

# DENMARK

## MARKET OVERVIEW

By the end of 2011, Denmark had installed 3 952 MW of wind capacity. According to the Danish Transmission System Operator (TSO) Energinet.dk, wind power represented a share of 28.3% of the country's total electricity demand in 2011, by far the largest share of any country in the world<sup>37</sup>. Wind power accounted for 9 765 GWh of electricity generation in 2011.

For Denmark, the 2009 European Renewable Energy Directive targets a share of renewable energy in the country's final energy demand rising from 17% in 2005 to 30% in 2020. The government has set a target of 50% wind energy in electricity consumption by 2020 as part of its long-term strategy to achieve a 100% renewable energy mix in the electricity and heat sector by 2035, and in all sectors by 2050 (Danish Energy Agency (DEA), 2012a)<sup>38</sup>.

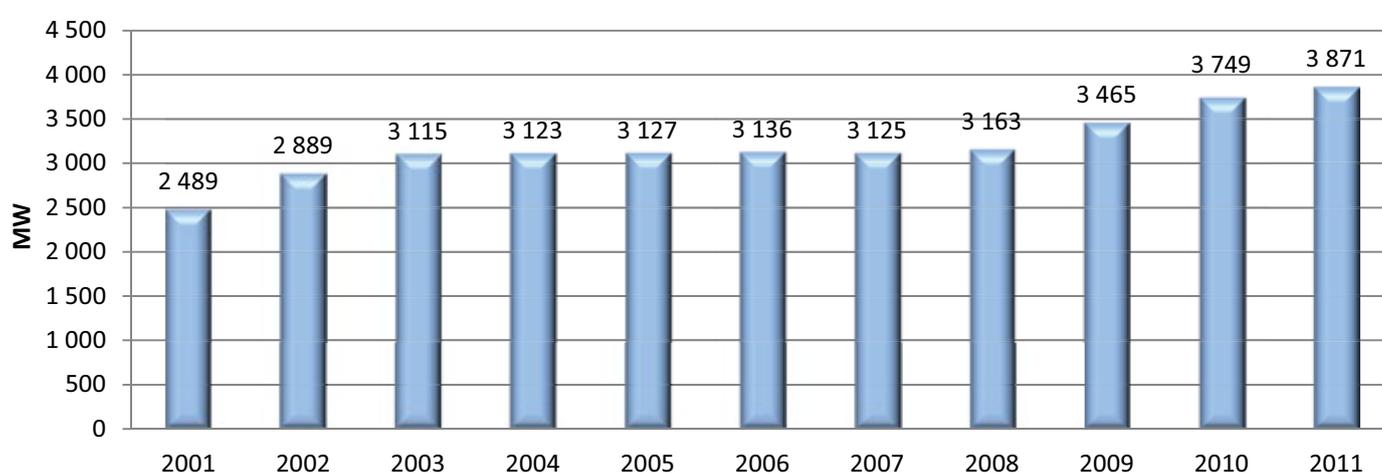


Figure 6: Cumulative Wind Installation (MW) of Denmark (GWEC, 2011)

## HISTORY AND EVOLUTION OF THE POLICY AND REGULATORY FRAMEWORK FOR WIND ENERGY

The history of wind energy in Denmark goes back hundreds of years although real commercialisation of the technology started only after the oil crises of the 1970s. In 1973 Denmark had an exceptionally high dependency on oil in its energy mix with more than 90% of its energy supply based on imported oil. This situation led to significant economic difficulties triggered by the 1973 and 1979 oil crises. It stimulated Denmark to shift from oil to coal for electricity production and propose the use of nuclear power to ensure security of supply. These decisions became part of a proactive energy policy promoted through four energy plans over the following two decades (DEA, 2010).

### Phase 1:

#### First Energy Plan, (Dansk Energipolitik): 1976

This plan was developed to safeguard the country against energy supply crises and reduce dependence on imported oil. Its focus was on energy savings and converting Danish power plants from oil to coal and nuclear power. At that time, renewable energy only had a marginal role in the country's energy supply.

Energy taxes on electricity prices were imposed in the mid-70s, and used to support R&D for renewable energy. This provided financial support for public research, while spreading the costs of that research among all electricity customers. In 1979, Denmark created its Ministry of Energy.

In 1973 the electricity companies announced their intention to build nuclear power plants and by the following year 16 possible locations had been identified. However an anti-nuclear movement (OOA) soon started in the country and over the next 11 years took the lead in a broad public campaign ending in March 1985, when a majority of the members of the Danish parliament decided to exclude nuclear power from future energy planning.

This development had major help from two alternative energy plans published by independent groups of energy experts: “Sketch for an energy plan in Denmark”<sup>39</sup> published in 1976 and “Energy for the future: alternative energy plan”<sup>40</sup> published in 1983 (Blegaa, et al., 1976; Hvelplund, et al., 1983).

Wind power was included in these plans as one of the key alternatives to nuclear power. Together with the anti-nuclear movement, the plans were significant drivers for the introduction of wind and other renewables which, together with energy efficiency and natural gas in decentralised cogeneration plants, offered an alternative to nuclear power (Greenpeace, Denmark 2012).

By the early 1980s several manufacturers were producing wind turbines with a capacity larger than 55 kW. However, since these turbines were too costly for most individual owners, the concept of local wind cooperatives – where groups of people invest jointly in shared wind turbines – developed (Grobbelaar, 2010). Many individual owners invested in wind turbines to meet their own energy consumption needs with the option of selling excess electricity generation to the grid.

## Phase 2:

### Second Energy Plan (Energiplan81): 1981

This plan laid the ground for rapidly growing indigenous energy production and nuclear power. It included oil and gas recovery in the North Sea, the development of a nationwide grid for natural gas, and the introduction of subsidies for the construction and operation of wind turbines and biomass plants.

The support brought by the Energy Plan helped establish a strong home market for renewable energy and a local industry associated to it, while taxes imposed on oil and coal helped increase the competitiveness of renewable energy plants. Furthermore, during the 1980s Danish families were offered tax incentives for generating power for their community. As a result, more and more wind turbine cooperatives started to invest in community-owned wind turbines.

Another important parallel development during the 1980s was the large renewable energy market in California, which created an export opportunity for Danish wind turbine manufacturers until the California wind market came to a halt in 1985 (see page 134 for further discussion).

In 1985, a parliamentary majority rejected nuclear power. An agreement between the Ministry of Energy and the utilities, “100 MW Agreement”, was reached to develop 100 MW of wind power between 1986 and 1990 (Organisation for Economic Co-Operation and Development (OECD), 2000). This agreement supported the local wind industry’s growth at a time when its overseas sales had fallen. The government set ambitious targets for utilities to install wind power, with two orders of 100 MW issued in 1985 and 1990, and a further order of 200 MW for completion in 2000.

The Danish government initially provided capital grants of up to 30% of the installation costs, progressively reduced to 20%, and then 10%. With sound growth in reliability and improved cost-effectiveness of the turbines, the subsidy for wind power was repealed in 1988<sup>41</sup>.

Denmark reduced the capital subsidy and required utilities to interconnect and purchase power from wind projects. Utilities were also required to provide a fair price. The total installed wind power capacity increased to approximately 300 MW, mostly based on 100 kW wind turbines.

Some subsidies introduced under this plan continued to be available through research funds into the mid-2000s. Grants were also made available for replacing old wind turbines.

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<sup>37</sup> Interview with Sune Strom, Sr. Economist at Danish Wind Industry Association in 2012 (Danish Wind Industry Association (DWIA), 2012).

<sup>38</sup> This agreement was reached under a broad energy agreement (on 22 March, 2012) supported by all major political parties in Denmark (apart from one).

<sup>39</sup> “Skitse til alternativ energiplan for Danmark”

<sup>40</sup> “Energi for fremtiden: Alternativ energiplan”

<sup>41</sup> In 1988, the newly elected government cut the subsidy by half. However, the return on investment in wind energy was maintained between 15% and 25%, and community-owned wind energy was supported by three principles: 1. The right to connect to the electrical grid; 2. A legal obligation for electrical utilities to purchase wind energy; and 3. A guaranteed fair price (Christianson, n.d.).

## Phase 3:

### Third Energy Plan (Energi 2000), Feed-in tariff: 1990

The third plan was one of the first energy plans in the world without nuclear power. It set a target of reducing Danish CO<sub>2</sub> emissions by 20% between 1988 and 2005. Specific targets included providing 10% of electricity from wind turbines by 2005.

By 1992, the “fair price” for wind power was set at 85% of the retail electricity rate. The rules provided guaranteed interconnection and power purchase of wind-based electricity. Noticeably, the price was set relative to retail rates, and not relative to the cost of production for wind generators (Farrell, 2009).

By 1992 systematic planning procedures, which included directives for local planners, were developed and implemented at the national level. At the same time an executive order from the Minister of Environment and Energy ordered municipalities to find suitable sites for wind turbines throughout the country. The planning directives included provisions for public hearings prior to any actual applications for siting of turbines, which was a significant help in getting public acceptance for their installation (Krohn, 2002).

A fixed feed-in tariff for electricity production was introduced in 1993 and decoupled the power purchase price from existing electricity rates. The price paid for electricity generated from wind turbines was set at 85% of the utility’s production and distribution costs. In addition, wind projects received a refund from the Danish carbon tax and a partial refund on the energy tax. These refunds effectively doubled the payment to wind projects for the first five years of their operation (Bolinger, 2001).

This support was provided equally across the country, irrespective of the wind conditions, which prompted wind farm developers to establish wind turbines at the best onshore locations. The outcome of the “Energi 2000” plan was that 10% of Danish electricity consumption would be supplied by wind energy by 2005.

## Phase 4:

### Fourth Energy Plan (Energi 21): 1996

In the fourth plan, it was envisaged that renewable energy would provide 12-14% of total energy consumption in 2005, and 35% by 2030. By 1997 a further set of planning regulations had been developed for offshore wind farms, with the creation of a central national authority. The Danish Energy Agency was in charge of implementing the renewable energy policies. This solution provided a dedicated agency for supervising planning permissions (Krohn, 2002).

By 1996, there were around 2100 cooperatives throughout the country, which created the basis for continuing popular support for wind power in Denmark. By 2001, wind turbine cooperatives, including more than 100 000 families, had installed 86% of all turbines in Denmark. In 1998 the Danish government ordered an additional 750 MW of offshore wind power to be installed across five parks (Krohn, 2002).

By the turn of the century Denmark had become a net exporter of energy. In the following years, rising oil prices and an increased awareness of climate change influenced new energy policy guidelines, with higher ambitions for renewable energy.

## Phase 5:

### Electricity market liberalisation and Renewable Purchase Specification introduced (1999-2008)

In 1999, the new government passed a resolution to liberalise Denmark’s electricity market by 2002<sup>42</sup>. The electricity reform set the target for electricity from renewable sources at 20% of the Danish electricity consumption by 2003, largely from wind and biomass (Department of Trade and Industry (DTI), 2004).

In 1999, Denmark decided to abandon its feed-in tariff and to support renewable energy through a renewable portfolio standard (RPS) mechanism with a system of tradable green certificates. Although a new tradable green certificate system was introduced, the supporting legislation failed to be passed by parliament (DWIA, 2012).

Under the new policy guidelines, the Danish government emphasised the need to increase competition in the energy sector, and to encourage greater competitiveness

<sup>42</sup> Outside Denmark’s major cities, the consumers traditionally owned electricity supply and distribution networks. Competition was introduced into the electricity supply sector when it was liberalised in 2002, but the distribution networks remained monopolistic.

<sup>43</sup> Support instruments are regulated by Law No. 1392/2008 on the Promotion of Renewable Energy, by the Act on Electricity Supply, and by the Act on Transmission Grid Operator Energinet.dk

of the renewable energy plants. As part of the new governmental policy, two of the planned five offshore parks were cancelled and the feed-in tariffs were changed substantially in 2002.

By 2003, all wind generators were connected to the grid under the new renewable portfolio standard. The remuneration was made up of the market price plus a premium. This premium was capped, setting a maximum price that the wind producers could receive. However, the new scheme no longer guaranteed interconnection.

Additions to wind power capacity declined rapidly, and the wind energy market stalled until 2008, when a new support framework was introduced. From 1993 to 2004, Danish wind power grew from 500 MW to over 3 000 MW but once the feed-in tariff was abandoned in 2004, the wind power development stagnated.

Between 2001 and 2008, the energy policy developments in Denmark were considered very unambitious. The period 2004 to 2008 saw an addition of only 129 MW of wind capacity.

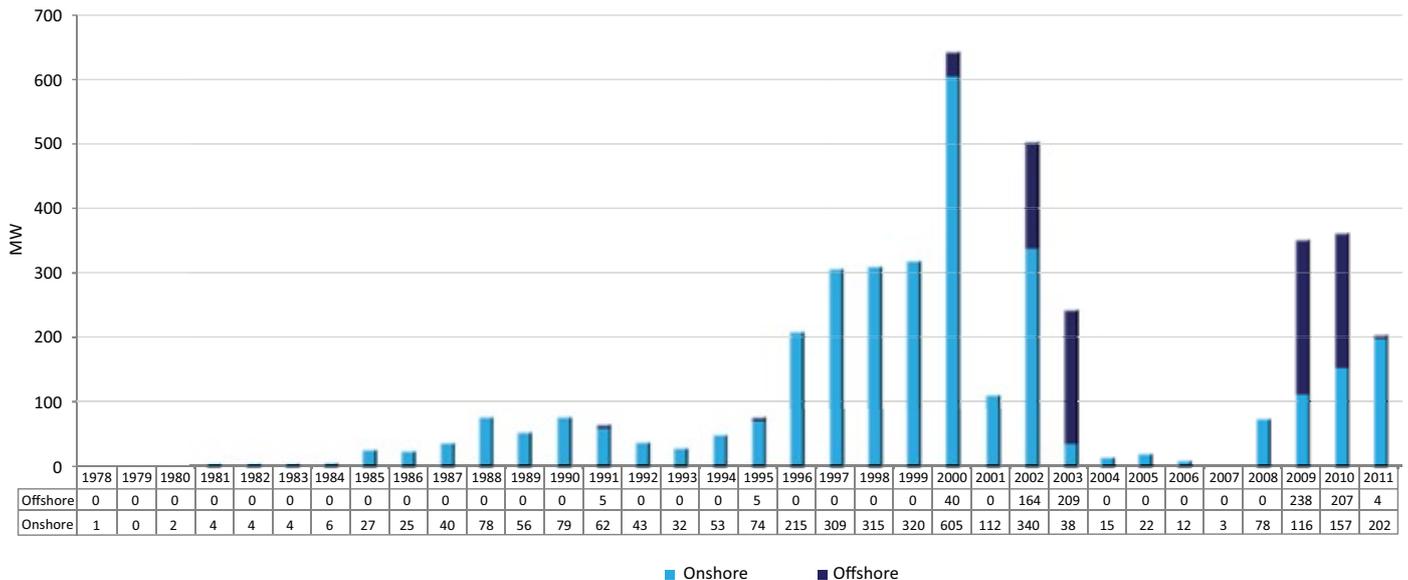


Figure 7: Annual Wind Installations in Denmark 1978-2011 (DWIA, 2012)

In 2004 there was considerable restructuring of Denmark’s power supply sector. The power companies were privatised, and power distribution, transmission and production became independent sectors each with distinctive frameworks (Maegaard, 2009).

- » Power distribution became the responsibility of local not-for-profit cooperatives, municipalities, or companies with a concession.
- » Power transmission (> 60 kV) became the responsibility of Energinet, a new, wholly state-owned company.
- » Power generation was divided as follows (a) central power plants owned by DONG Energy (76% owned by the Danish state), (b) Plants owned by Vattenfall (a Swedish state-owned company) and E.ON (a German company), (c) municipal and local consumer-owned combined heat and power plants, and (d) wind power with 85% ownership by Independent Power Producers and the rest by the central power companies.

In 2008, the government developed an energy agreement valid until end 2012, which included the installation of two offshore parks of 200 MW each (installed in 2009 and 2010), and gave responsibility to the municipalities to plan for 75 MW onshore wind power in 2010 and 75 MW onshore in 2011 (Greenpeace Denmark, 2012).

In its energy policy statement of 2008<sup>43</sup> the Danish government committed itself to address climate change at minimal economic costs and without risking security of energy supply. This included making improvements in the nation’s energy efficiency, increasing renewable energy and technological development. The government specifically committed to:

- » Reduce total energy consumption by 2% by 2011 and by 4% by 2020, based on 2006 figures; and
- » Increase the use of renewable energy to 20% of gross energy consumption by 2011.

To help meet these ambitious targets, the government committed to increasing funding for R&D and demonstration of energy technology to EUR 135 million (USD 201 million) per year.

## Phase 6:

### Rejuvenation and strengthening of the wind sector: 2009-2012

In 2009, Denmark saw a significant rise in installations with 116 MW of new capacity being erected onshore and 238 MW in national waters, bringing the total installed wind capacity up to 3 482 MW (DWIA, 2012).

In 2009, the main policy support mechanism for wind energy in Denmark was an environmental premium of DKK 0.25/kWh (USD 0.05/kWh) for 22 000 full load hours (equivalent to some 10 years of operations) added to the market price. An additional compensation of DKK 0.023/kWh (USD 0.004/kWh) was provided for balancing costs. The grid connection costs for offshore wind farms were financed by the electricity consumers, and special tariffs were defined based on competitive tenders (GWEC, 2009).

The support scheme for electricity from renewable energy sources was based on price premiums added to the market price, and tenders for offshore wind power. The financing instruments were conceived and managed by the Danish Energy Agency. The combination of market price and premium ensured stable revenues for the producer. All subsidies costs were passed on to consumers as an equal Public Service Obligation tariff on their total electricity consumption (Rathmann, et al., 2009)<sup>44</sup>.

During that period of time, many of the wind turbines installed in the 1980s and 1990s were reaching the end of

their lifespan. The repowering of old turbines was likely to become an important part of the national market<sup>45</sup>.

In February 2011, the government published its Energy Strategy 2050. The government's goal under this strategy was to achieve independence from coal, oil and gas by 2050, with an interim objective of 30% of the final energy demand supplied by renewable energy by 2020.

In 2011, a new government was elected. The winning party's manifesto had, among other things, proposed the following actions under its plan on energy and climate:

- » All energy needs shall be covered by renewable energy in 2050.
- » The electricity and heat sector shall be 100% supplied by renewable energy in 2035.
- » Coal will be phased out from power plants and private oil boilers will be phased out by 2030 at the latest.
- » The government will adopt a target of reducing the greenhouse gas emissions by 40% compared to 1990 levels.
- » Half of the traditional electricity consumption shall come from wind by 2020.
- » A comprehensive new strategy will be developed for creating smart grids.

In March 2012, a broad energy agreement was reached for the period up to 2020 (Danish Ministry of Climate, Energy and Building, 2012). According to this agreement, wind energy in 2020 would cover 50% of electricity consumption, and the greenhouse gas emissions from the Danish energy sector would be reduced by 34% in 2020 compared to 1990 levels. The remaining six percentage

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<sup>44</sup> For onshore wind since 2009: guaranteed price premium of DKK 0.25/kWh (USD 0.05/MWh) for 22 000 full load hours. Additionally, DKK 0.023/kWh (USD 0.004/kWh) is received during the entire lifetime of the turbine to compensate for the cost of balancing. Systems financed by utility companies: maximum subsidy (premium plus market price) of DKK 0.33/kWh (USD 0.06/kWh), applicable for 10 years from the date of connection of the system, plus guaranteed bonus (unlimited term) of DKK 0.10/kWh (USD 0.02/kWh).

For new offshore wind since 2009: premium plus market not exceeding (depending on location) DKK 0.518 or DKK 0.629/kWh (USD 0.1 or USD 0.12/kWh) for up to 10 TWh within 20 years of grid connection. Systems financed by utility companies: maximum subsidy (bonus plus market price) of DKK 0.353/kWh (USD 0.07/kWh), applicable to 42 000 full load hours, plus guaranteed bonus (unlimited term) of DKK 0.10/kWh (USD 0.02). Additionally, DKK 0.23/kWh (USD 0.04) is received during the entire lifetime of the turbine to compensate for the cost of balancing etc.

<sup>45</sup> For wind turbines connected to a grid on 21-02-2008 or later, the premium (on top of market price) offered was DKK 0.08 /kWh (approximately USD 15.9/MWh) or maximum subsidy (premium plus market price) of up to DKK 0.38 /kWh (approximately USD 75.7/MWh) for electricity production corresponding to 12 000 peak-load hours, provided the double the amount of the installed output of the dismantled wind turbine (Rathmann, et al., 2009).

<sup>46</sup> For new onshore turbines coming online from 1 January, 2014 the premium will stand at DKK 0.25/kWh (approximately USD 0.05/kWh) for the first 22 000 full load hours, reduced when the market price of electricity exceeds DKK 0.33/kWh (approximately USD 0.06/kWh), and set to zero when the electricity price reaches DKK 0.58/kWh (approximately USD 0.11/kWh) or higher (Greenpeace Denmark, 2012).



Table 4: Share of Wind Energy as percentage of total electricity consumption in Denmark (Energinet.dk, 2012)

2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
12.3%	14.0%	16.0%	18.8%	18.7%	17.0%	19.9%	19.3%	19.4%	22.0%	28.3%

points to meet the 40% reduction of domestic carbon emissions by 2020 would be addressed through efforts in the transport and agriculture sectors in line with the forthcoming climate change plan.

It was also decided to build a total of 3 300 MW new wind power capacity. The Danish wind sector is expected to expand under this agreement. Offshore, the wind parks of Horns Rev III (400 MW) and Kriegers Flak (600 MW) will be tendered over 2013-2015 and are due to be commissioned over 2017-2020 (DEA, 2012b).

Furthermore, 500 MW near-coast wind and 1 800 MW new onshore wind are foreseen, from which 1 300 MW will be achieved through repowering.

The expansion of the electricity grids will be financed through a Public Service Obligation (PSO) scheme via the Energy Bill under the new agreement (DEA, 2012a). In the first half of 2013 the possibility of further reduction in surcharge (price-adder) for onshore wind where the

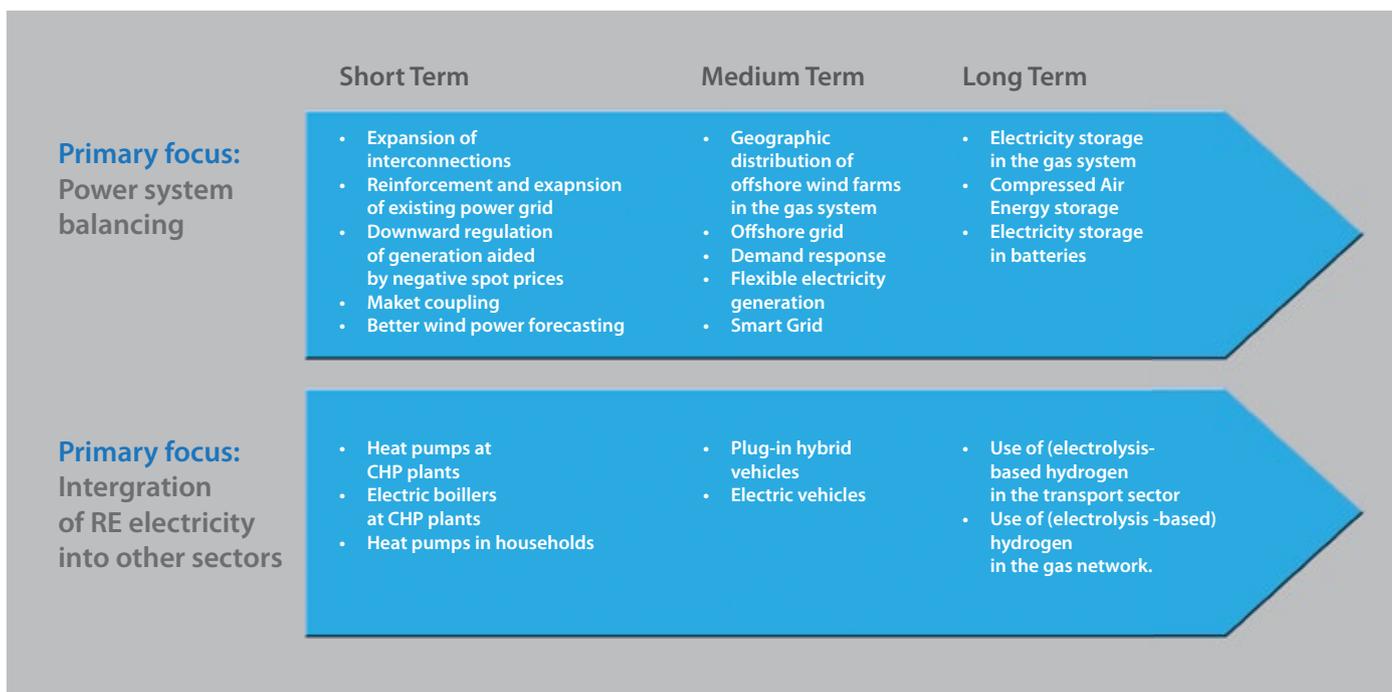
full surcharge is not needed will be discussed and agreed to<sup>46</sup>.

## CURRENT CHALLENGES

In order for Denmark to reach its goal of 50% wind power penetration in 2020, industry developments will need to progress faster than currently.

Connection to the electricity grid is a challenge. The Transmission System Operator (Energinet.dk) is supportive of the developments, and plans to supply 50% of the demand with wind power by 2025. The following chart (Energinet.dk, 2011) outlines the company's approach and the steps it would take between now and 2025 to meet this target.

Over the last ten years some sections of the local communities have been protesting against any further building of onshore wind turbines across the country. This has made private sector development of wind farms very cumbersome in the last decade.



Source: Energinet.dk (2011)

## CONCLUSION

Renewable energy and the efficient use of energy have played a central role in Danish energy policy for more than three decades. The country is the pioneer of wind energy development in Europe, and its wind farms now provide on average more than a quarter of the country's electricity needs. Its wind industry is today among the most significant exporting industries of the national economy. Denmark has for a long time been a global centre for wind turbine manufacturing with Bonus, LM, Siemens and Vestas -some of the world's leading turbine manufacturing firms- based in the country. According to the Danish Energy Agency, close to 100% of the manufactured wind turbines in Denmark were exported during the years 2004-2008, and the trend has continued to date.

Under its energy plans, the Danish government was Europe's first country to bring in large subsidies for its nascent wind industry, including the feed-in-tariff system<sup>47</sup>, which was successfully replicated in Germany. The industry also received significant subsidies for R&D in the late 1970s and the 1980s.

As a result of the Danish energy debate, the four energy plans, and the comprehensive reform of the electricity sector by the current Danish government, Denmark has for several years now been a net energy exporter<sup>48</sup>. The country's electricity grid connects hundreds of small-scale "distributed" generators making use of wind resources and efficient use of a range of fuels.

The country is also a pioneer in the use of environmental taxation, with a range of primary energy taxes introduced since the 1980s. These taxes were designed inter alia to reduce air pollution and CO<sub>2</sub> emissions, encourage energy efficiency, and support renewable energy. These taxes helped support development, with the revenue being used to support a range of technologies<sup>49</sup> (DTI, 2004).

Cooperatives have played an important role in the development of wind power by helping create public acceptance. Their engagement has ensured that communities directly benefitted from wind power development, especially in the form of profit-sharing from electricity generation from renewable energy sources and

<sup>47</sup> The tariff for wind energy in Denmark depends on several variables: the start date of operations, the number of full-load hours delivered, and whether the project is located offshore or onshore. The tariff comprises a market price element, a compensation for balancing, and a government subsidy. The level of support for electricity produced from wind turbines was increased during summer 2008. New wind turbines, both onshore and offshore, are receiving a price premium of EUR 0.033/kWh (approximately USD 0.05/kWh) for 22 000 full load hours.

<sup>48</sup> Denmark's grid is connected to the Nordic Power Market (consisting of Finland, Sweden and Norway) and Germany, which helps evacuate excess power, especially at night. Norway and Sweden's dams act like large battery storage for excess wind electricity.



from lower energy taxes. The planning responsibility for offshore wind farms is currently managed at government level, while the planning of onshore wind farms is collaborative.

In the 1970s rising environmental awareness, the oil crisis and the anti-nuclear debate had a major impact on the reformulation of the Danish government's energy policy. In the 1980s the government focused its policy on reducing dependence on fossil fuels and subsidising clean energy sources. The large wind energy market in California was a major importer of wind turbines, and drove the Danish industry. However, with the reduced demand from overseas markets by the mid-80s, subsidies to the industry were curtailed and rationalised.

In the early 1990s, a new energy plan provided a feed-in tariff for wind, which led to rapid growth in the wind sector between 1994 and 2002. Coordinated government support mechanisms such as long-term R&D support, premium tariffs for wind electricity generation and ambitious national targets helped the domestic wind industry to mature. However, with a change in government in 2001, and the phasing out of the feed-in tariff there was stagnation in the wind sector till the end of 2008.

In 2009 the market was revived due to the United Nations Climate Change Conference in Copenhagen 2009, and the setting of a long-term European target for promoting electricity generation from renewable energy sources. (Lund, et al., 2010).

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<sup>49</sup> Denmark was one of the world's first countries to introduce a CO<sub>2</sub>-tax on both household and businesses energy consumption. With the aim of encouraging energy efficiency and switching towards fuels with less CO<sub>2</sub> content a standard tax rate was set at EUR 13.4 (approximately USD 27). As part of an overall reform of the Danish tax system, energy and CO<sub>2</sub> taxes on household energy consumption were increased in 1993. The revenues from the environmental taxes were used to compensate for labour taxes. The social disparities of indirect environmental taxation on lower-income groups were compensated by reductions in low-income taxation and an increase in child support.

## ANALYSIS OF ENABLING CONDITIONS FOR WIND ENERGY

<p><b>Effective rule of law; and transparency in administrative and permitting processes</b></p>	<p>A coherent and long-term policy framework has been in place since 1979. However, the wind sector experienced stagnation on the period 2001-2008, due to limited political support for the technology. There has been a strong revival of political support for wind energy post-2009.</p>
<p><b>A clear and effective pricing structure</b></p>	<p>Electricity production from renewable sources is supported through price premiums added to the market price, capped at a maximum amount, and tenders for offshore wind power. These instruments are drawn up and managed by the Danish Energy Agency. The combination of market price and premium ensures stable revenue to the producer. All subsidy costs are passed on to consumers as an equal Public Service Obligation.</p>
<p><b>Provisions for access to the grid (incentives &amp; penalties for grid operators)</b></p>	<p>Priority access is guaranteed to renewable energy producers.</p>
<p><b>An industrial development strategy</b></p>	<p>Four energy plans – the outcome of which was that Denmark became a net exporter of energy.</p>
<p><b>A functioning finance sector</b></p>	<p>The investment for wind farms initially came from individuals through cooperatives. However, turbines became larger, the size of the projects increased, requiring private sector investment. Small individual developers have difficulties in investing in large projects (onshore), due to the amount of investment required. Offshore projects are mostly financed by utilities.</p>
<p><b>Expression of political commitment from government (e.g. targets)</b></p>	<p>The country aims to generate 50% of its electricity consumption from wind power by 2020, aiming at a full independence from coal, oil and gas by 2050.</p>
<p><b>A government and/or industry led strategy for public and community buy-in.</b></p>	<p>Stakeholder engagement and consumer awareness have played an important role in shaping the Danish energy sector. The country has a large number of cooperatives. The 1996 Energy Plan aimed at creating an energy sector rooted in a “democratic, consumer-oriented structure”.</p>
<p><b>An employment development strategy</b></p>	<p>Subsidies have been available to the wind sector for R&amp;D, and the government supported the initial phase of exports.</p>
<p><b>NOTE</b></p>	<p><b>Continuous government support has been in place since the 1980s, including support to long-term R&amp;D, premium tariffs and the setting of ambitious national targets. All of these have helped the domestic wind industry to expand internationally.</b></p>

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