doi:10.3723/ut.30.027 International Journal of the Society for Underwater Technology, Vol 30, No 1, pp 27–33, 2011

The Danish wind industry 1980–2010: Lessons for the British marine energy industry

Kyle Smith
Aquamarine Power, Edinburgh, UK
Current address: University of Edinburgh, Edinburgh, UK

Abstract

The following paper presents the differences in the development of the Danish and UK wind industry in order to highlight key issues that led to their respective success and failure. By comparing the political, economic, social and technological policies that have defined the growth of the two industries, the paper contends that the lack of a clear and consistent market price support mechanism together with a slow planning process and delayed grid access were significant weaknesses in the UK. It also suggests that these factors must be addressed to ensure the same barriers do not stunt the growth of the UK marine renewable industry. To maintain the lead in an emerging marine energy industry, the UK government must facilitate strong public support for wave and tidal energy in parallel with assisting with R&D and project capital grants. Clear and consistent policy with regard to price support mechanisms and priority access to the grid are necessary to ensure a stable and reliable market. Lessons learned from the success of the Danish wind industry must be applied if the UK wishes to secure a stronghold in this market.

Keywords: Aquamarine Power, marine energy, Danish wind industry, support mechanisms

1. Introduction

Denmark is the undisputed leader of the modern wind energy industry. It has leveraged its long history of windmill use in agriculture to create and sustain a comparative technological advantage in the sector. This advantage built the foundation for a technological revolution that has resulted in a global export market worth over £4.8 billion (€5.7 billion) in 2008 (see Fig 1). With a 20% share of the global wind turbine market (Ministry of Foreign Affairs of Denmark, 2010), the Danish wind industry employs 28 000 workers and contributes £1.2 billion (€1.5 billion) in gross value added (GVA) to the national economy each year (Centre for Policy Studies (CEPOS), 2009). It is therefore evident that clean electricity is just one of the many benefits that wind energy has brought to this nation.

It is no coincidence that the modern wind energy industry was founded in Denmark. R&D support to the industry in the late 1970s helped to identify the three-bladed wind turbine as a standard design for wind energy generation, around which the industry rapidly coalesced (Krohn, 2002). This design consensus was quickly reinforced by early political vision, including consistent financial support mechanisms and priority grid access, which provided security for private investors to develop wind energy on a commercial basis. The early technological support and experience in large-scale commercial wind installations provided Danish manufacturers with a first-mover advantage over competing manufacturers in other countries. Through the 1980s Danish companies formed an international reputation for innovation, efficiency and reliability, which continues to this day.

The UK, by contrast, has failed to capture the full economic benefits of the onshore wind energy phenomenon, with the majority of turbines being imported and there being no major large-scale local turbine suppliers. This retrospective analysis of the development of Danish and British wind energy seeks to identify the disparities in the support mechanisms that enabled Denmark to establish a domestic wind industry but where lacking in the UK, caused its reliance on technology imports.

There are strong parallels between wind energy and marine renewables. With similar vision and structured political support, the potential of this industry could be captured in the UK. By recognising the mechanisms that facilitated wind energy in Denmark, the required government support for a British marine energy industry is set in context.

2. Comparative development of Danish and British wind industries

As Denmark has limited conventional energy resources, this concern drove policy makers to

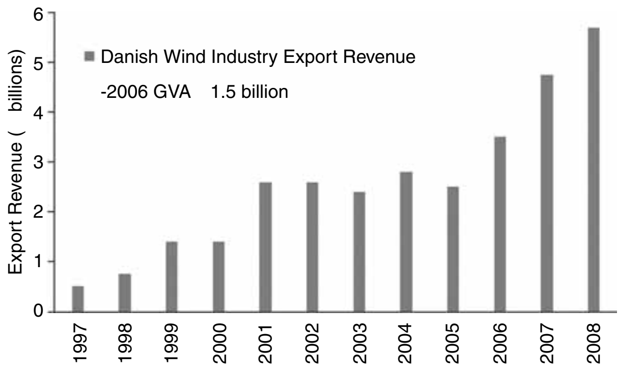


Fig 1: Danish wind industry export revenue (Danish Wind Industry Association, 2010)

explore alternative energy options to reduce reliance on imported fossil fuels. Early funds were provided to support wind energy R&D in the 1970s, which assisted in developing the technology standard based on the three-bladed wind turbine. Vestas (then a Danish crane manufacturer), purchased the manufacturing rights to a three-bladed, up-wind turbine called the HVK in 1979 and began commercial production shortly after. A decade of capital grants allowed small-scale wind turbines (22kW) to be erected at a rate of 18 in 1979, to 100 per year from 1980 onwards (Musgrove, 2010). Manufacturers gradually increased the turbine size through the 1980s as experience with the three-bladed concept developed.

In 1985 the Danish government ruled to prohibit the development of nuclear energy plants. Concurrent to this, the Danish government put in place a system of fixed incentives, favouring early development by independent investors in cooperation with local communities, which lasted for almost 20 years. At the same time, the government offered them priority access to the grid and put in place infrastructure improvements to enable additional capacity. This combination created grass-roots support for wind energy, early investment security to de-risk the technology and time to establish a reputation for reliable performance. Fig 2 illustrates the development of the Danish wind sector since 1980.

The UK had a different energy outlook in the 1980s. Nuclear energy was on the agenda, North Sea oil was plentiful and some coal reserves remained. While R&D investments were made in the wind energy sector, the industry was not considered a priority from a policy perspective and installed capacity grew very slowly (International Energy Agency (IEA), 2004).

The introduction and implementation of the Non Fossil Fuel Obligation (NFFO) in the 1990s provided a price support mechanism for renewable energy developers to compete for premium priced energy contracts. The NFFO scheme was originally intended to support nuclear energy as part of a move to privatise the industry. In total there were five NFFO funding tranches during the decade that attracted bids from renewable and nuclear project developers. Bidders competed primarily on price; the lowest prices received government-allocated capacity first. The development of the wind energy sector in the UK is illustrated in Fig 3.

The competitive nature of the NFFO scheme resulted in the average price of wind energy being reduced from 11p to 2.9p/kWh over the decade (Department of Trade and Industry (DTI), 2001). While the NFFO funding rounds assisted in

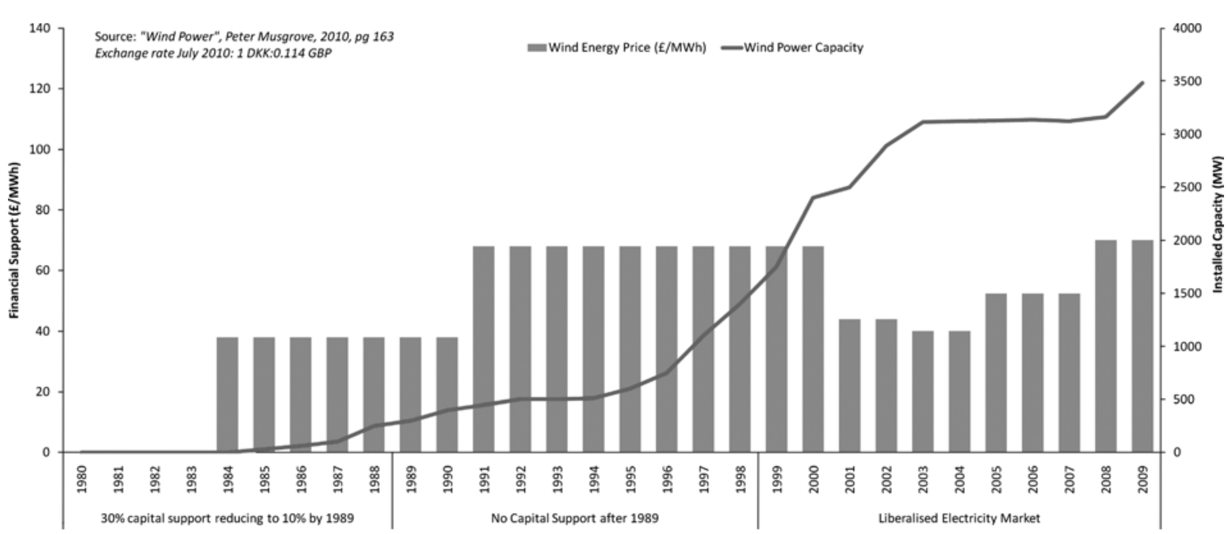


Fig 2: Danish production incentives and installed wind power capacity over 20 years (Musgrove, 2010). In 2001, a change in government and policy reduced the rate of growth in wind power capacity by implementing variable incentives based on turbine size and hours of full production

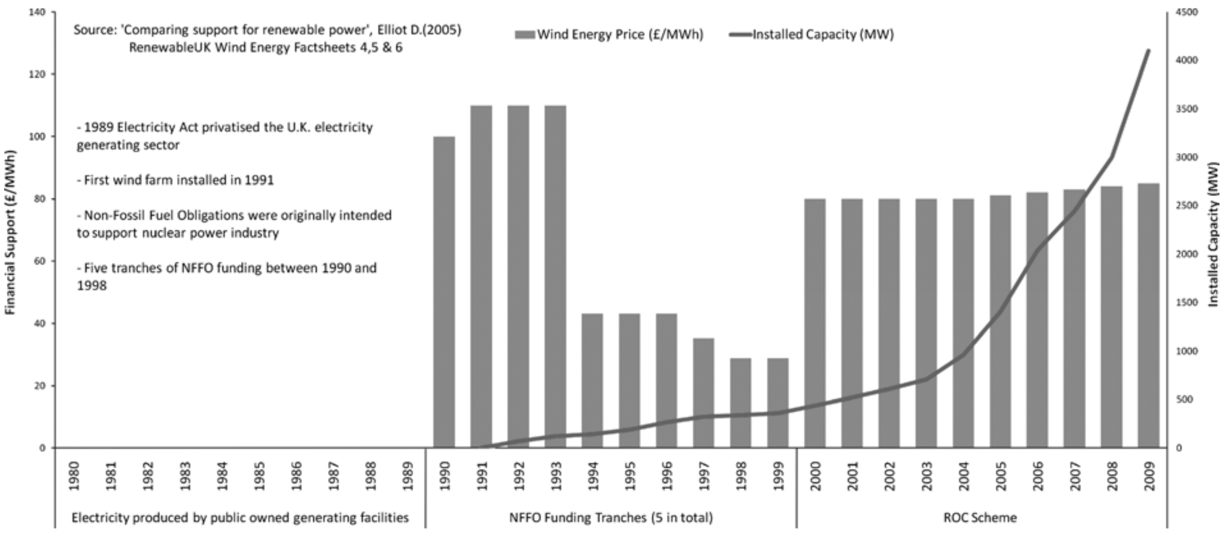


Fig 3: Financial support and installed capacity in the UK over time (DTI, 2001; Elliott, 2005). The higher, consistent ROC prices resulted in an exponential growth in wind power capacity. An approximate electricity market price of £50 per MWh has been assumed

advancing the competitiveness of renewable energy with fossil fuels, contracts awarded under NFFO 1 and 2 expired in 1998. Therefore, developers had a fixed period of time to maximise energy production under premium prices. This restriction put a strain on existing manufacturing facilities, forcing developers to import turbines that could be rapidly installed and commissioned at scale, sometimes in the face of strong and vocal local opposition. At the same time, a focus on oil and gas exploration diverted UK attention away from developing a wind energy sector.

Foreign wind turbine manufacturers were also reluctant to establish a UK presence because of the inconsistency in allocated wind energy capacity in each NFFO funding round. This insecurity was compounded further by an average three-year consenting period, which reduced the amount of time available to produce energy under contracted premium prices. Over the five NFFO rounds, contracts for 2680MW of wind power capacity were awarded, but by 2000 only 395MW were operational (DTI, 2001).

Table 1 compares the political, economic and social frameworks that supported wind energy in Denmark but failed to help create a UK wind industry. It can be seen from Fig 4, which charts the total annual public R&D spend since 1974, that between 1980 and 2000 both nations spent similar sums on wind energy research and development. The UK, however, was late in providing a stable market pull mechanism. Denmark began offering premiums for wind energy in the early 1980s, and over 20 years the government spent £800 million supporting the industry. The UK's NFFO scheme allocated £633 million to renewable energy in the 1990–2000 period. It is estimated that of this amount, £240 million was spent on wind energy projects (Elliott, 2005).

A first mover advantage and clear, consistent policy support were Denmark's primary success factors. Capital grants for wind energy began a decade before the UK implemented the NFFO programme and were quickly reinforced with premium prices six years before the UK. The Danish government mandated utilities to install 100MW of wind power by 1990 – a year before the UK commissioned its first wind farm. Early familiarity with wind turbine technology established safety and performance standards, which provided security to international investors. Denmark's success was not only attributable to early R&D spend during this period, but it also was achieved through a coordinated policy package. This package was based on capturing the benefits of first mover advantage, securing public support, achieving design consensus and providing premium tariffs for energy production.

The UK's late renewable energy policy and an inconsistently funded, competitive incentive scheme failed to develop a fledgling wind industry during the 1990s. This resulted in the majority of economic benefit (e.g. GVA and jobs) being lost to other countries, including Denmark.

3. Creating a British marine energy industry

The information presented here suggests that Danish wind energy developers had one distinct advantage over British counterparts: 20 years of consistent market support. Renewable energy investors

Table 1: A comparison of the socio-economic framework in which wind energy developed in Denmark and the UK between 1980 and 2000

Denmark	UK
Political	
• £800 million (€950 million) was spent on market incentives between 1980 and 2000.[1] • £120 million (€140 million) was spent on R&D 1980–2000.[4] • Stable financial support was given for 20 years; 85% of retail price and later, a premium of 3p/kWh spurred domestic growth of wind energy. • Change of government in 2001 altered the support scheme and, as a result, stalled domestic growth of wind energy. New support mechanisms vary according to size of turbine and hours of full production.	• £240 million was spent from 1990 to 2000 NFFO.[2] • £140 million was spent on R&D from 1980 to 2000.[3] • The Electricity Act 1989 privatised UK electricity generation. The Non Fossil Fuel Obligation was intended to support the nuclear industry, but was later expanded to include renewables. • Policy during first decade of wind energy was uncertain, and NFFO contracts made electricity pricing highly competitive.
Economic	
• Danish agricultural sector was in decline. Companies such as Vestas, Bonus and Micon moved from traditional industries to a new energy industry.	• The UK government supported nuclear and had a strong offshore oil and gas industry. Wind energy was not a priority.
Social	
• Wind energy continues to achieve a 90% approval rating. Public support was encouraged by allowing anyone within a prescribed vicinity of a wind farm to purchase shares in the development. • Structured financial support favoured individuals over power companies. In 2002, 80% of the 6300 wind turbines in Denmark were owned by wind energy cooperatives or individual farmers.[5]	• There was widespread public objection to wind turbines between 1990 and 1995, because of developments in areas of high potential for conflict, and limited cooperation with local communities.
Technical	
• Early R&D support defined three-bladed turbines as the design of choice before market pull techniques were employed. • Early support provided the industry with a long-term stable framework in which to further develop system reliability and gain a lead over other nations. • Priority access to grid and infrastructure improvements streamlined additional capacity.	• Domestic demand did not offer the degree of development certainty to support domestic manufacturing during the decade of NFFOs. Developers had no choice but to import wind turbines in order to maximise energy production during fixed NFFO price and contract period. • NEG Micon bought the British Wind Energy Group in 1998, which effectively ended a domestic wind turbine manufacturing sector.

[1](Aquamarine Power, 2010); [2](Elliott, 2005); [3](IEA, 1980–2000b); [4](IEA, 1980–2000a); [5](Krohn, 2002)

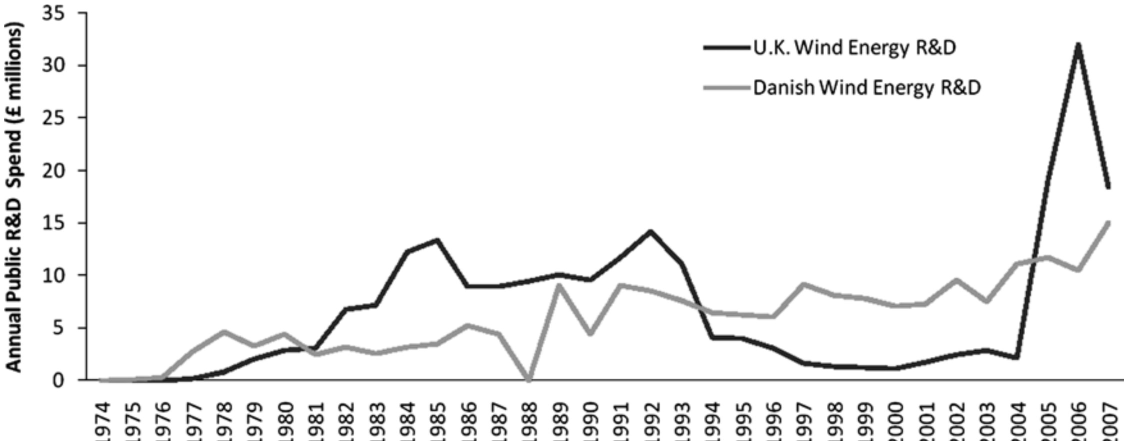


Fig 4: A comparison of UK and Danish annual public R&D spend on wind energy (Elliott, 2005)

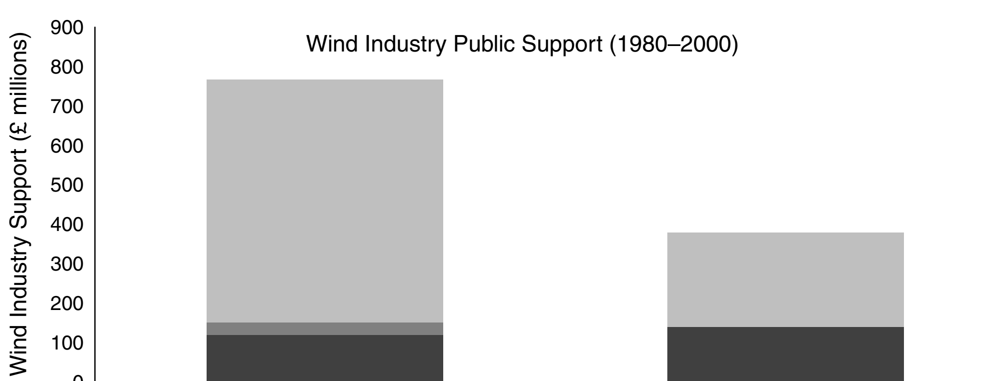
seek stable markets supported by clear government commitments that present a prosperous future for an emerging industry. Denmark was early in offering this assurance to project developers and individual owners, which indirectly provided market security for the first wind turbine manufacturers to invest in refining a design concept.

To develop a UK marine energy sector it will be necessary to create an environment that offers long-term assistance to investors through guaranteed price support mechanisms, reduced site consenting timelines and priority access to the grid at an affordable cost. In addition to stable market pull conditions, the emerging UK marine energy industry will continue to require R&D capital grants. The Danish wind market benefitted from targeted R&D and, given the greater technological challenges faced by the marine sector, it is likely that high levels of targeted R&D funding will be required to support the most promising marine technologies through to commercial projects.

For marine energy developers, it is intuitive to search for answers in the case of 'Danish wind' and to assume that marine energy will evolve in a similar manner. However, it is important to note that marine and wind energy converters require very different technological solutions. The existing wave and tidal energy devices deployed to date possess a rated power output up to 30 times greater than the first prototype wind turbines from the 1970s. The early 10–20kW wind turbines could be deployed in areas owned by a single person without interference from the state or multiple land owners. These small-scale wind turbines provided an opportunity for communities to finance local projects, which the Danish government then encouraged with preferential energy pricing. Early and continuous community involvement reduced public opposition to wind energy and created broad acceptance of the industry.

Consenting to a small-scale wind turbine was relatively simple compared to the legislative hurdles that wave and tidal energy developers presently face. The current consenting regime in Scotland is onerous, requiring up to two years of baseline bird and mammal observation data in support of an 'environmental statement' to accompany an application to Marine Scotland, with a further nine-month determination period on that application. There is also very restricted access to the electricity grid, with low to 0MW capacity in the key development areas of Orkney and the Western Isles. It also has a transmission charging regime which levies the highest charges to electricity generators on the periphery of the UK – the very sites with maximum wave resource.

UK legislators should also recognise that Danish wind turbine manufacturers were able to test and refine design concepts with relative ease and little expense. This is not the case for marine energy,



	DENMARK	UK
Production incentives	615.4	240
Capital grants	31	0
R&D	122	141

R&D budget: calculated using Danish Energy Agency data services – total support derived using historic wind energy generation and price premiums
Capital grants: based on Nielsen (2002) for Denmark
Production incentives UK: estimate based on ratio of wind energy capacity to other funded energy sources from NFFO Renewable Funding table (Elliott, 2005)
Production incentives Denmark: Derived using wind energy generation and applying supportive prices per kWh during period

Fig 5: Value of wind industry public support (Aquamarine Power, 2010; Nielsen, 2002; Elliott, 2005) and it should be acknowledged that the current planning system introduces considerable delay for early-stage developers and causes potential detriment to the early growth of the industry.

The UK's native marine energy resource and decades of marine engineering knowledge provide the country with a natural comparative advantage over other coastal nations. However, both Ireland and Portugal offer competitive price premiums for wave and tidal energy, and therefore the market pull from these European states is also strong. To maintain the lead in an emerging marine energy industry, the UK government must facilitate strong public support for wave and tidal energy in parallel to assisting the most promising technology developers with R&D and project capital grants. Transparent performance assessments of prototype technologies will create streamlined investment in the most effective devices, allowing recognised designs to emerge.

4. Conclusion

Denmark provided the wind industry with £800 million (€950 million) of public finance over a 20-year period and, at the same time, offered priority access to the electricity grid and associated infrastructure (see Fig 5). This support has resulted in an expanding export market that has grown from £0.4 billion (€0.5 billion) in 1997 to nearly £5 billion (€6 billion) in 2008. The UK now has a similar opportunity to capitalise on its own early mover advantage in the marine energy industry. A framework of consistent financial support, capital grants, clear consenting procedures and timely grid access will create the secure investment environment that the industry requires to grow incrementally, giving the UK a real opportunity to become a global leader in this new technology.

The current regime of Renewable Obligation Certificates (ROCs) is an appropriate market pull mechanism which is well understood and offers a clear price signal to investors. However, the application of marine energy ROCs is inconsistent; in Scotland there are five ROCs per MWh for wave energy and three for tidal, whilst in the rest of the UK there are only two ROCs per MWh for each technology. The current level of five ROCs for wave energy in Scotland offers a price premium marginally higher than the feed-in tariffs on offer in other competing countries and is proving sufficient to attract early-stage investment. In this respect the Scottish government should be advised for putting in place exactly the type of market mechanism that enabled Denmark's nascent wind industry to grow.

However, the industry is also faced with the need for developers to underwrite the capital costs of transmission upgrades, and they are also required to pay punitive transmission charges for connections to the prime development locations of Orkney, the Western Isles and Shetland. As long as these charges remain in place, it is unlikely these island communities will be able to benefit from the natural advantages their islands confer, and the industry's growth will be impeded as a consequence.

If the UK and Scottish governments were to put in place a consistent ROC banding regime for wave and tidal energy across the UK, or a clear and well understood feed-in tariff which offered long-term price security *and* address the urgent issues of transmission upgrades and charging, then they will have put in place two of the fundamental elements on which a successful new industry can be built.

Acknowledgements

This paper is a revised and updated version of a report that was first published on the Aquamarine Power website in 2010.

Aquamarine Power is a wave energy developer and has plans to deploy its Oyster wave energy device off the coast of Scotland and other locations worldwide.

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