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Clean Energy – Danish Style

Denmark has been a leader in alternative energy since as far back as the 1950s, tapping wind power and other renewable sources in its vision for a completely fossil-free energy system. In the following essay, Danish energy expert Jørgen Kjems provides an update on the latest developments.

By Jørgen Kjems, Senior R&D Consultant, Former Director of Risø National Laboratory, Denmark

Danish society is poised to make clean energy a way of life and a way of living. Hosting the COP15 event in December 2009 has triggered an avalanche of activities by government, local administrations, business and nongovernmental as well as industrial organizations. COP15 is seen as a golden opportunity to gain more visibility in global audiences and markets. Many of the projects now in the works are part of concerted efforts directly aimed at the COP15 gatherings in Copenhagen. They ride on a wave of more spontaneous initiatives by citizen groups, municipalities, universities and research institutions, individual companies and trade organizations. All of this reflects a consensus opinion that a low-carbon economy is not

only beneficial for the environment, but is also feasible and holds potential for sustainable economic growth. Rural communities like the island of Lolland have seen a dwindling shipyard industry replaced by a booming supply industry for wind turbines over the past decades. This has strengthened entrepreneurial courage, and the island is now testing ground for a domestic hydrogen energy society as well as maritime algae-based biomass production. The renowned Roskilde Rock Festival has become a meeting place where scientists from the nearby Risø Laboratory debate climate issues and demonstrate polymer-based solar cells embedded in clothing. Townships have set ambitious goals for climate-proof developments of infra-

structure and operations, spearheaded now by six proclaimed energy cities in Denmark that are working hard to become climate neutral. This has encouraged the government to set a long-term vision for a completely fossil-free energy system for Denmark, and to commission a panel to show how it can be done.

A Long Tradition of Energy Awareness

Denmark has a history of quite radical developments and transitions in the energy system in response to emerging energy challenges and changing international circumstances. A national electric power grid was established in the 1950s based on centralized power stations that were mainly fueled by

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oil. At the same time, district heating systems were established in many towns – using excess heat from power stations where feasible. The oil crisis in the 1970s induced a rapid shift to coal at power plants and larger district heating plants. It also triggered a decision to build a natural gas grid that could tap the recently discovered energy resources in the North Sea. In the 1990s, government regulation introduced an increasing amount of biomass (mainly straw) substituting for coal at power plants. Many district heating plants switched to natural gas and combined power and heat production. That same period saw the rapid growth of wind power in Denmark. In the beginning, the expansion was land based, but it has taken place almost exclusively offshore in the last decade. About 20 percent of the total final energy consumption is based on

renewable energy sources (2008). As a result Denmark has in fact become more than energy self-sufficient – mainly due to the North Sea energy resources. Economists still argue whether all these investments have been prudent from an overall economic perspective. The buildup of wind power and the maturing of the technology behind it have required substantial subsidies from government and customers. On the other hand, this has led to a rapid growth of a successful energy industry, with exports growing twice as fast as the Danish industrial average.

Lessons for Other Emerging Technologies

The development of the Danish wind turbine industry is an interesting story – one that contains lessons to be learned for other emerging energy

technologies. It could have been a fairy tale by Hans Christian Andersen. However, it is no coincidence that modern wind power development took place in Denmark.

Wind climate conditions in Denmark are good, and wind power has for centuries been exploited. In the 19th century, there were more than 2,000 wind grain mills in Denmark. In the early 20th century, these were replaced by other power sources, but wind power development was never completely abandoned. Engineer Johannes Juul designed and built the so-called Gedser Turbine in 1957 with a capacity of 200 kW. The novel three-blade concept became the model for Danish wind turbine industry and is now a global industry standard.

The energy debate in the 1970s in Denmark was spurred by the oil crisis and by nuclear power issues. Renewables gained both public and political support, while the established energy utilities and the industry remained skeptical. It was realized early on, however, that a concerted effort on technology and quality learning curves was needed. This led in 1980 to the creation of a Danish test station for wind turbines at Risø, whose certificates were required to obtain government subsidies and whose databases with operational data and faults reports quickly became a valuable asset for the whole industry.

Learning from Denmark's Example

A synergetic loop of interactions in the wind energy community started early on. It involved manufacturers, customers, scientists and regulators. It was not without conflicts, but in hindsight it is easy to see that it was this special Danish dialogue, combined with fierce competition between the different manufacturers, that gave the industry a leading edge. It enabled the very rapid upscaling to megawatt units, and it led eventually to a dominant role for Danish manufacturers in the global markets.

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Another important lesson learned concerns the interaction modes between industry and science. Mutual trust and respect turned out to be a prerequisite for a constructive dialogue and the efficient flow of knowledge. The scientists gained credibility and acceptance by agreeing to work on short-term problems facing the developers. In turn, the industry partners supported grant applications to tackle longer-term issues connected to wind resource modeling, the aero-elasticity theory, and numerical models of turbulent flow – the results of which have become essential elements of the modern design and decision-making toolbox for both manufacturers and developers of wind farms. As a result, 20 percent of the electricity supply in Denmark is now generated by wind, and two of the largest wind turbine manufacturers, VESTAS and Siemens Wind Power, have their base here.

Small Country, Big Energy Gains

Accommodating 20 percent of wind power in the Danish electricity system is possible because Denmark is part of the Nord Pool power exchange market and has good interconnections to Germany. Nevertheless, fluctuating wind conditions and power consumption patterns, combined with inadequate regulation, leads to less than op-

timal economic and societal use of wind resources. More end-use flexibility and means for shifting of loads would be beneficial. This has triggered an ambitious plan to introduce electric vehicles on a large scale in Denmark, with the first tests already in 2009 and a large-scale commercial launch planned for 2011. The idea is to build a system where car batteries are charged when the wind is blowing and used as backup power in shortage periods.

As a first step, a project named EDISON was launched in September 2008 to develop the technical solutions and supporting infrastructure and to carry out tests in real-life conditions on the island of Bornholm. The tests are part of building a national facility that offers a full-scale demonstration of the power system at Bornholm. It will be Europe's most powerful real-time power system simulator, capable of simulating larger complex electricity grids than any other European facility. Wind power penetration will reach 30 percent of the electricity supply when more large-scale offshore wind farms come online in the coming years. Danish companies intend to continue their growth in world markets once the economic climate improves.

Facts and Figures*

“Currently, America produces less than 3 percent of its electricity from renewable sources, like wind and solar. Denmark gets almost 20 percent of its electricity from wind power,” said US president Barack Obama, visiting a wind power plant in Iowa on Earth Day 2009. Denmark is a small north European country with 5.5 million inhabitants and a labor force of 2.8 million (agriculture 3 percent, industry 21 percent, and services 76 percent). GDP per capita is 31,120 euro (2008 est.). Since 1980, the Danish economy has grown by 78 percent, while energy consumption has remained more or less constant, and CO₂ emissions have been reduced. This development reflects an increase in energy and CO₂ efficiency. A majority of countries have seen underlying increases in their energy and CO₂

efficiencies, but the Danish increase is among the greatest in the OECD area. 19 percent of total energy consumption comes from renewable resources (biogas 3 percent, heat pumps 8 percent, straw 14 percent, wind 20 percent, waste biodegradable 23 percent and wood 32 percent). Wind power accounts for about 20 percent of the electricity production with 3,200 MW of installed capacity. More than 1,500 MW new offshore wind farms are planned for the next five years by DONG Energy alone. DONG is one of Northern Europe's leading energy groups. “We've obtained a lot of experience in this field and committed to using our specialized knowledge,” says Anders Eldrup, CEO of DONG Energy. 10 percent of the total Danish exports, or 7.7 billion euro, was cleantech in 2007. The sector comprises nearly 500

companies and employs 32,000 people. In 2008, the Danish wind energy industry exported wind technology to a value of 5.7 billion euro, up 20 percent from 2007. “Tackling climate change is a pro-growth strategy,” says Jørgen Mads Clausen, Chairman of Danfoss, one of Denmark's largest industrial companies and a leader in development and production of mechanical and electronic products and controls. Denmark has an ambitious Kyoto target to reduce emissions of greenhouse gasses by 21 percent in the period 2008–2012, relative to 1990. So far, the emissions of greenhouse gasses have been reduced from 79 million tons CO₂ equivalent in 1990 to 66 million tons CO₂ equivalent in 2006.

*Source: Danish Energy Agency