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A comparison of offshore wind power development in Europe and the US: Patterns and drivers of development

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ABSTRACT

Since the turn of the 21st century, the onshore wind industry has seen significant growth due to the falling cost of wind generated electricity. This growth has coincided with an interest in the development of offshore wind farms. In Europe, governments and developers have begun establishing small to medium sized wind farms offshore to take advantage of stronger and more constant winds and the relative lack of landowner conflicts. In the US, several developers are in the planning and resource evaluation phases of offshore wind farm development, but no wind farms are currently operational or under construction. In this paper, we analyze the patterns of development in Europe and compare them to the US We find significant differences in the patterns of development in Europe and the US which may impact the viability of the industry in the US. We also discuss the policies used by European nations to stimulate offshore wind development and we discuss the potential impacts of similar policies in the US.

1. Introduction

Wind energy is the alternative energy source with the most realistic chance to displace large amounts of fossil fuel combustion. Over the past several years, the onshore wind energy industry has seen dramatic growth, both in the US and Europe. In Europe, the growth in the onshore wind energy industry has been supplemented with growth in the offshore industry (Fig. 1) which at present represents 1.8% of the total installed European wind capacity.[1] The first offshore wind farm began operating in 1991; by the end of 2008 there were approximately 1500 MW of installed capacity. By 2009 or 2010 the wind capacity in Europe is expected to grow by another 1500 MW [1], and by 2015, the rate of growth of the European offshore industry is expected to be 1700 to 3000 MW per year [2].

In the US there has been significant interest in the development of an offshore wind energy industry (for example [3,4]). Increasing coal, natural gas and oil prices, reliance on foreign sources of oil, and concerns about global climate change have made domestic, renewable and low carbon sources of energy particularly attractive to policy makers. As of late 2008, no offshore wind farms are under construction in the US, but resource assessments are ongoing at Cape Cod, Massachusetts, and Galveston, Texas.

There are a number of reasons why offshore wind development has lagged behind in the US. Both the offshore wind resources and the governmental subsidies for offshore wind power differ in Europe and the US, and it is not clear if offshore wind power will be profitable in the US in the short term. For offshore wind development to succeed, a combination of events must hold. The revenue potential from offshore wind must exceed the associated costs and risks, federal involvement in advancing renewables through regulatory programs and economic incentives must be in place, state involvement through renewable portfolio standards must continue, and public acceptance of offshore wind farms must occur.

We begin this paper with a discussion of the patterns of offshore development in Europe and compare to the proposed developments in the US. We discuss the current status of offshore wind plans and testing in the US and reasons for the cancellation of some projects. We discuss the policy drivers of the offshore wind energy industry in Europe, and compare these drivers to those in place in the US. We end the paper with a discussion of the effects of potential US policies on the offshore wind industry.

2. Offshore wind energy development in Europe

2.1. European wind farms

There are a number of operational (Table 1) and approved but not constructed offshore wind energy projects in Europe [5,6]. Denmark and the UK have the largest share of operational offshore capacity (Table 2). Germany has the largest share of planned capacity, but has no significant operational wind farms [5]. In total, there are 40 approved offshore wind farms with 20,000 MW of planned capacity, 81% of which is in German waters [5,6].

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[1] Due to the higher wind speeds over the ocean, offshore wind generates a disproportionate percentage (3.3%) of the wind generated electricity in Europe [1].

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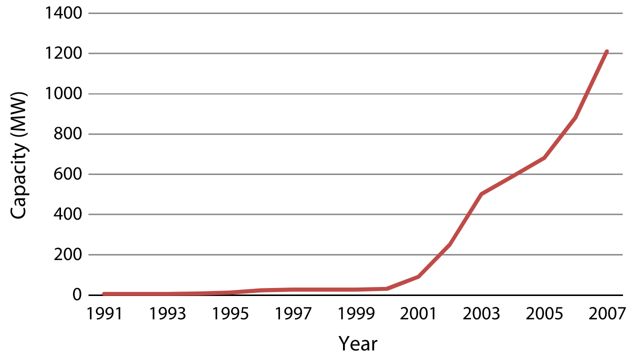

Fig. 1. Growth of capacity of European offshore wind farms. Data from Table 1.

2.2. Trends in Europe

One of the clearest trends in the offshore wind industry in Europe is the increasing size of wind farms (Fig. 2). Additionally, developments have progressed into deeper water, farther from shore and have adopted larger turbines (Figs. 3–5).

In Europe, developers and nations began by developing relatively small test projects (10–50 MW), then developments of 100–200 MW, and are now building or planning projects of 400–1000 MW [2]. This slow development has been intentional and has occurred primarily due to government planning. The large farms currently being planned may allow for large cost reductions through scale economies.

The deepest offshore turbines constructed to date have been at Beatrice where turbines were constructed on jacketed foundations in 45 m of water. Excluding Beatrice, the deepest offshore wind farms have been built in water only 10–20 m deep, due largely to the constraints of monopole and gravity foundations. Floating wind turbines are being tested by Blue H in Italy which would allow for development in water over 100 m deep. The wind farm farthest from shore is Thornton Bank which is 27 km from the Belgian coast. In the near future the Belwind wind farm will be built over 40 km from the Belgian coast. While both Thornton Bank and Belwind will be connected with AC cables, the costs of DC transmission are declining which will allow for development further from shore. While these farther offshore wind farms have a number of advantages (stronger winds further from shore and fewer user conflicts) it is not clear how the long distances and open seas will impact the time available for maintenance [7].

The turbine capacity used in both onshore and offshore wind farms has increased over the past decade. Larger turbines are thought to allow for lower operation and maintenance costs, installation and foundation costs per unit of capacity. The largest turbines used so far have been 5 MW built by REPower and were used in Beatrice and Thornton Bank. However, Enercon has

Table 1
Operational commercial offshore wind farms in Europe as of January 2009.

Wind farm	Nation	Year built	Capacity (MW)	Total cost (million)	Depth (m)	Developer	Foundation type	Turbine manufacturer	Turbine size (MW)	Hub Height (m)	Distance to shore (km)
Vindeby	DK	1991	5	11.2	3.5	SEAS	gravity	Bonus	0.45	38	1.5
Lely	NL	1994	2	4.8	7.5	Energie Nord West	mono	NED Wind	0.5	39	0.8
Tuno Knob	DK	1995	5	11.2	4	Midtkraft		Vestas	0.5	40.5	3
Dronten	NL	1996	11	28.6	1.5	Nuon	mono	Nordtank	0.6	50	0.03
Bockstigen	SDN	1997	3	4.8	6		mono	wind world	0.55	41.5	
Blyth	UK	2000	4	7	8.5	Nuon, Shell, E.ON		Vestas	2	69	1
Middlegrunden	DK	2001	40	53	6	Energie E2	gravity	Bonus	2	64	2
Utgrunden	SDN	2001	10	14	8.6	Vattenfall	mono	Enron	1.425		
Yttre Stengrund	SDN	2001	10	18	8	Vattenfall	mono	NEG	2	60	
Horns Rev	DK	2002	160	500	10	Vattenfall	mono	Vestas	2	70	14
Frederikshaven	DK	2003	10		4		1 suction, 3 mono	Vestas, Bous, Nordex	3	80	0.2
Nysted	DK	2003	165	373	7.75	DONG	gravity	Bonus	2.3	70	10
Samso	DK	2003	23	52	20		mono	Bonus	2.3	63	3.5
North Hoyle	UK	2003	60	148	12	npower	mono	Vestas	2	67	7
Ronland	DK	2003	17.2	26	1			Bonus/Vestas	2.3	78	0.1
Scroby Sands	UK	2004	60	155	16.5	E.ON	mono	Vestas	2	68	2.5
Arklow	IRE	2004	25	70	3.5	Airtricity	mono	GE	3.6	74	10
Ems Emden	GMN	2004	4.5		3	Enova		Enercon	4.5	100	0.04
Kentish Flats	UK	2005	90	217	5	Vattenfall	mono	Vestas	3	70	10
Barrow	UK	2006	90	190	17.5	DONG	mono	Vestas	3	75	7.5
Egmond aan Zee	NL	2006	108	334	18	Nuon	Mono	Vestas	3	70	10
Rostock	GMN	2006	2.5		2			Nordex	2.5	80	0.5
Burbo Bank	UK	2007	90	185	5	DONG	mono	Siemens	3.6	83.5	6.5
Beatrice	UK	2007	10	70	45	Talisman	Jacket	Repower	5	88	22
Lillgrund	SDN	2007	110	300	7	Vattenfall	gravity	Siemens	2.3	69	10
Q7 (Princess Amalia)	NL	2007	120	590	21.5	Econcern	Mono	Vestas	2	59	23
Thronton Bank	BEL	2008	30	197	20	C-Power	Gravity	Repower	5	94	28
Kemi A jos	FIN	2008	24			PVO-Innopower	Artificial island	WinWind	3	88	<1
Inner Dowsing	UK	2008	97	300	10	Centrica	Mono	Siemens	3.6	80	5.2
Lynn	UK	2008	97	300	10	Centrica	Mono	Siemens	3.6	80	5.2
Brindisi	ITL	2008	0.08		108	Blue H	Floating		0.08		20
Hooksiel	GMN	2008	5		2–8	BARD	Tripod	Enercon	5		<1

Sources [1,3,8,69–81].