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# What Does Fossil Free Denmark Mean for Renewable Energy?

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## What Does Fossil Free Denmark Mean for Renewable Energy?

WHAT DOES

# Fossil Free Denmark

MEAN FOR RENEWABLE ENERGY?

DENMARK'S VISION TO DROP OIL, COAL, AND GAS FOR A MORE SUSTAINABLE FUTURE



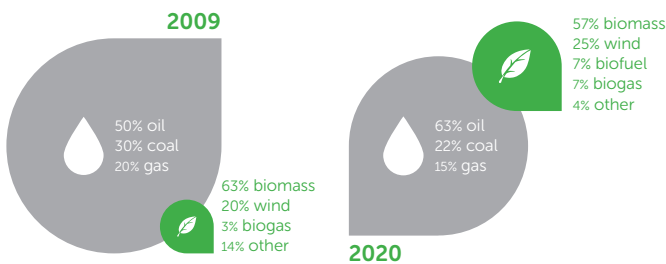
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**“In 2012, 29.8% of the country’s electricity came from wind power compared to 1.9% in 1990.”**

In February of 2011, Denmark released their Energy Strategy 2050 which officially declared the country’s ambitious goal of becoming independent from oil, coal, and gas by 2050. It is the first declaration of its kind by an entire country. This move is in part a reaction to fluctuations in fossil fuel prices and the hope of increasing Danish energy security in the long term by removing dependency from fossil fuels, which currently make up approximately 80% of Denmark’s energy usage.<sup>1</sup> The next stepping stone is running the country on 33% renewable power by 2020<sup>2</sup> as compared to 20% in 2009, the majority of which will be comprised of wind and biomass energy (Figure 1). This 2020 goal, however, does not factor in the transportation sector or activities related to North Sea exploitation. Denmark’s energy program also does not include nuclear power. The reasons for this have been rationalized as financial rather than as a mentality for risk aversion.



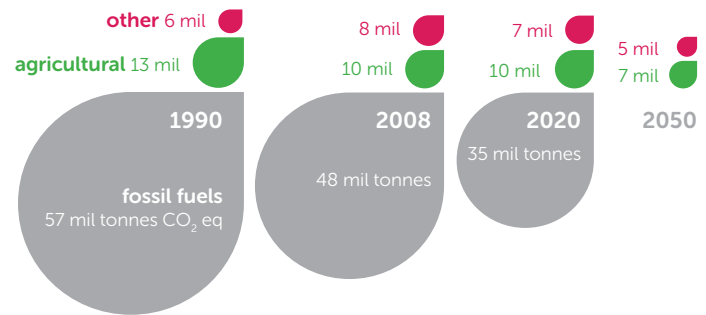
**figure 1** Consumption of fossil fuels and RE (excluding extraction and refining). Data estimated from Danish Energy Agency figures.<sup>15</sup>

Overall, the Energy Strategy 2050 is part of a broader strategy to reduce the country’s greenhouse gas (GHG) emissions by 80-90% by 2050. Note that not all GHGs will be eliminated as the remaining part of released GHGs will be from agriculture and non-fossil fuel burning activities (Figure 2).

<sup>1</sup> The Impact of the Energy Strategy 2050 on the Danish Consumer. (n.d.). Retrieved March 7, 2015, from <http://denmark.dk/en/green-living/strategies-and-policies/the-impact-of-the-energy-strategy-2050-on-the-danish-consumer/>

<sup>2</sup> Base year = 2009

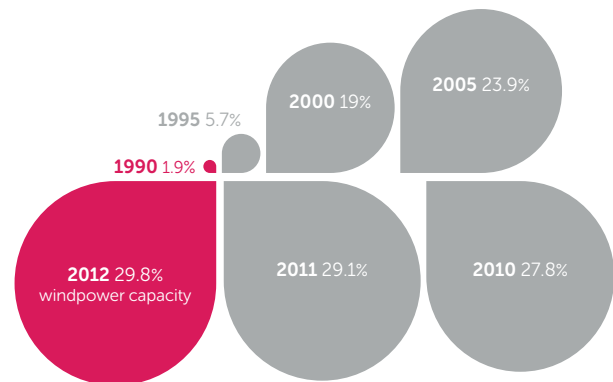
<sup>3</sup> Renewable Energy. (2014). In Energy Statistics 2012: Data, tables, statistics and maps (p. 9). Copenhagen K: Danish Energy Agency. Retrieved from [http://www.ens.dk/sites/ens.dk/files/info/tal-kort/statistik-noegletal/aarlig-energistatistik/energy\\_statistics\\_2012.pdf](http://www.ens.dk/sites/ens.dk/files/info/tal-kort/statistik-noegletal/aarlig-energistatistik/energy_statistics_2012.pdf)



**figure 2** Denmark’s greenhouse gas emissions in (adj. emissions, excluding carbon storage). Data estimated from Danish Energy Agency figures & Danish Commission on Climate Change Policy.<sup>16</sup>

### Why Denmark?

Unlike in almost any other country, Denmark’s specific geographic, economic, political, and social situation is highly favorable towards the move to becoming fossil fuel independent. The country has seen a rapid rise in wind energy development over the course of the past few decades due to advantageous conditions for wind power. In 2012, 29.8% of the country’s electricity supply came from wind power compared to 1.9% in 1990 (Figure 3).<sup>3</sup> Eco-



**figure 3** Wind power’s share of domestic electricity supply. Data taken from Danish Energy Agency.<sup>3</sup>

<sup>4</sup> Randall, T. (2013, February 13). Highest & Cheapest Gas Prices by Country. Retrieved from <http://www.bloomberg.com/slideshow/2013-02-13/highest-cheapest-gas-prices-by-country.html#slide11>

<sup>5</sup> Petroleum & Other Liquids: U.S. All Grades All Formulations Retail Gasoline Prices. (2015, April 6). Retrieved from [http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=p&t=s&emmm\\_epm0\\_pte\\_nus\\_dpg&f=m](http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=p&t=s&emmm_epm0_pte_nus_dpg&f=m)





**Avedøre power plant:** converted from coal-powered to biomass-power

nomically, the Danish population feels a greater push towards becoming fossil fuel independent in part due to high gas prices for automobiles. In February 2013, gas cost an average of \$8.22 per gallon in Denmark<sup>4</sup> versus an average of \$3.74 per gallon in the same month in the United States.<sup>5</sup> At that time, Denmark had the tenth highest price on gas in the world and the seventh highest gas tax in Europe, contributing to the high cost.<sup>4</sup> With difficult-to-predict long term political situations in countries that are rich in oil supplies, much of the Danish population feels that it is advantageous to move to more localized and predictable energy sources. In fact, the Danish national goal to remove fossil fuels from the energy system is supported by all parties of the Danish Parliament and 90% of Danes,<sup>6</sup> a number that even beats the University of Pennsylvania's fossil free referendum percentages of 87.8%, on what may be considered an extremely liberal U.S. college campus.<sup>7</sup> In addition, business culture is much more collaborative between both companies and the government than in the U.S.; groups have already formed to create strategies for tackling energy needs. Needless to say, with this kind of support for going fossil free all over the country, Denmark will face few of the political and social barriers that most other countries would face in its transition over the next few decades. What really becomes the decisive factor in this is how Denmark will balance transforming its energy grids and transportation systems with the economic viability of the country's proposed strategies.

**“Over 60 companies are already part of Denmark’s collaborative Smart Grid Hub.”**

### Strategy: Short- and Long-term Planning

Denmark intends to tackle its energy goals with short- and long-term solutions. The government has set high but theoretically manageable goals for the long term in its Energy Strategy 2050. However, they have also divided their 2050 goal into smaller goals to be achieved in shorter time increments, the next of which will occur by 2020. The purpose of this kind of planning is to make

<sup>6</sup> Richardson, K. (2012, March 5). Fossil Fuel Independence for Denmark: Why, When and How?. Lecture conducted from Stanford University: Precourt Institute for Energy, Stanford. Retrieved from <http://energyseminar.stanford.edu/node/415>

<sup>7</sup> Schroeder, E. (2015, March 2). Fossil Fuel referendum draws larger voter turnout than midterm elections. Retrieved from <http://www.thedp.com/article/2015/03/fossil-fuel-divestment-referendum-passes>



**District heating pipes**

sure that the country stays on track and to make sure that government plans stay astride of and adapt to technological advancements in the future.

### Increasing Energy Efficiency

The first workable action point for the Energy Strategy 2050 is increasing the efficiency of energy usage by 6% by 2020, which is above the 4% target goal set for that date. For companies, the incentive to invest in things such as more efficient heating systems will come from the relatively short payback periods for doing so. For residential areas, this is a little bit more difficult. Heating systems in some areas will be restructured to replace individual heating with district heating powered by increasing amounts of biomass energy, upwards of the 62% of households that already have district heating. All transitions are already planned to be fully financed by steadily increased energy bills over time. By 2020, household energy bills should see an increase by 900 Kr (\$176) per year and household electricity costs by 250 Kr (\$49) per year.<sup>1</sup> This is assuming about a 5.1 Danish Krone to U.S. dollar exchange rate. However, by 2050, costs are expected to return to base year values due to increasing efficiency.

<sup>8</sup> Bowers, D. (2013, March 4). Denmark pumps oil money into rail upgrades. Retrieved from <http://www.railjournal.com/index.php/europe/denmark-pumps-oil-money-into-rail-upgrades.html>



*Better Place electric car and charging station*

## Electrification of Everything

Tied in with replacing oil and gas heating with electrically powered heat pumps, Denmark wants to electrify everything, including industry and transportation. Electrification of main rail lines is currently being financed by Denmark's North Sea oil revenues for completion in 2025.<sup>8</sup> However, the more difficult question is how to replace fossil fuel-driven cars, an area yet to be fully tackled. The company Better Place was in charge of building 5 minute battery quick-swap stations for electric cars<sup>9</sup>, but the company went bankrupt in 2013<sup>10</sup>, leaving many skeptical about the feasibility of implementing a system that can support electric cars.

## Wind and Biomass

The main sources of renewable energy that Denmark is seeking to use are wind and biomass. Production of wind energy has risen in Denmark to the point that about a third of consumed Danish electricity comes from their wind turbines. The total wind production capacity as of 2013 is 4772 MW.<sup>11</sup> About a fourth of that capacity is from offshore wind while the rest is from onshore. This much wind potential means that, during good windy periods on the occasional day, Danish wind can generate over 100% of the country's electricity needs.<sup>12</sup> Of course, wind energy runs into the issue that the wind does not blow all of the time. This is where biomass and investment in battery technology come in. Biomass burning plants, similar to coal powered plants, can be shut on and off relatively quickly as energy demands needs it, to make up for times when wind and solar do not work. Good battery technology does not exist yet for storing energy from high production periods for use during lower production periods, but companies like Tesla are optimistic and making progress in this field. By 2020, it is expected that almost half of electricity will be produced by wind and about one fifth from biomass.<sup>13</sup> Estimates for 2050 are more difficult to determine, but the vast majority of energy will come from wind and biomass with the rest coming from sources like solar, biogas, wave power, and burning of waste. The exact energy mix will likely be determined by future biomass prices.<sup>6</sup>

<sup>9</sup> Berman, B. (2011, July 29). Plug-and-Play Batteries: Trying Out a Quick-Swap Station for E.V.'s. Retrieved from [http://www.nytimes.com/2011/07/31/automobiles/a-plug-and-play-plan-for-ev-batteries.html?\\_r=1](http://www.nytimes.com/2011/07/31/automobiles/a-plug-and-play-plan-for-ev-batteries.html?_r=1)

<sup>10</sup> Berman, B. (2013, December 13). Better Place Pulled Down Israel and Denmark Electric Car Markets, Say Local Drivers. Retrieved from <http://www.pluginCars.com/better-place-pulled-down-israel-and-denmark-electric-car-market-say-local-drivers-129094.html>

<sup>11</sup> The Danish Market: Statistics on the development of wind power in Denmark 2003-2013. (2013). Retrieved March 7, 2015, from [http://www.windpower.org/en/knowledge/statistics/the\\_danish\\_market.html](http://www.windpower.org/en/knowledge/statistics/the_danish_market.html)

<sup>12</sup> Morris, C. (2013, November 8). Denmark surpasses 100 percent wind power. Retrieved from <http://energytransition.de/2013/11/denmark-surpasses-100-percent-wind-power/>

<sup>13</sup> Independent From Fossil Fuels by 2050. (n.d.). Retrieved March 7, 2015, from <http://denmark.dk/en/green-living/strategies-and-policies/independent-from-fossil-fuels-by-2050/>

## A SMART Grid to Manage It All

While the idea of a SMART Grid may seem daunting or scary in an I, Robot kind of way, many countries including Denmark and the U.S. are investing in these due to their vast energy saving potential. A SMART Grid is a system in which energy production, consumption, and purchase rates are monitored by computers and energy is distributed using this information in the most efficient and economically clever way possible. An example of its potential use is for managing periods for charging electric cars or using household appliances such as dishwashers. Say if you live in an area where 1,000 people own electric cars and everyone plugs in their car when they get home to make sure they have a fully charged car in the morning; this adds a stress to the electricity grid, as everyone would be charging their cars at the same time. A SMART Grid system would be able to detect that 1,000 people had plugged in their cars at around 5:30pm and would be able to calculate how to distribute power to those 1,000 cars over the course of the night based on real-time energy generation patterns so that each car is charged in the morning, but not all cars are charging at the same time to reduce stress on the electricity grid. Though still in development, SMART Grid technology has the potential to revolutionize energy trading and help in the introduction of renewable energies like solar and wind, which can have unpredictable production rates. Over 60 companies are already part of Denmark's collaborative Smart Grid Hub.<sup>14</sup>

## What Does This Mean For Everyone Else?

The Danish transition to a fossil free system is extremely admirable and fascinating, but is not likely to be replicable in most other places. For one, Denmark is a very small country of about 5.6 million people and has a landmass of about 16,639 square miles. For comparison, New York City has a population of about 8.4 million, and a total metropolitan landmass of 13,318 square miles. The scale at which the Danes are changing their energy system is much smaller than for most other countries. Being a coastal country, the sheer amount of wind energy they can produce compared to the needs of their country is very favorable, and compared with their neighbor Germany that wants to have at least 60% renewables by 2050, Denmark has it easy. Germany, having less wind potential, has to deal with much more solar integration, which has more seasonal variability than wind. Extreme long-term battery storage capabilities are needed to support a solar dominated energy mix as winter months produce much less energy than summer months. In the U.S., with so much transportation infrastructure compared to human population density, electrification of the transportation sector seems almost jaw-droppingly impossible. However, this does not mean that other countries, states, or regions should just give up on renewables. Denmark's ambitious energy initiatives and successes thus far show that a combination of strong cooperative planning while keeping stride with the best of today's technologies can be used to produce more efficient, clean, and financially predictable energy to the ultimate benefit of consumer, industry, country, and the global community.

<sup>14</sup> In Focus: Smart Grid Hub. (n.d.). Retrieved March 7, 2015, from <https://stateofgreen.com/en/focus/smart-grid-hub>

<sup>15</sup> The Danish Ministry of Climate and Energy. (2011). On the way towards fossil fuel independence by 2050 - effects and benefits of the government's initiatives. In Energy Strategy 2050 - from coal, oil and gas to green energy (p. 49). Copenhagen K: The Danish Government. Retrieved from [http://www.ens.dk/sites/ens.dk/files/dokumenter/publikationer/downloads/energy\\_strategy\\_2050.pdf](http://www.ens.dk/sites/ens.dk/files/dokumenter/publikationer/downloads/energy_strategy_2050.pdf)

<sup>16</sup> The Danish Ministry of Climate and Energy. (2011). On the way towards fossil fuel independence by 2050 - effects and benefits of the government's initiatives. In Energy Strategy 2050 - from coal, oil and gas to green energy (p. 53). Copenhagen K: The Danish Government. Retrieved from [http://www.ens.dk/sites/ens.dk/files/dokumenter/publikationer/downloads/energy\\_strategy\\_2050.pdf](http://www.ens.dk/sites/ens.dk/files/dokumenter/publikationer/downloads/energy_strategy_2050.pdf)