

RESULTS

The analyses show that it is possible to reach a target of CO2-neutrality in 2050. The central elements in reaching the target lie in:

1. Energy efficiency: Reduction in consumption by 0.8 % per year compared with today. Business-as-usual would indicate an increase on 1.2 pct. The efficiency is gained from technology improvements, and change in technology use. E.g. change from conventional cars to electric vehicles or change for boiler to heat pump in individual households.
2. Flexibility in energy demand is increased and used to balance a large share of renewable energy in particular wind power. Flexibility from import and export is also extensively utilised in the scenario.
3. The main part of the use of oil and natural gas is replaced by power. In 2025 electrical vehicles, heat pumps and power kettles can replace 87 PJ of fuel with 8.2 TWh of power. This substitution makes good sense, since the CO2-content in power is reduced from 440 g/kWh to 200 and 0 g/kWh in respectively 2025 and 2050.
4. Fuel use is based on renewable energy, in particular wind power and biomass, but also sun power, wave power, and biogas is included. The overall amount of renewables are increaseed from 17 % today to 40 % in 2025 and 80 % in 2050.
5. There is a need to store CO2 by use of the CCS-technology (Carbon Capture and Storage) to become CO2-neutral. When CO2 is stored with CCS on central power plants, we choose to use both coal and biomass a fuel on these plants in order to actually get a negative contribution on emissions from the power sector.

REFERENCES

1. European Commission (2007) “Towards a low carbon future”, COM(2007) 723 final.
2. European Union (2009), “Directive of the European Parliament and the Council on the promotion of the use of energy from renewable sources amending”, PE-CONS 3736/08
3. Danish Energy Association: ”Power to the people”, Dansk Energi, juni 2009 (http://www.danskenergi.dk/Indblik/Power_to_the_people.aspx).
4. www.balmorel.com
5. Teknologirådet, 2007