



State of the art and trends regarding offshore wind farm economics and financing

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Objectives and approach

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- Review of economics of offshore wind energy carried out as part of CA-OWEE
- Economics of past wind farms
- Current plans (where available/avoiding commercial conflict)
- Comparing costs of on- and off- shore wind farms
- Future trends
- The full report is available on-line:
<http://www.offshorewindenergy.org/>



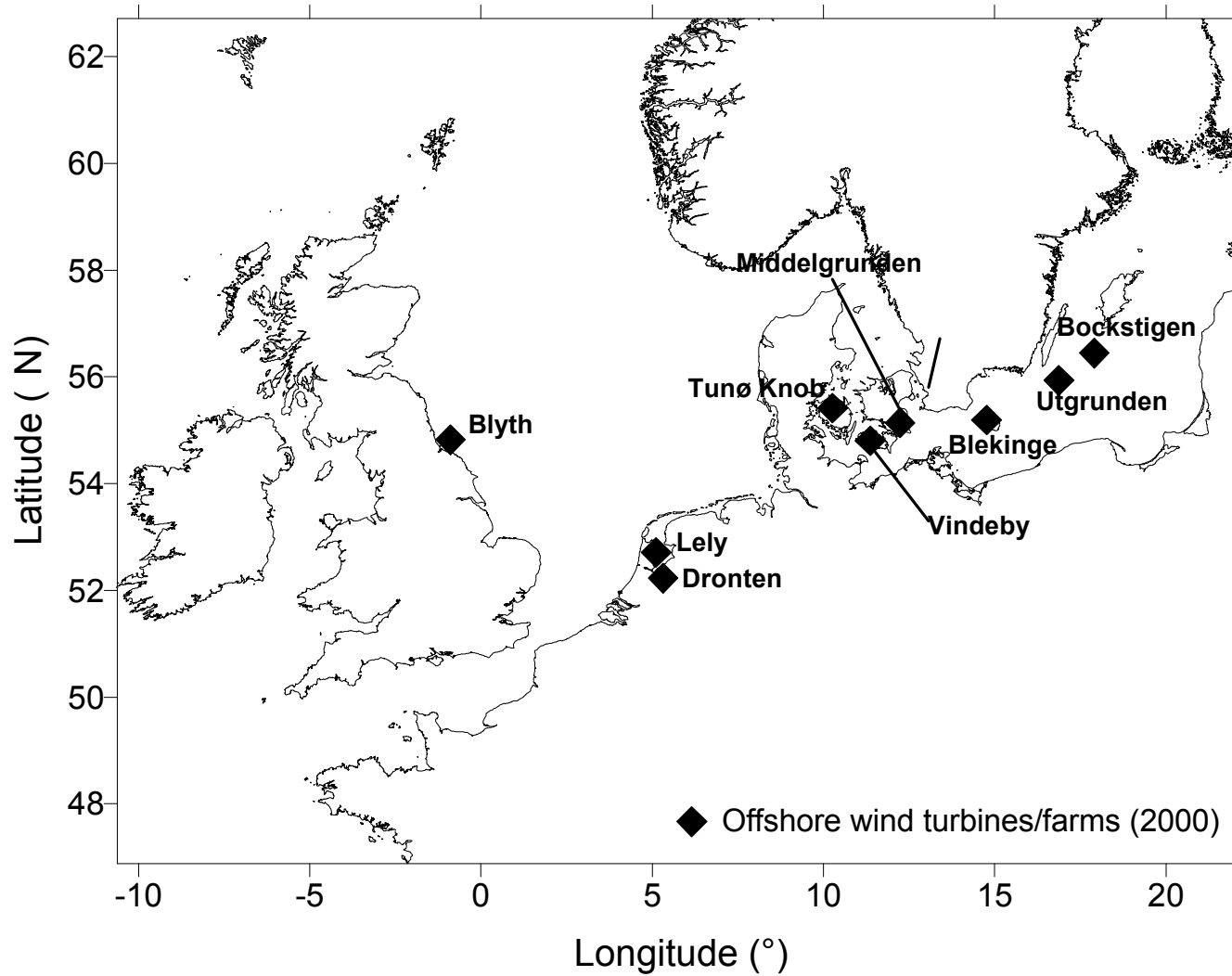
Onshore vs Offshore

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- Onshore
- Investment 700-1000 € /kW
- Cost ~3-8 € cents /kWh
- O&M ~ 1-3% of installed cost
- Can be built in smaller units
- Less suitable for 2MW+ turbines
- May need to run less optimally (e.g. noise considerations)
- Offshore
- Investment ~ 1650 € /kW (site dependent)
- Cost ~5-10 € cents /kWh
- High initial investment (foundations/grid connections)
- Higher O&M ~ 30 € /kW + 0.5 € cents/kWh variable
- Large turbines
- Large farms (reduces unit cost)



Current offshore wind farms





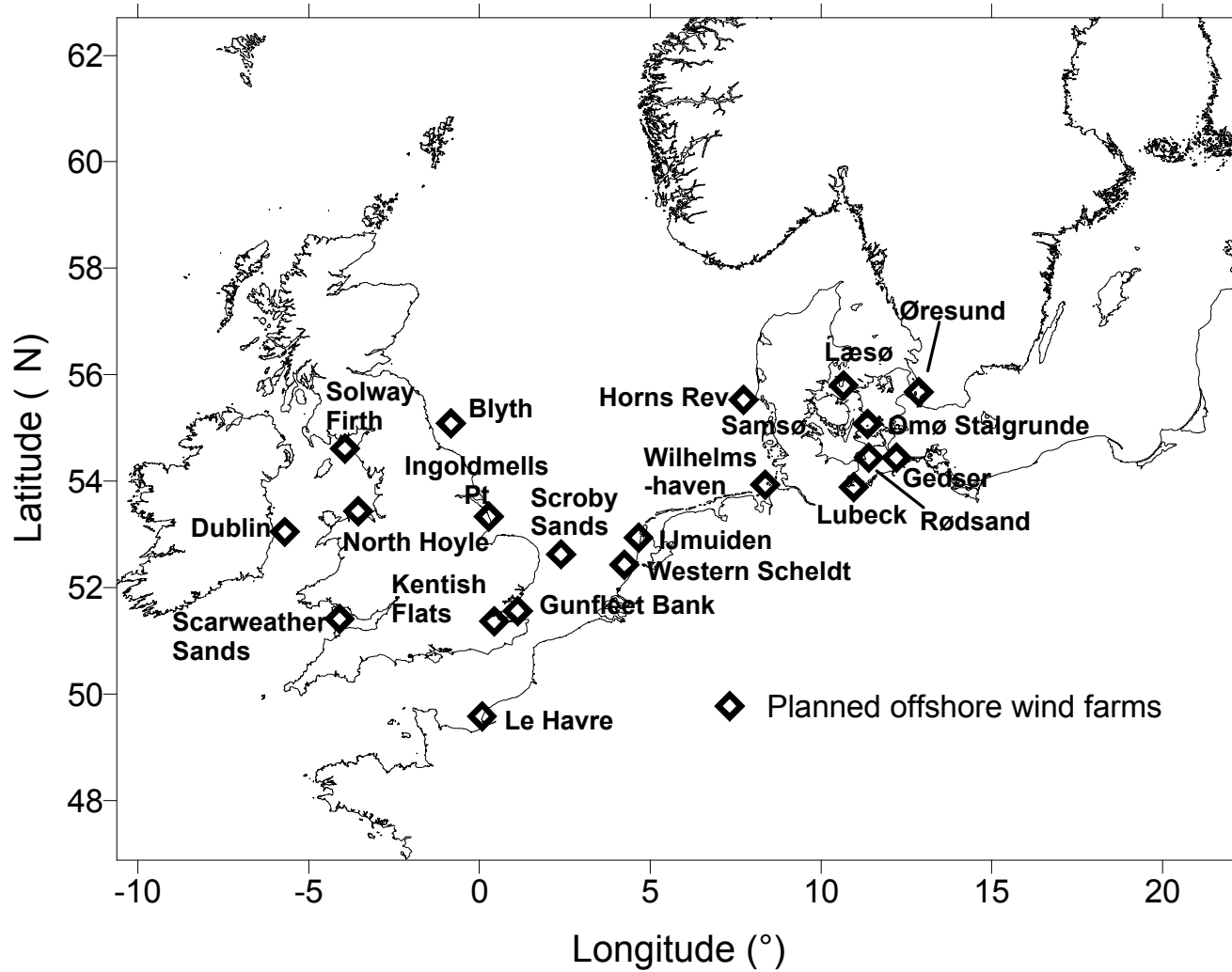
Current offshore wind farms

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Name	MW	Year	€ cent kWh	Production MWh/y	Investment (€/kW)
Nogersund SE	0.22	1990		0	
Vindeby DK	5	1991	8.5	11200-11730	1939-2150
Lely, NL	2	1994	8.6-13.7	3800	1700-2600
Tunø Knob, DK	5	1995	6.6-8.17	12500-12700	2040-2200
Irene Vorrink, NL	16.8	1996		37000	
Bockstigen, SE	2.75	1998		8000-8500	1455
Blyth, UK	4	2000	7-8	12000	
Middelgrunden, DK	40	2000	6	81000	
Utgrunden, SE	10	2000		38000	
Yttre Stengrund	10	2001		30000	1300



Planned wind farms (2001)



NB: Large scale plans in UK/DE not shown



Planned wind farms

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Name	Total MW	Year	€cent/ kWh	Production MWh/y
Klasården, SE	42	2001?		
Horns Rev, DK	150	2002	4.7	
Rødsand, DK	150	2002	4.8	
Q7-WP, NL	100	2002		
Breedt, FR	7.5	2001	6.4	
Læsø Syd, DK	150	2003	4.8	396,000
Nearshore, NL	100	2003	7-8	300,000
Omø Stålgrunde, DK	150	2004	5.0	434,000
Gedser, DK	150	2006	5.1	
Arklow Bank, EI	500			
Kish Bank, EI	250			
Lillegrund, SE	72			
Scroby sands, UK	40		5.4	102,000



Past/current offshore wind farms

- Past
 - Turbines 200-600kW
 - Wind farms <20MW
 - Shallow water/sheltered sites
- Demonstration projects
 - ‘Over-engineering’
 - Lack of experience
 - Costs (e.g. at Vindeby) ~twice land sites
- Positives
 - Good experience gained
 - Wind farms have been successful!
- Current
 - Turbines ~2MW
 - Wind farms 40-80MW
 - Deeper water/less sheltered
- Commercial projects
 - Use previous experience
 - Develop more cost/time efficient techniques
 - Some economy of scale



Cost comparison



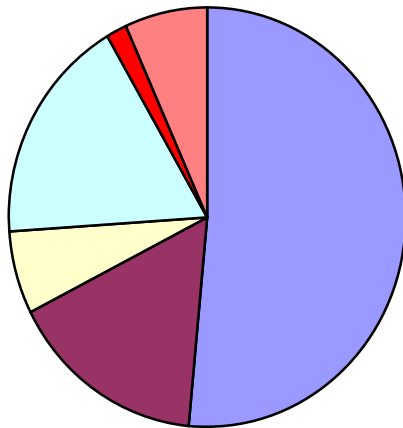
- Demonstration projects
 - 6-8 € cents /kWh
- Current generation
 - 4.6-6 € cents /kWh



Component costs (%)

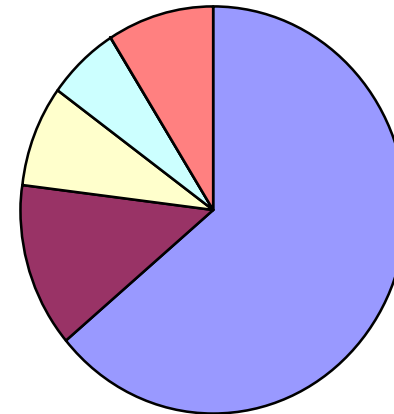


Offshore



- Turbine
- Civil engineering
- Electrical infrastructure
- Grid connection
- O&M infrastructure
- Other

Onshore



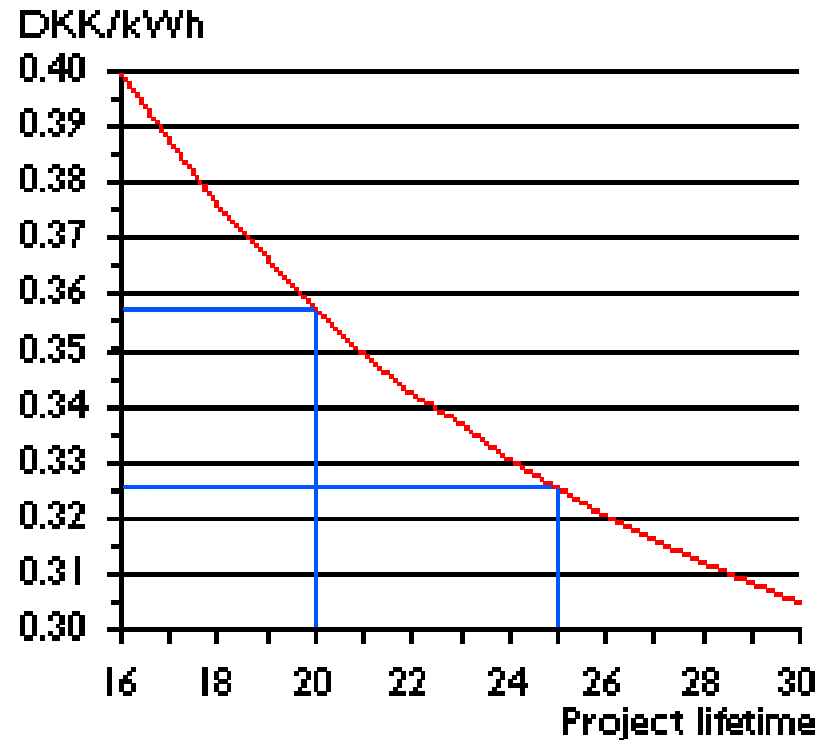


Effect of project lifetime



- If lower turbulence offshore=longer component lifetime then costs reduced up to 5 % (?)
- If major infra-structure (foundations, tower etc) has a lifetime >30 years (~50 years?) costs are reduced up to 20%

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web site www.windpower.org.





Targets



- Should targets focus on generation costs?
- Targets - UK DTI € 1200 /kW installed by 2010
- O&M <2 € cents/kWh
(just over current onshore costs)
- Availability of 95% cf onshore 98%



Uncertainties

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- Resource estimation - complex in coastal areas
- Vertical profiles - not currently measured to hub-heights
- Wake losses - in large offshore clusters/effects of stability
- Farm losses - if large clusters are located within 50 km of each other
- Markets - benefits of forecasting
- Market futures
- Penetration limits





Future trends



- Large turbines - 5 MW range
- Large wind farms - support infrastructure development
- Offshore costs falling in line with DWIA estimates for wind energy 10 to 20 per cent to year 2005?
- Maintenance costs reduced
 - experience
 - 'smart' components
 - better monitoring
- Floating platforms for deeper water
- Better predictions of in-farm and between farm wake losses & coastal boundary layers



Summary

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- Increasing commercial nature of offshore wind energy limits information availability
- Near-future - at reasonable sites - costs \sim 4-6 € cents/kWh
- Viability - more market dependent than limited by physical resources
- Market liberalisation may jeopardise development



Acknowledgement & Sources



- Acknowledgement: EC funding through CA-OWEE
- Main sources:
 - Danish Wind Industry Association web site www.windpower.org.
 - OPTI-OWECS/ Kuhn (2001)
 - BWEA
 - DEA/CADDET
 - Greenpeace
 - Prospects for offshore wind energy (Altener report)