

# Denmark's commitment to 100% renewable energy

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During the last week of October, the world's leading climate scientists will gather in Copenhagen to finalise and launch their latest scientific assessment. Now is the time to shift the focus from problems to solutions. Denmark, the host country, provides a rare example of the kind of climate change solutions we need now: Denmark has committed to a fossil fuel free, 100% renewable energy future by 2050.

On 2<sup>nd</sup> November, the United Nations' Intergovernmental Panel on Climate Change, the IPCC, will release the synthesis of its 5<sup>th</sup> Assessment Report, AR5, summarising the latest findings in climate change science. Central to the report is the increased emphasis on urgency. Global greenhouse gas emissions are still rising, and if we are to stand a reasonable chance of avoiding 'very dangerous' and 'irreversible' climate change, we need to act now.

According to the IPCC: A 'fundamental transformation of our energy system is needed' including a 'long-term phase-out of unabated fossil fuel technologies.' Stabilising the climate will require greenhouse gas emissions to be reduced to virtual zero in the coming decades.

So far, Denmark is one of the few countries in the world whose energy policies are in line with this goal. Not only do Denmark's climate targets include a complete phase-out of fossil fuels. Denmark has committed to replacing fossil fuels with 100 per cent clean, green, safe, renewable energy; no carbon capture and storage (CCS) or nuclear power included.

In just five years from now, half of Denmark's electricity will be produced from wind and by 2030 coal will be phased out entirely. By 2035 *all* of Denmark's energy demands in electricity and heating will be met by renewable energy – and, by 2050, *all* of Denmark's energy will be clean, safe and renewable.

Denmark will also reduce its domestic greenhouse gas emissions by 40 per cent by 2020 relative to 1990 levels – without the use of carbon credits. That's ten years ahead of the proposed EU target.

#### Denmark's long-term climate and energy targets include:

- 100% renewable energy by 2050
- 100% renewable energy in electricity and heating by 2035
- A complete phase-out of coal by 2030
- 40% reduction of domestic greenhouse gas emissions from 1990 by 2020
- 50 % of electricity demands met by wind by 2020

With 34 per cent of Denmark's electricity consumption currently covered by wind, Denmark's energy transition is already well underway. Already now, the process is boosting employment, increasing exports and reducing fuel import expenses and dependence on volatile fossil fuel prices.

With a successful decoupling of economic growth and energy consumption (since 1980, Denmark's energy consumption has remained largely stable whilst the economy has almost doubled), transitioning to 100 per cent renewable energy is expected to continue to benefit the national economy, employment and overall wellbeing.

## **The Turbine Adventure**

Denmark's ambitious climate targets are, in part, the result of a decade-long, hugely successful people-led movement against nuclear power and in favour of renewable energy. The movement, or rather movements; one against nuclear power, one for the development of renewable energy, started in 1974 in response to the oil crisis. As the Danish electricity companies proposed to build nuclear reactors, public opposition grew and groups of determined citizens set out to demonstrate that nuclear power was the desired non-oil based energy could be obtained from safe and renewable sources, particularly from wind.

In the late 1970's and early 1980's, all over the country, dedicated and resourceful individuals built their own wind turbines. This was the beginning of what the Danes affectionately refer to as the 'Turbine Adventure.'

As the movements, supported by environmental scientists, engineers and a growing number of politicians, gained momentum, support for nuclear power diminished and in 1985 nuclear power was eliminated from Denmark's future energy strategy. Instead the Danish government provided subsidies for people investing in wind power. For every new turbine built, the Danish government provided 40 per cent of the initial capital investment.

Alongside single citizen turbine ownership, wind turbine cooperatives became exceedingly popular. Co-ownership of the turbines has had the effect of making wind power widely popular and to this day almost the entire population supports the continued expansion of turbine capacity in the country.

Although, with larger turbines and increasing industrialisation, co-ownership has fallen somewhat, even today, three quarters of Denmark's wind turbines are still owned by ordinary citizens.

## **Land of climate change believers**

In Denmark, anthropogenic climate change is overwhelmingly perceived as a fact. As a result, the ambition of transitioning to a fossil-free energy future is supported by the Danish political 'right' and 'left' alike. Greenpeace has worked hard for and fully endorses the government's climate targets.

## **Greening and growing**

Denmark's emissions reductions have not affected the economy negatively. The decoupling of economic growth from energy consumption is partially due to Danish companies being subsidised for using renewable energy and increasing energy efficiency, which in turn increases their creativity and prompts energy savings.

Job creation is an explicit objective of the Danish Climate Plan, and because Denmark has invested heavily in research and promotion of renewable energy, energy-efficient technologies and renewable heat supply systems, the climate and energy system has already created thousands of jobs. The full transition to 100 per cent renewable energy is expected to generate at least 30 to 40,000 new jobs in a country of 5.5 million people<sup>1</sup>.

## Synergy between climate action and wellbeing

Acting on climate change is often perceived as too hard and too costly, but the Danish example proves the opposite. Investments in renewable energy have boosted the economy and created jobs and in no way has the wellbeing of the population been compromised. In fact, Denmark boasts the world's most liveable city (Copenhagen) and the world's happiest people (according to some surveys).

## Denmark's 'recipe' for a fossil fuel free future

In 2010, the Danish Commission on Climate Change Policy conducted an analysis showing that Denmark has the potential to become entirely independent of fossil fuels by 2050 without the use of nuclear power or carbon capture and storage (CCS). Phasing out fossil fuels completely would bring Denmark in line with the EU policy goal of reducing greenhouse gas emissions by 80-95 per cent by 2050. The decision to become fossil fuel free was made in 2011, and, from September 2011, the new government went even further. In the report, 'Our Energy'<sup>2</sup>, the government outlined its primary energy targets including a transition to 100 per cent renewable energy in electricity and heating by 2035 and in transport by 2050.

## Denmark's Energy Scenarios

In May 2014, the Danish Energy Agency presented four different energy scenarios, or roadmaps<sup>3</sup>, outlining the ways in which Denmark could achieve its 2020, 2035 and 2050 climate and energy targets. The scenarios differ mainly in terms of the relative reliance on wind power versus biomass. Because the full transition will take time, the government will be required to choose a scenario no later than 2020. From an environmental and climate change perspective, two of the scenarios, the 'wind scenario' and the 'hydrogen scenario', are preferable to the others. These scenarios rely on large amounts of wind power and minimal amounts of biomass. All of the scenarios assume large energy savings.

Although Denmark's roadmap to fossil fuel independence and 100 per cent renewable energy is specific to the Danish context, many of the recommendations are relevant and applicable to other nations around the world. One finding may be of particular interest: The costs of phasing out fossil fuels are expected to be almost equivalent to or only marginally more expensive than a 'business as usual' scenario.

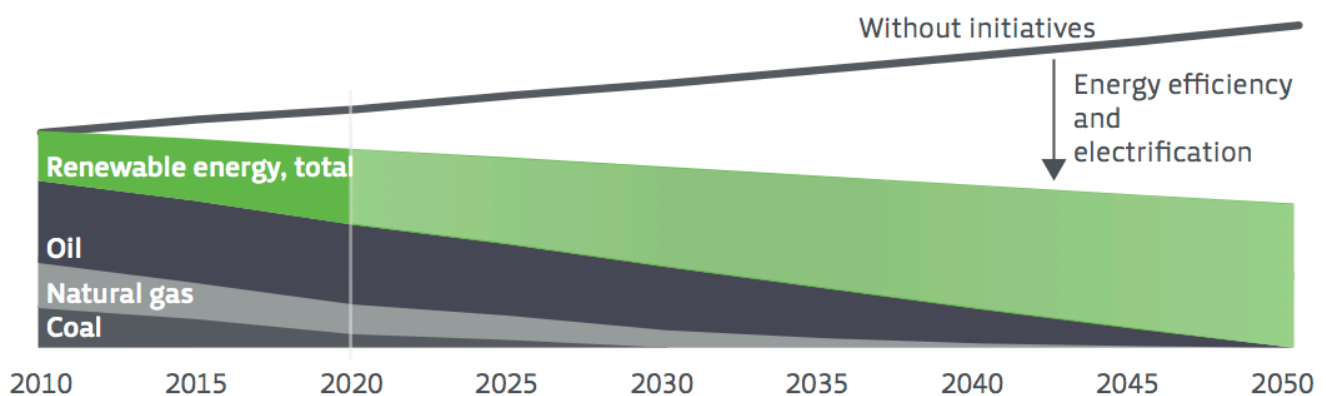


Figure 2.1 Illustration of energy consumption up to 2050

Illustration of energy consumption up to 2050. Source: Danish Government: Our Future Energy

## **Wind power is key**

According to the Danish Energy Agency, the key to making Denmark independent of fossil fuels is increasing wind turbine capacity, mainly offshore. Why? Because, owing to Denmark's decade-long history as a world leader in wind technology, a third of the country's electricity already comes from wind, the highest proportion in the world. During December 2013, wind power provided no less than 55 per cent of Denmark's electricity, a record high.<sup>4</sup>

In 2050 Denmark is expected to require between 11,000 and 18,500-megawatt (MW) wind capacity. The lower figure is based on a scenario with considerable biomass imports, the higher figure on a scenario where biomass use is limited to Denmark's own potential for production. For comparison, in 2013, Denmark had a wind turbine capacity of about 4,792 MW.<sup>5</sup> The majority of the new turbine fleet is expected to be situated offshore.

## **The new energy mix**

In the 'wind scenario,' by 2050, the use of biomass, excluding biogas and waste, will increase by 55 per cent relative to current levels, while in the 'hydrogen scenario' there is small reduction to biomass use compared to today's levels. In the 'biomass scenario' the biomass use is increased 2.7 times from current levels. By 2050, according to the 'wind scenario,' total energy consumption will be reduced by 27 per cent relative to 2012 levels through the implementation of energy efficiency measures.

In 2050, a large share of the energy used to heat buildings and for district heating is expected to come from electric heat pumps that use heat from soil, water or air. Several cities with district heating have access to geothermal resources, although, in in most cases, a heat pump boost will be required. Large solar installations are also expected to deliver heat for district heating. Following the most ambitious pathway, heat pumps, geothermal sources and solar heat are expected to provide a considerable part of Denmark's future energy.

## **Renewable energy technologies have developed fast**

In 2010, the Climate Commission did not regard photovoltaic (solar PV) and wave energy as competitive technologies and they were unable say whether these options would ever be able to compete with other renewable resources. Today, solar PV is ready to play an important role in Denmark's clean energy mix. About 36 MW of solar PV are currently being installed per month and by 2030 PV capacity is expected to reach 3,400 MW. It's a great example of the explosive development of renewable energy technologies.

## DENMARK IS PHASING OUT FOSSIL FUELS AND SHIFTING TO 100% RENEWABLE ENERGY.



### Economic tools and incentives

According to the Climate Commission, achieving fossil fuel independence will also require the use of economic instruments such as a gradually phased-in tax on the use of fossil fuels. And, because energy infrastructure is long-lived, disincentives designed to discourage investments in new fossil fuel infrastructure will most likely be important.

### Energy security – bridging the ‘gaps’

The following mechanisms are expected to bridge potential gaps between fluctuating electricity supply and stable demand:

1. Sustainable biomass, biogas and some waste-based energy from decentralised power plants to serve as back-up when wind power availability is low
2. Intelligent electricity storage systems including electric car batteries, heat pumps and demand-side management measures
3. Electricity transmission between neighbouring countries. Hydropower production in other Nordic countries can supplement Danish wind and vice versa. The cost of establishing the increased cross-border transmission capacity is expected to be offset by economic gain from increased electricity trade.

### Innovation in demand-side management

Smart City Kalundborg, a Danish 3-year smart grid pilot project, represents an innovative approach to deepening the connection between smart grids and smart cities. Whilst the project has much in common with other market-focused demand management projects in Europe, it differs in its attempt to include a wider range of city operations, including water management, transportation, and district heating. For more information, see: <http://www.navigantresearch.com/blog/in-denmark-demand-response-powers-a-smart-city>

### An affordable transition

The overall economic impact of the transition is surprisingly modest. The expected long-term additional costs of transitioning to 100 per cent renewable energy are in the order of 0.5 per cent of Danish GDP in 2050. The primary reason is the expected increase in the price of fossil fuels.

The complete transition of Denmark's energy system will however require significant investments in the following primary areas:

1. Conversion to electric cars
2. Expansion of offshore wind turbine capacity
3. Heat pumps for individual and district heating
4. Energy renovation and insulation of buildings
5. Expansion of cross-border electricity infrastructure

### **Commitment is key**

For Denmark to become entirely independent of fossil fuels by 2050 and to build a 100 per cent renewable energy system is not going to be an easy task. The technology is there, but there is still a long way to go. The important thing to focus on, however, is not where Denmark is, where Denmark came from or how far Denmark has yet to go. The important thing to focus on is the fact that Denmark's commitments are realistic and replicable and that they represent the kind of commitments that, if expanded on a global scale, could do much to solve the current climate crisis.

#### **No, it's not all perfect - yet**

Denmark is setting an admirable example, but, no, it isn't perfect. In the North Sea, beneath two of Denmark's major offshore wind farms, lie considerable oil and natural gas reserves. Denmark is the 32nd largest net exporter of crude oil in the world and from 1997 to 2012 Denmark was the only net energy exporter in the EU. In light of Denmark's ambition to phase out fossil fuels entirely in its own energy system and to transition to 100 per cent renewable energy, the continued exploration and production of fossil fuels is nothing short of contradictory. If we are to reduce the risk of run-away, irreversible climate change down to an 'acceptable' level, about 80 per cent of the world's known fossil fuel reserves will have to remain untouched, assuming no CCS. This clearly renders any further explorations for new fossil fuels obsolete. Needless to say, many Danes also strongly object to this obvious disharmony in policy and action. Denmark's ownership of oil and natural gas, on the other hand, illustrates that the country's ambitious climate and energy policy is not driven by necessity – such as lack of own energy sources. Danes have committed to reducing emissions simply because they *want* to.

#### **For further information, see:**

##### **The Danish Government (2011) Our Future Energy**

[http://www.cphcleantech.com/media/1465822/our\\_future\\_energy.pdf](http://www.cphcleantech.com/media/1465822/our_future_energy.pdf)

##### **The Danish Government (2013) The Danish Climate Policy Plan Towards a low carbon society**

[http://www.ens.dk/sites/ens.dk/files/dokumenter/publikationer/downloads/danishclimatepolicyplan\\_uk.pdf](http://www.ens.dk/sites/ens.dk/files/dokumenter/publikationer/downloads/danishclimatepolicyplan_uk.pdf)

##### **The FlexPower project (2013) Activating electricity demand as regulating power**

[http://www.ea-energianalyse.dk/reports/1027\\_flexpower\\_activating\\_electricity\\_demand\\_as\\_regulating\\_power.pdf](http://www.ea-energianalyse.dk/reports/1027_flexpower_activating_electricity_demand_as_regulating_power.pdf)

##### **Ea Energy Analyses (2012) Managing congestion in distribution grids - Market design consideration**

[http://www.ea-energianalyse.dk/reports/1236\\_READY-managing\\_congestions\\_distribution\\_grids.pdf](http://www.ea-energianalyse.dk/reports/1236_READY-managing_congestions_distribution_grids.pdf)

##### **Renewable Energy in Denmark and Denmark's Green Policies:**

<https://stateofgreen.com/en>

##### **Provision of Electricity and Natural Gas in Denmark:**

<http://energinet.dk/EN/Sider/default.aspx>

##### **Danish Ministry of Climate, Energy and Building:**

<http://www.kebmin.dk/en>

**Danish Meteorological Institute (DMI):**

<http://www.dmi.dk/en/klima/>

**Danish Wind Movement:**

<http://www.windsofchange.dk>

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<sup>1</sup> [http://www.energy-supply.dk/article/view/64607/eksperter\\_40000\\_jobs\\_i\\_nye\\_energijobs?ref=newsletter=e6zjtvp#\\_VDTq3ktjaG9](http://www.energy-supply.dk/article/view/64607/eksperter_40000_jobs_i_nye_energijobs?ref=newsletter=e6zjtvp#_VDTq3ktjaG9)

<sup>2</sup> The Danish Energy Agency (2011) 'Our Energy.' [http://www.cphcleantech.com/media/1465822/our\\_future\\_energy.pdf](http://www.cphcleantech.com/media/1465822/our_future_energy.pdf)

<sup>3</sup> [http://www.ens.dk/sites/ens.dk/files/dokumenter/publikationer/downloads/energiscenarier\\_-\\_analyse\\_2014\\_web.pdf](http://www.ens.dk/sites/ens.dk/files/dokumenter/publikationer/downloads/energiscenarier_-_analyse_2014_web.pdf)

<sup>4</sup> Denmark has the highest proportion of wind power in the world, with production in 2013 being 33% of total power consumption.

<sup>5</sup> Danish Energy Agency; GWEC Annual Report