Energy Vision 2030 for Denmark

By Gunnar Boye Olesen, International Network for Sustainable Energy – Europe (INFORSE-Europe) and "VedvarendeEnergi", September 2010

Just 20 years from now, in 2030, Denmark can be independent from fossil and nuclear energy. This is the conclusion of scenarios by INFORSE-Europe and *VedvarendeEnergi*. The scenarios show how the transition can be organised, how to manage the variations in a system with 100% renewable energy in 2030, and now also the economy of a future, renewable energy system for Denmark.

In 2030, where a large part of electricity is expected to come from intermittent sources (wind and wave energy), there is a need for flexible electricity demands with heat pumps with heat storages, smart charge of electric cars etc. In particular there is extensive use of heat-pumps in district heating systems. There is also use of electricity for hydrogen production for transport and hydrogen storages.

In many respects, Denmark is well on its way with the transition with an increase of windpower from 1% of electricity production in 1988 to almost 20% in 2005, a doubling of total renewable energy use since 1991, no nuclear power, and large increases in efficiency. In spite of the successes there is still a long way to go. We need clear political decisions to guide the development, and we need to give up some "holy cows", such as the coal use in power production, the untouchable car etc.
There are a number of good reasons while Denmark should embark on a fast transition to 100% renewable energy: Denmark is one of the richest countries in the world and one of the largest CO_2 emitters per capita. In addition Danish oil and gas resources will be virtually exhausted by 2030, self sufficiency with oil and gas will disappear well before 2020. Denmark has benefited from the first step of the transition with the development of large windpower and biomass industries. Add to all this the global dimensions: the fragile climate and and global oil supply that is rapidly diminishing.

The vision is based on studies of the possibilities for renewable energy and energy conservation, a model that has been developed based on the work of the International Network for Sustainable Energy, which developed a vision for a European transition to sustainable energy. Additionally is used the EnergyPlan model from the Aalborg University to model the hourly variations in demand and supply in 2030 to test that there is balance in the system every hour of the year.

Renewable Energies in the Vision
An important part of the Vision is rapid increase of renewable energy. **This includes a continued development** of:

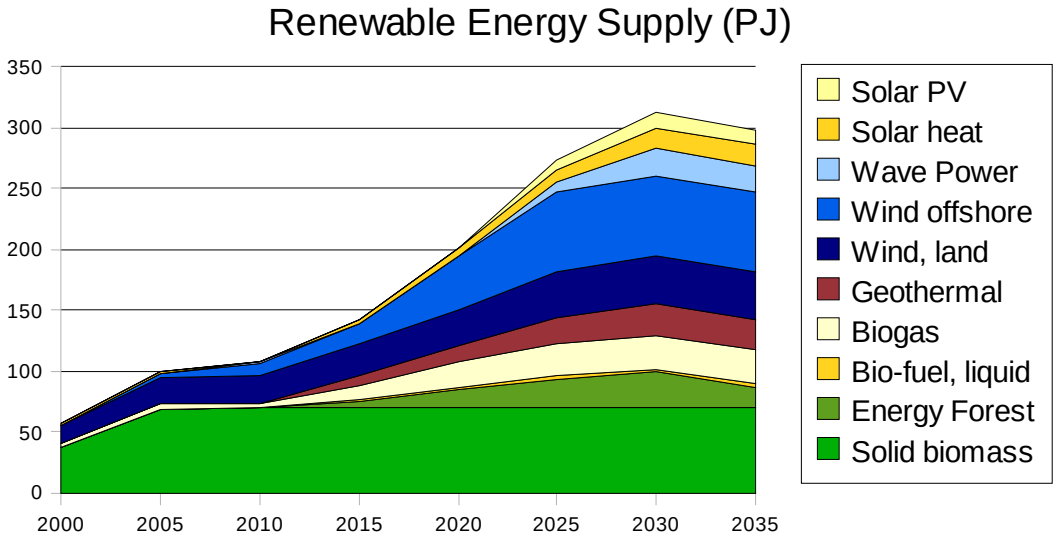
Windpower: The level in 2030 could be 10,000 MW of installed capacity or more, up from 3,700 MW today. It could be realised by replacing existing smaller windmills with new, large ones and expanding the off-shore development from to 5,000 MW or more in 2030. In this way 2/3 of the power production or more will come from wind.

Solar Energy: The solar energy use could be 13 m2 per capita for solar collection, 8 m2 solar PV electricity and 5 m2 of solar heating. Even though PV is expensive, the PV development is expected mainly after 2020. When this investment is shared over 20 years in a period with falling PV prices, it will not be a burden for Denmark. The solar heating will partly be for district heating.

Biomass: Biomass from existing production (wood, straw etc.) will continue at present level while biogas should be substantially expanded, to use half of Danish manure, grass from extensively used land 7.5 times the present level. Also energy crops should be expanded, and could cover 150,000 ha. Also increased straw and wood from cuttings is included. A number of scenarios are developed with more or less biomass and windpower.

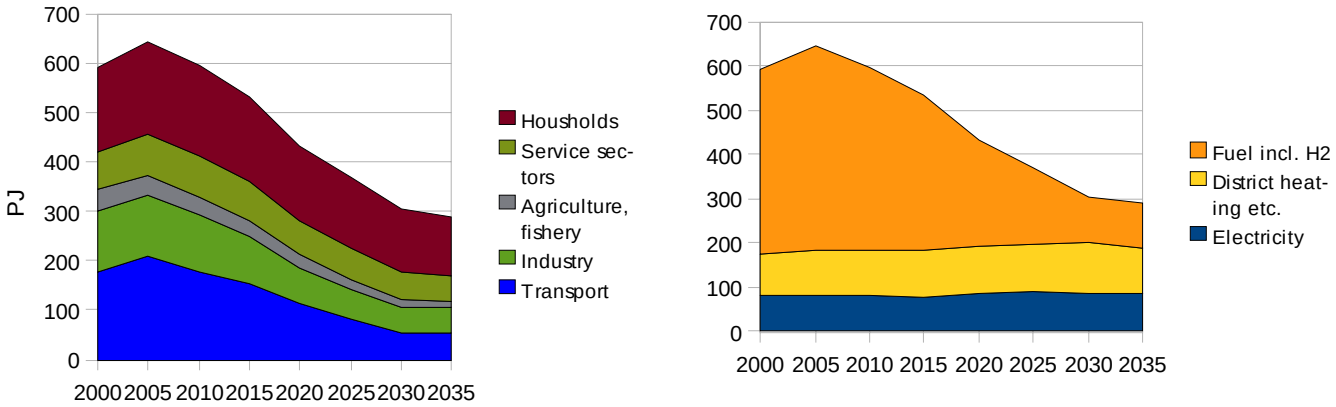
In addition geothermal energy use should be expanded as have been done in Copenhagen, and wave-power should be used to supplement windpower. If the technical problems of wave power are not solved, windpower should be developed with additional 2,000 MW, but only after 2020, when the technology will be ready.

Strong Emphasis on Energy Efficiency



For electricity consumption, industrial production and transport is expected that the end-use efficiency can be increased a factor-4 compared with today's level until 2050. It is well documented that thus is possible with use of best available technologies. The increase of efficiency is a slow process, and until 2030 is "only" expected increases from 40% to 64% in different sectors.

Regarding transport OVE is in favour of a transport vision with a 40% reduction of personnel car use and almost 50% reduction of truck transport. This will partly be replaced by a factor-3-6 times increase in rail transport and doubling of bicycle use. This will require a shift of existing trends and doing away with the perception that longer distances of commuting and increasing goods transport are positive developments. If the vision is realised, it will remove most traffic jam, reduce noise and pollution in cities and in several other ways contribute to better lives.



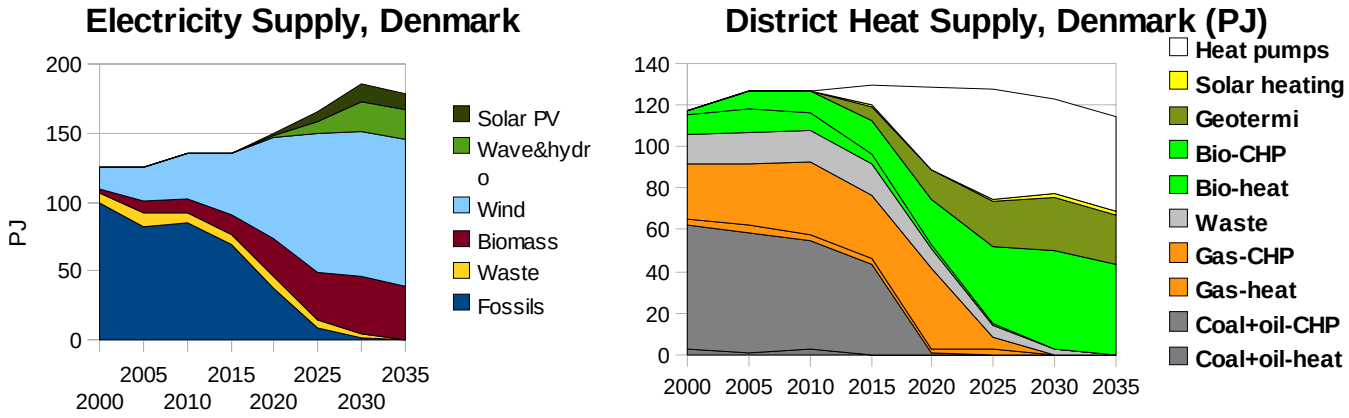
Final Energy Consumption in Sectors and in Energy Forms

Regulating Varying Supply

Large parts of the energy supply will come from varying sources. Solar heating is also

expected to cover part of district heating, which also will require expansion of heat storages These heat storages can be used for storing heat from cogeneration of heat and electricity, de-linking the electricity production from the heat consumption. In the power system the requirements are larger as in 2030 about 80% of the power production should come from windpower, wave power, and solar. Almost half of the varying production could be used for flexible electricity use such as heat pumps and hydrogen production, while the other half should be used for normal consumption. This will require electricity exchange with Norway and Sweden as Denmark does today, but no new power lines.

The Vision does not end in 2030. The efficiency can continue to increase, which can free biomass that can be used in the chemical industry, where it can replace fossil fuels as feed-stock for production of plastics, lubricants, etc.



Good economy in a transition to renewable energy in 20 years
INFORSE-Europe and VedvarendeEnergi have assessed the economy of a rapid transformation in 20 years, and compared it with a situation where renewable energy and energy efficiency will expand at a slower pace. This assessment is also done with the EnergyPlan programme.

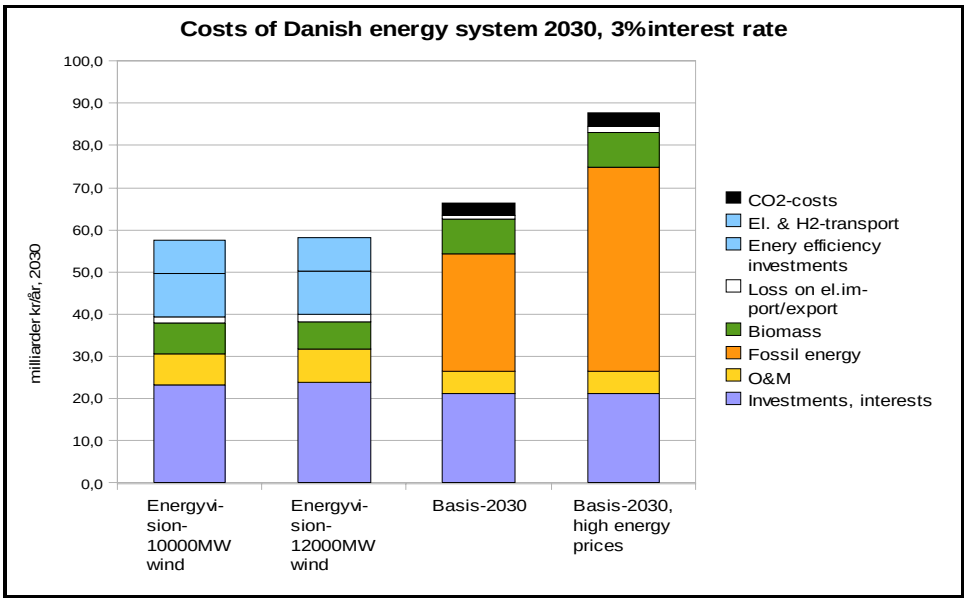
In Energivision2030 all the energy resources comes from sources in Denmark, including biomass. At the alternative scenario, Basis2030, Denmark will be dependent on imports of fossil energy, since the Danish production of oil and gas will be very modest in 2030.

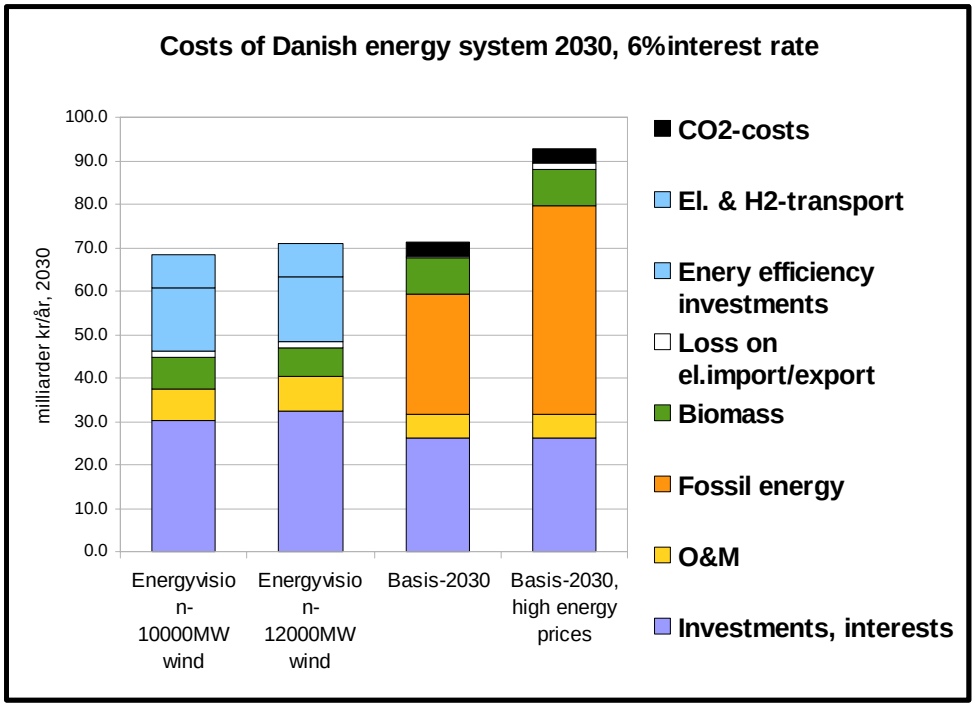
The Energivision2030 requires more investments than Basis2030. This means that the lower interest rate, the better the economy will be in Energivision2030's rapid transformation. The calculations have been performed with 3 % interest rate and 6 % interest rate. The 3 % interest rate is the average rate over the past 15 years, while the 6 % interest rate is the rate that the Danish Energy Agency recommends at the planning of the investments in energy facilities.

The higher energy prices, the more expensive it will be to wait. In the assessment were used two price scenarios: lower and higher energy prices for fossil fuel. The low prices are the Danish Energy Agency expected energy prices until 2030. This includes that the coal prices won't raise compared to today's level. With the higher prices is assumed an oil price of U.S. $ 200 per barrel, which is 2.5 times more than today. By comparison, oil prices have raised approx. 2.5 times in just 10 years on top of normal inflation.

By these fairly conservative assumptions, the calculations show that there is good economy in a rapid transition to 100% renewable energy. Even with a high interest rate and a low raise of energy prices, there is no financial gain by continuing the current slow pace.

The calculations for the two scenarios are conducted with the same assumptions about production, construction and transport, including a transition to a more sustainable transport system. Using the same assumptions of society's physical development, the two scenarios are directly comparable, because the scenarios provide energy for the same society.





A fast start is crucial.
The economy of the transition is dependent on the right decisions for investments in a timely mannmer. The sooner we start, the more harmonious the development can be to replace old, inefficient power plants with new ones, which are powered by renewable energy. If we wait and continue to invest in fossil energy, the transition will be more costly. There may be costly bottlenecks in the transition, and we may be forced to scrap the newer plants.

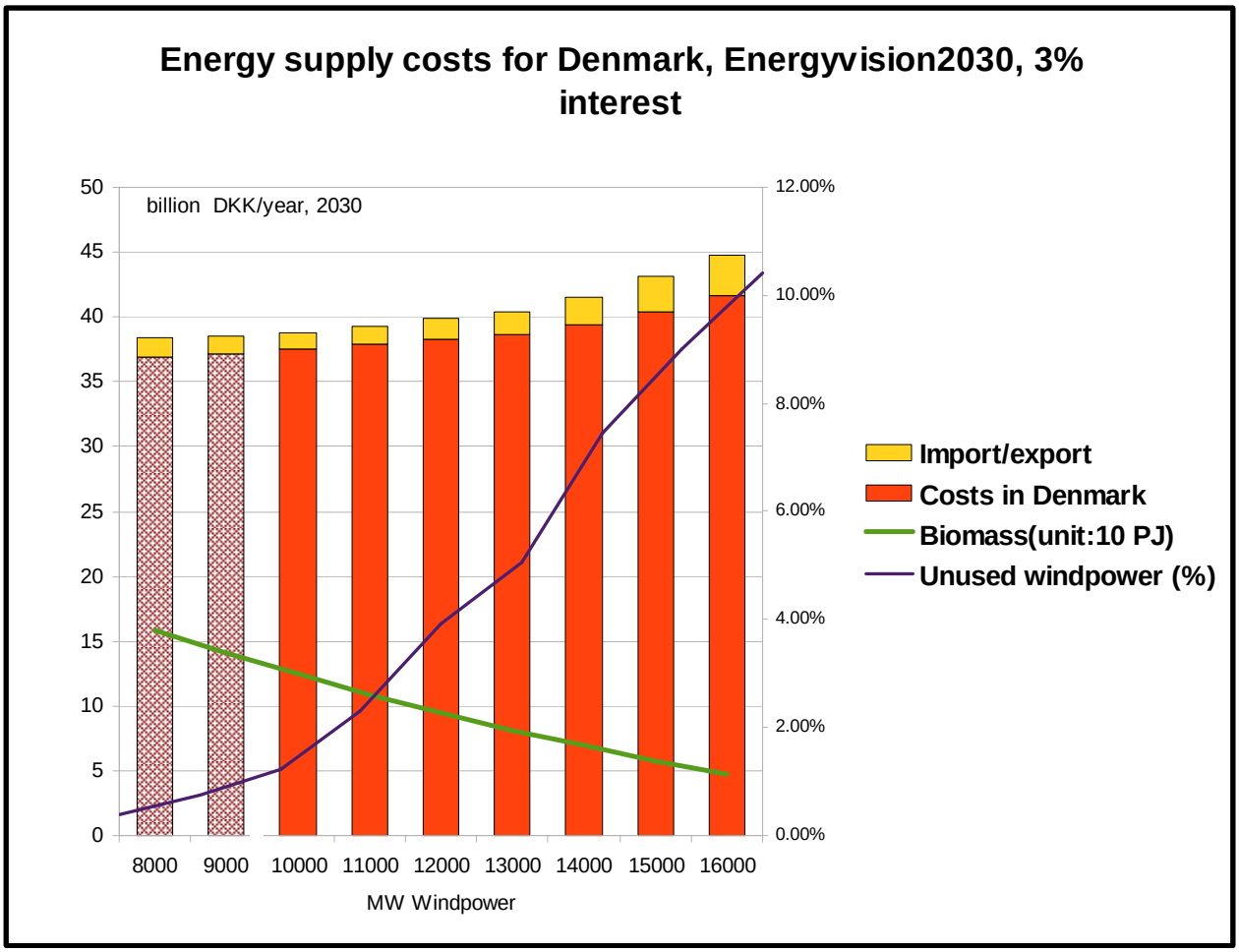
7 scenarios with different development of wind power and biomass
One of the discussions of a future energy system with 100% renewable energy is “how much biomass is needed?”. It is possible to choose a larger supply of wind and in turn less biomass. Therefore is developed 7 scenarios with different uses of wind power and biomass, for the Energyvision2030:

Scenario	1	2	3	4	5	6	7
Wind power	10.000 MW	11.000 MW	12.000 MW	13.000 MW	14.000 MW	15.000 MW	16.000 MW
Biomass	125 PJ	109 PJ	95 PJ	81 PJ	70 PJ	57 PJ	48 PJ

There are limits to how much wind you can use without the need for energy storage in the form of, for example large batteries, that are not included in the Energivision2030. With the proposed energy system both the costs and the unused wind power will be greater with larger windpower capacity above 10,000 MW in total. However, the difference between the total costs of alternatives with higher and lower amounts of wind power respectively biomass is relatively modest. If you want to limit the amount of biomass, or use more of it rather than wind power, it can be done without major economic consequences, at least within certain limits.

The possibilities to vary between wind power and biomass are shown in the graph below, for respectively 3% interest rate and 6% interest rate. For the examples with less than 10000 MW of wind power, the Energyvision2030 does not explain how to obtain the biomass in a sustainable manner and therefore they are not to find among the sustainable scenarios. This gives 7 scenarios with 10,000 to 16,000 MW wind power.

The assumptions for the energy savings, is the same in the 7 scenarios. With a further effort for energy savings, the need for renewable energy becomes smaller, while a weaker energy saving efforts will make it harder to get enough Danish renewable energy in a sustainable manner.



Sources for Calculations
Important assumptions about the energy prices and costs for the operation and maintenance is based on figures from Danish Energy Agency and the quota price of CO2 is set at 20 € (150 € / ton). More detailed assumptions can be seen in the memo “Background note for the total energy system” to Energyvision2030 on www.ve.dk/vision (in Danish).

Read more about visions at www.inforse.org/europe

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