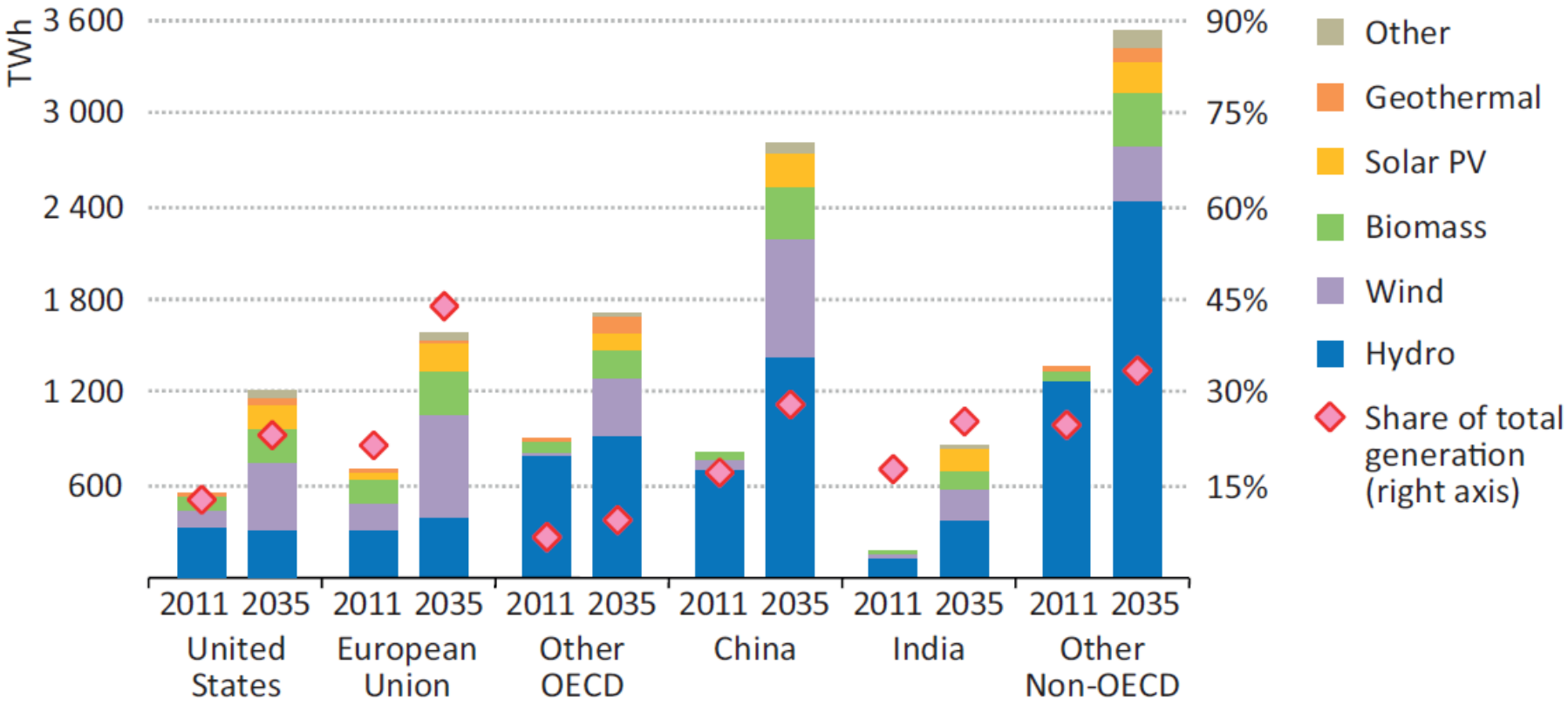
Is floating offshore wind turbines an option?

The history of Hywind and the way forward.

Finn Gunnar Nielsen, Sr Advisor, Statoil RDI, prof. UiB

The role of renewables

Figure 5.13 ▷ Renewables-based power generation and share of total generation by region in the New Policies Scenario



Source: IEA Energy Outlook 2013

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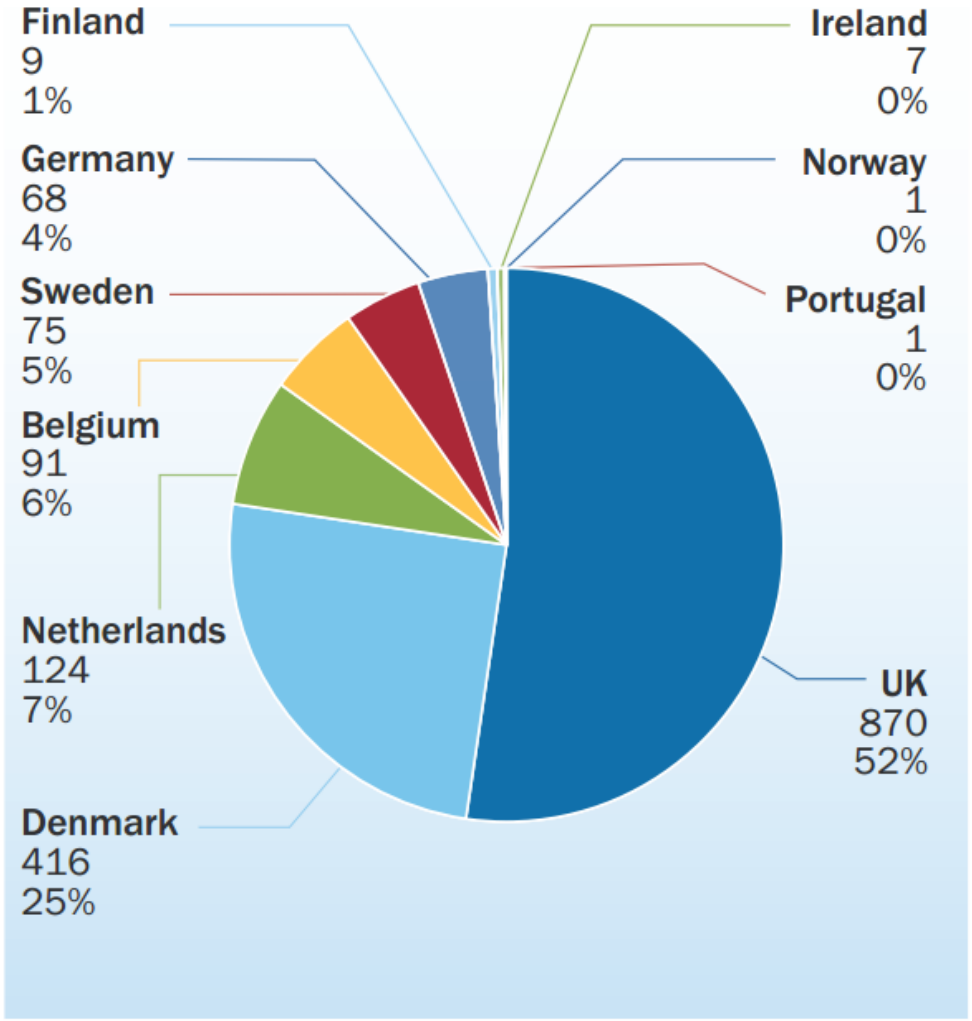
Installed offshore wind turbines – by country



Globally Land + offshore, end 2013:

318 GW installed (+11%)

Offshore:

7.0 GW (+30%)

Source: EWEA 2013 /14

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Trends in cost of wind energy

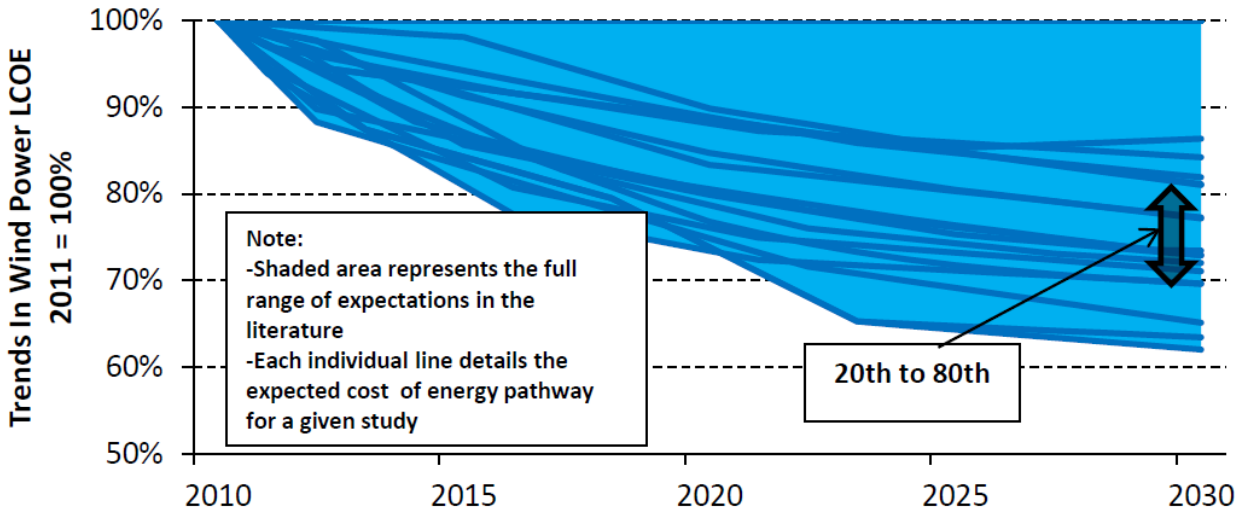

Figure ES-3. Estimated range of wind LCOE projections across 18 scenarios

Sources: EREC/GPI 2010, Tidball et al. 2010 (includes modeling scenarios from multiple other sources), U.S. DOE 2008, EIA 2011, Lemming et al. 2009, EWEA 2011, EPRI 2010, Peter and Lehmann 2008, GWEC/GPI 2010, IEA 2009, and European Commission 2007

Source: IEA wind, 2012

- EU:
  - Security of supply
  - Work places
  - Reduced emissions

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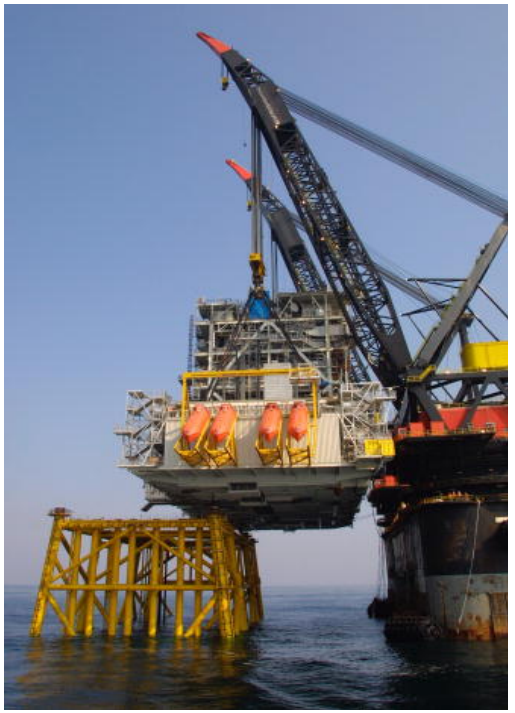
Where we are coming from:

- Deep water
- Harsh environment
- Advanced marine operations
- Advanced projects



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Portfolio: Step wise growth in offshore wind

Offshore wind development based on core competence

2.3MW

Hywind Demo

317MW
1.1 Twh / yr

Sheringham Shoal

Appr. 407MW

Dudgeon

30MW / 5 units

Hywind Pilot Park

Up to 9GW

Dogger Bank

Hywind Commercial Park

Increase Portfolio?

2009- **2012-** **2012-**

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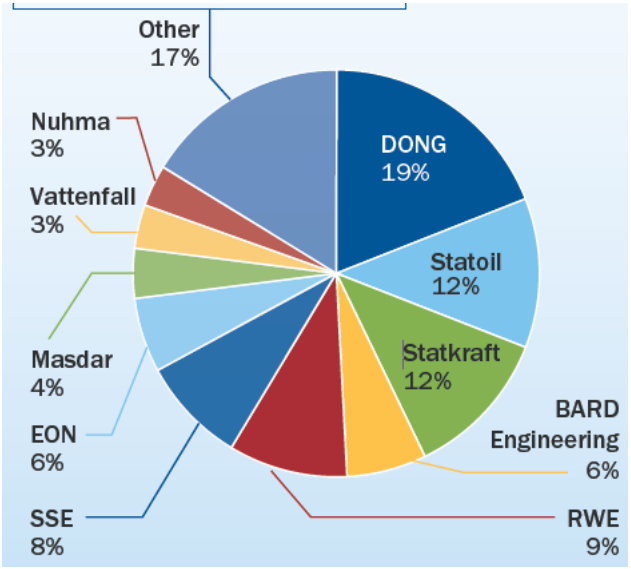
Sheringham Shoal

- 315 MW of capacity
- Located off the coast of Norfolk, England
- Covers an area of approximately 35 km2
- 88 wind turbines, each with a capacity of 3.6 MW.
- Turbine blade length 52 meters (170 feet)
- Turbine tower height 80 meters (262 feet)
- Two offshore substations
- On grid 2012



Share of 2012 installations

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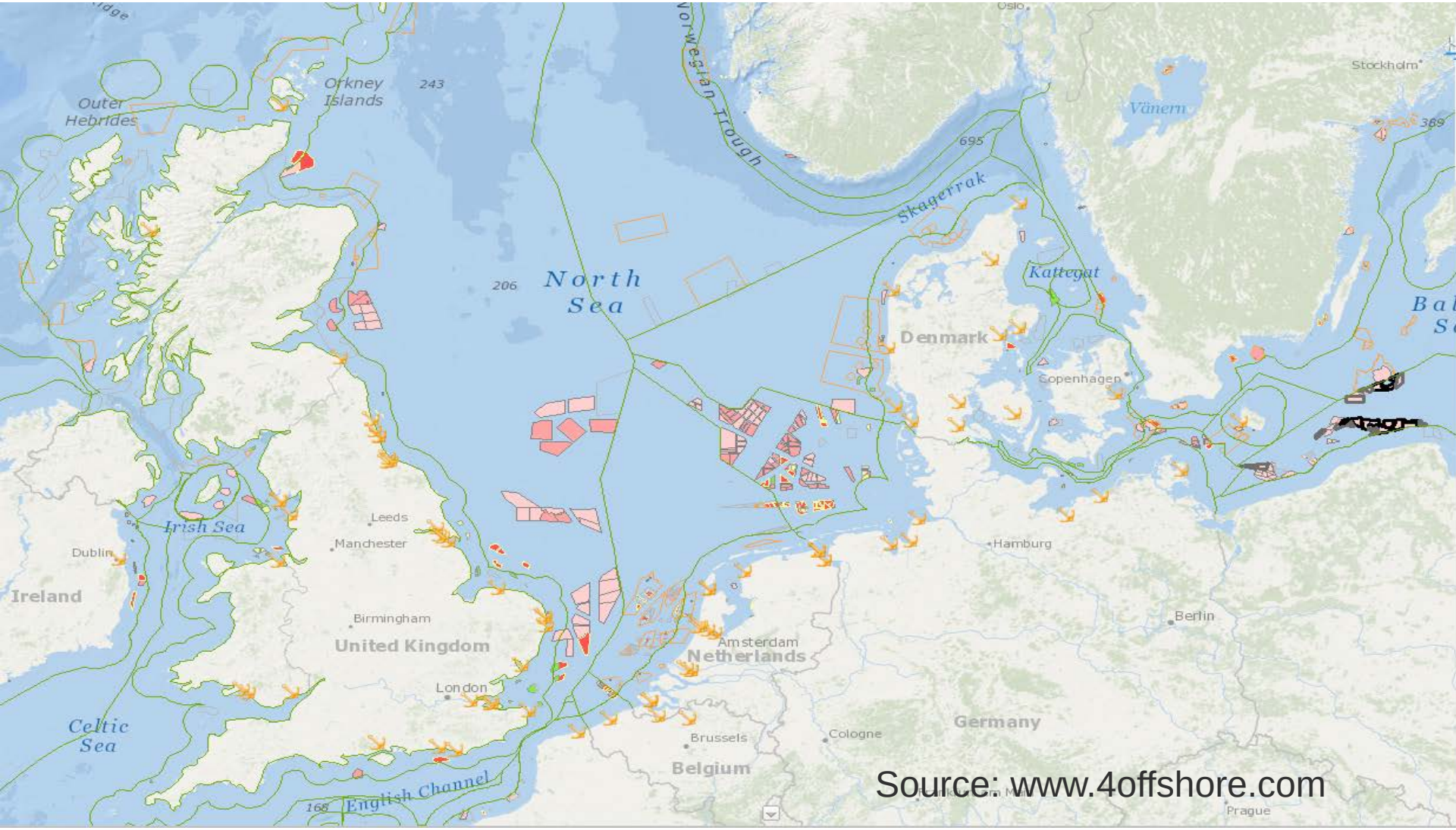
Location of offshore wind farms.

Present and future



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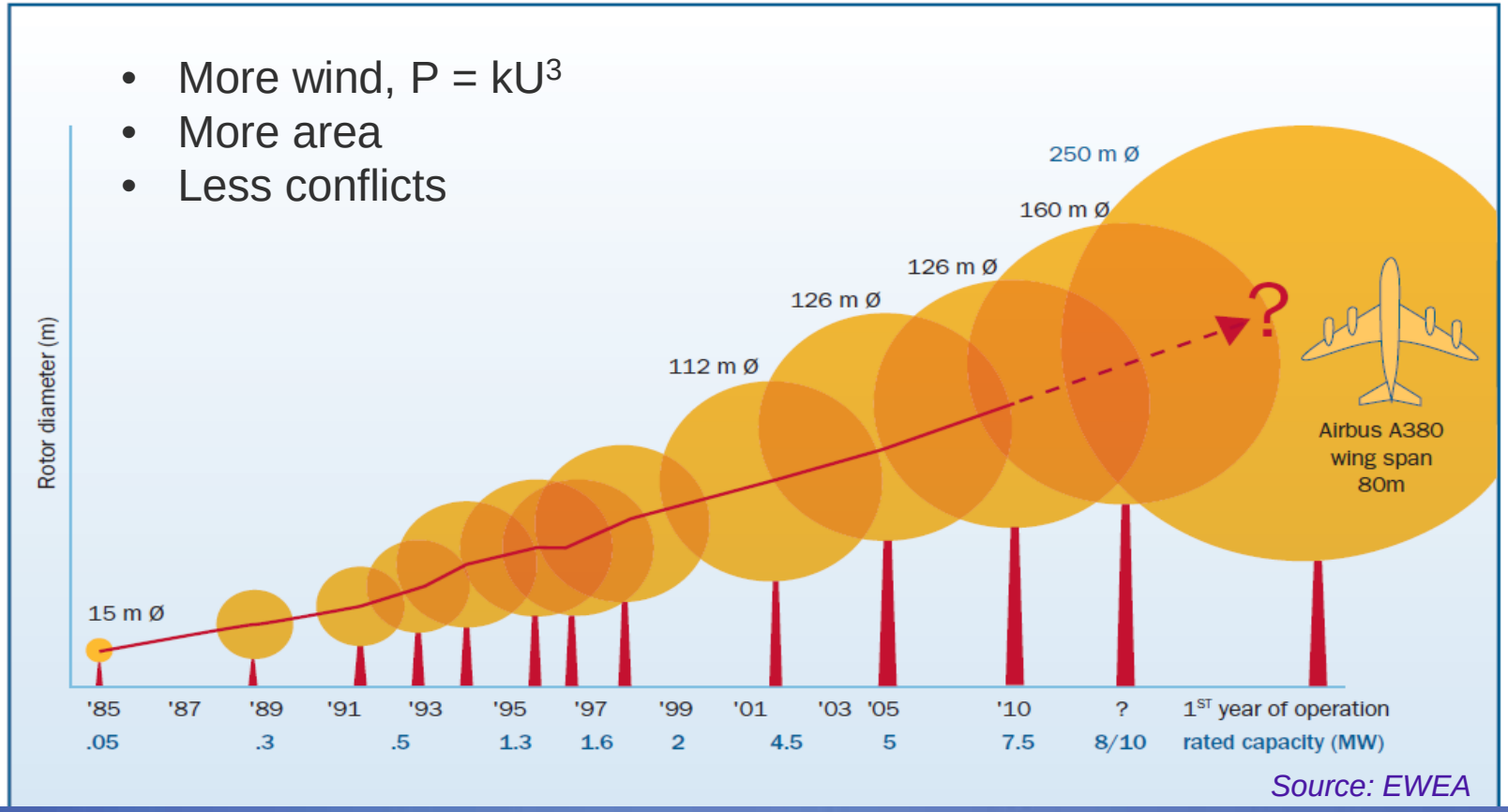
Why offshore?

- More wind, $P = kU^3$
- More area
- Less conflicts



Source: EWEA

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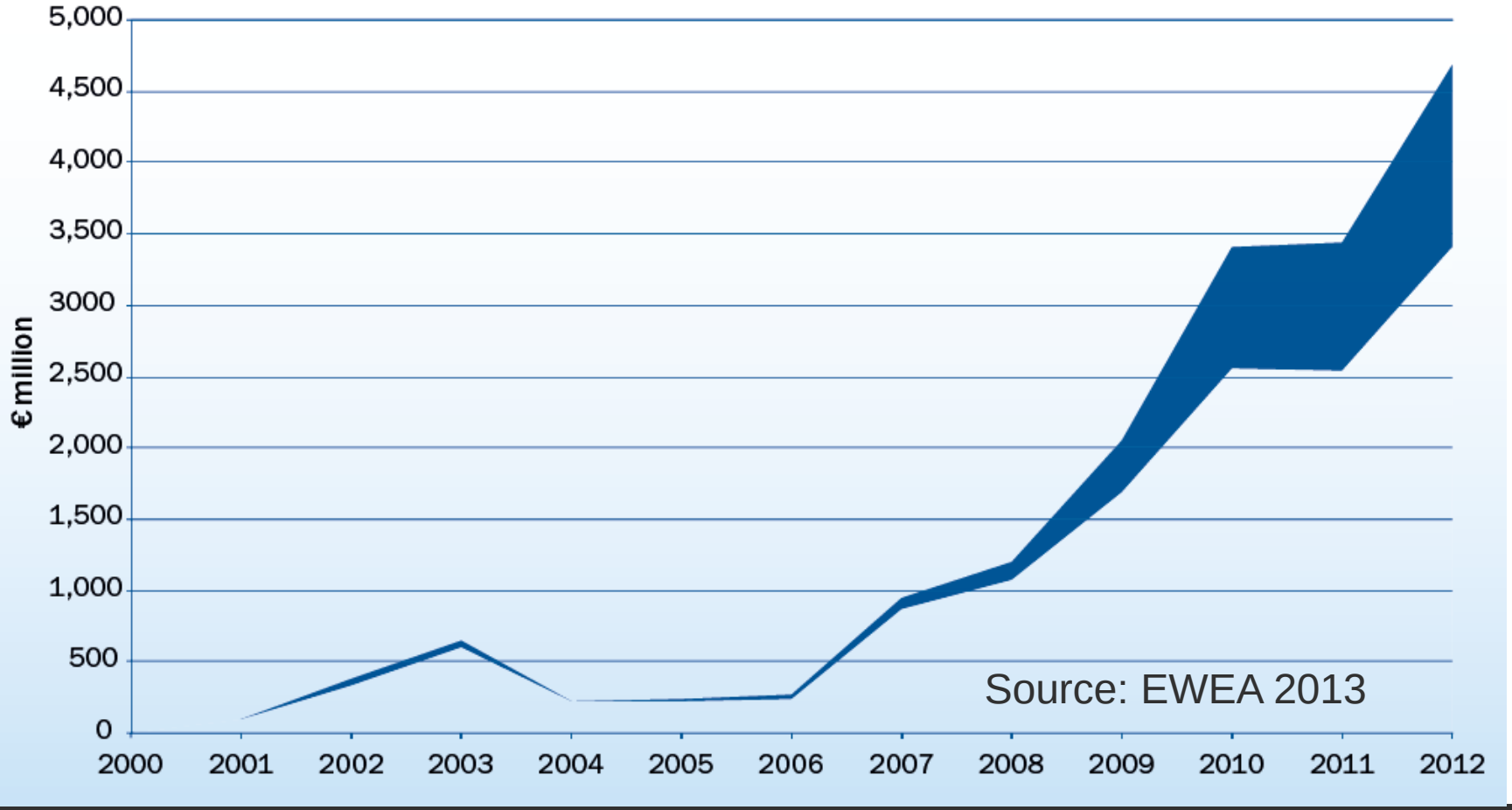
Annual investments in offshore wind farms (Europe)



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Two National centres for offshore wind

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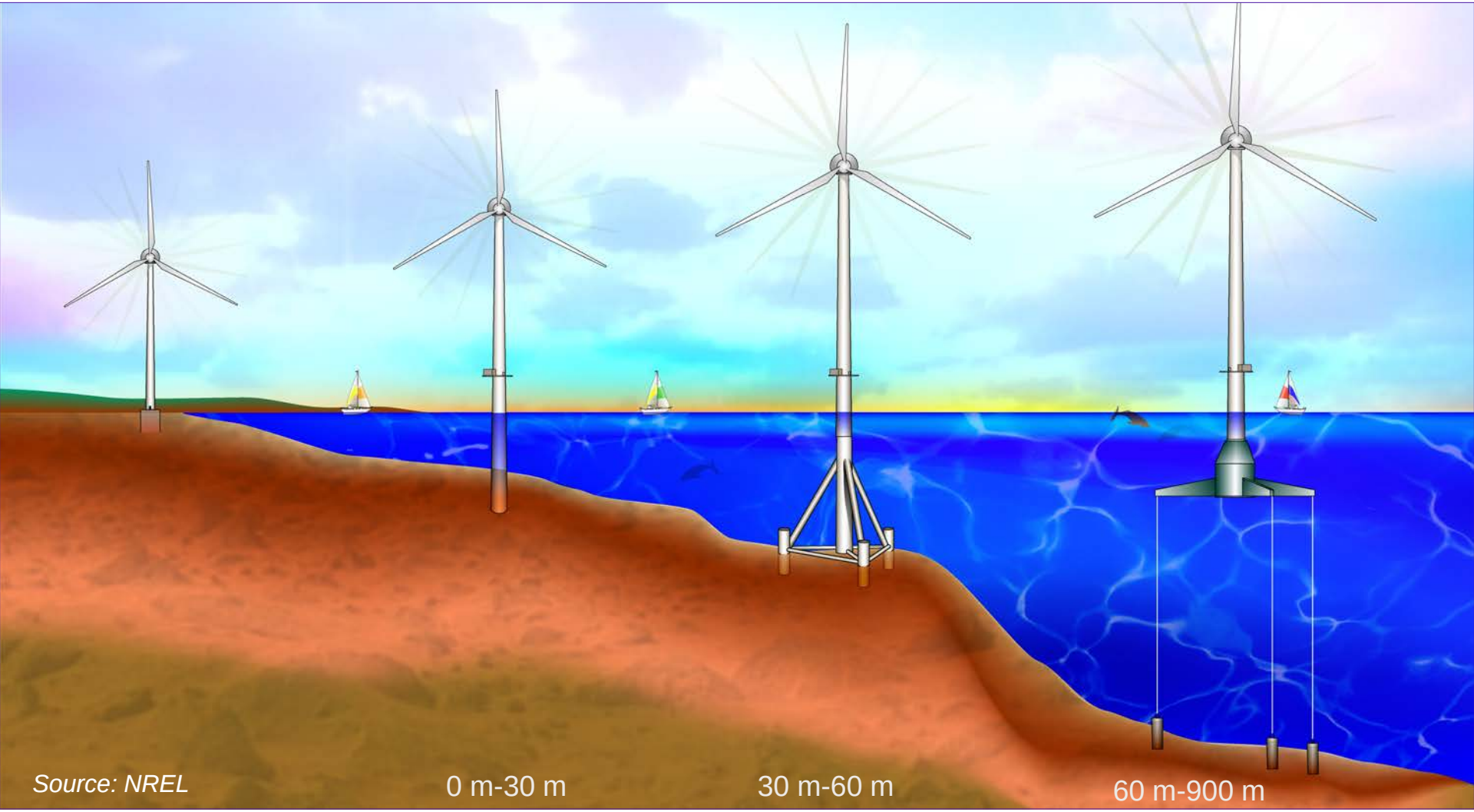
Wind power. On the move from land to deep water



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The marine industry entered the scene.
New concepts to handle the marine environment

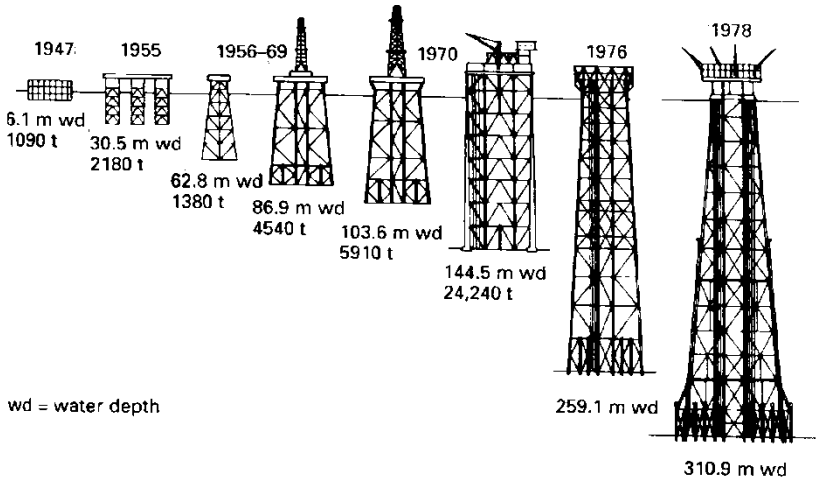
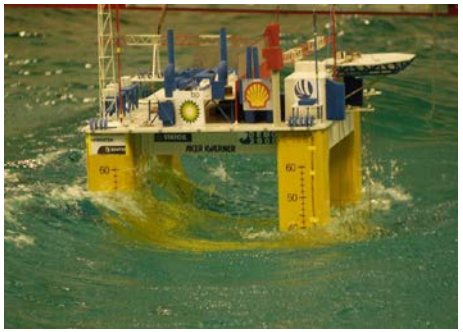
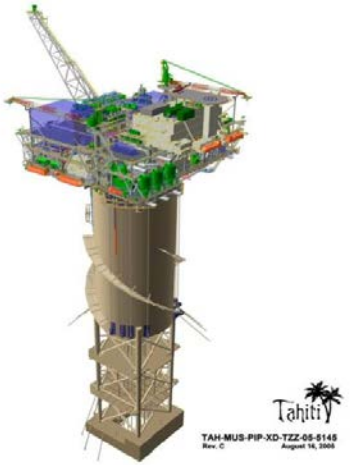


Figure 2.5 Evolution of deep water production capability (from Lee 1980)





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Floating wind turbine concepts

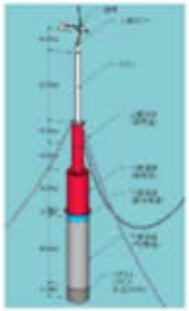
SPAR-BUOY


HyWind


Njord


HiPRWIND


Sway


Sasebo


Nautica AFT

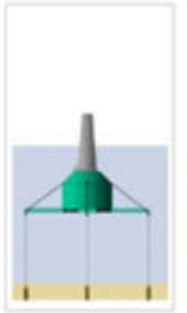

Deepwind

TLP


DIWET


MES


PelaStar


NREL

SEMI-SUBMERSIBLE


Windfloat


WinFlo


WindSea


Vertiwind

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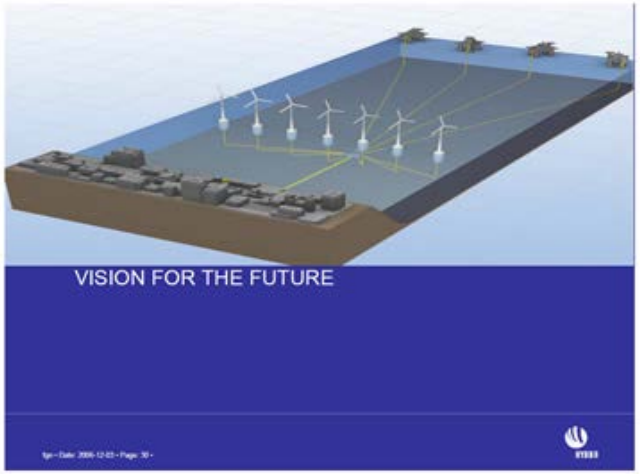
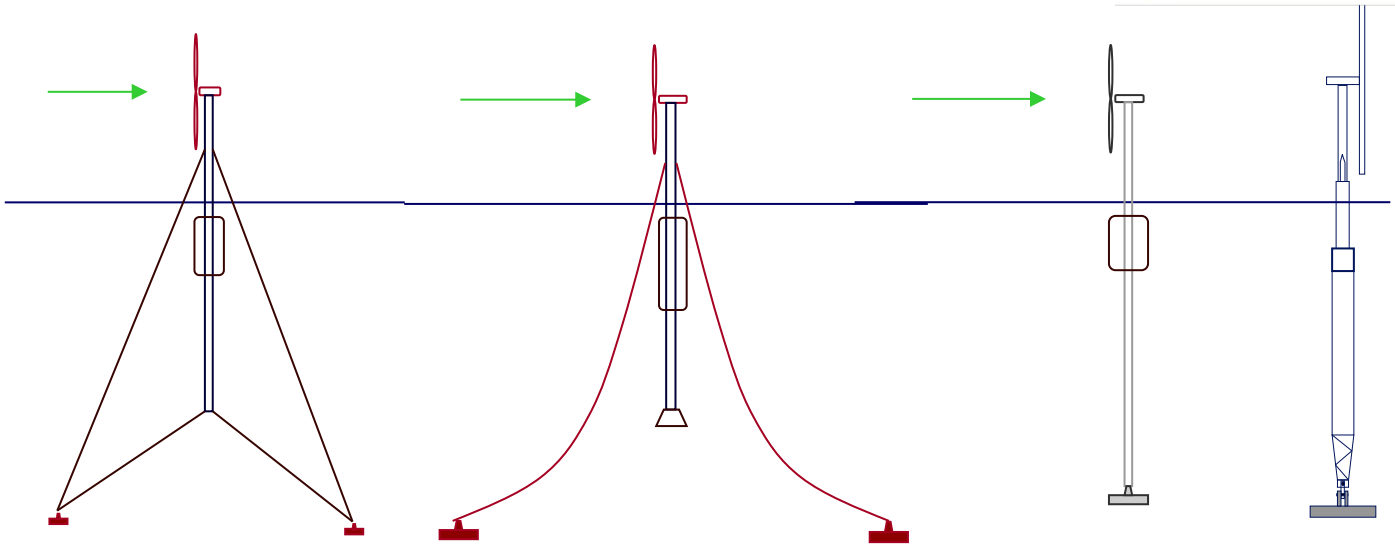
Hywind - The starting point -2001

- Inspired by floating sailing marks.
  - “Seawind” matured during 2002
- Challenge: Could we supply oil and gas platforms by wind power?





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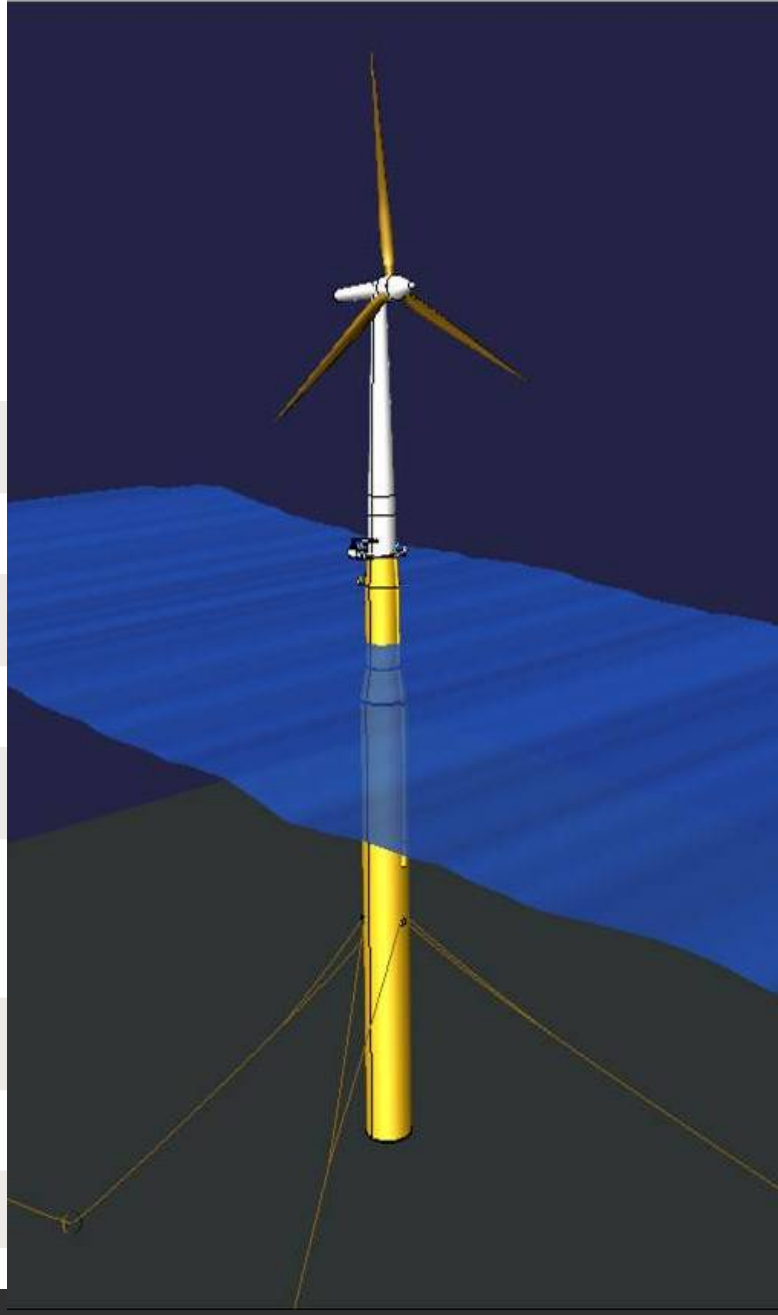
The Hywind concept

Key features

- Combines known technologies
- Designed for harsh environment
- ”Standard” offshore turbine
- Water depth >100 m
- Assembled in sheltered waters, towed to field

Relies upon experience from :

- Floating platforms
- Electrical power production
- Onshore wind turbines



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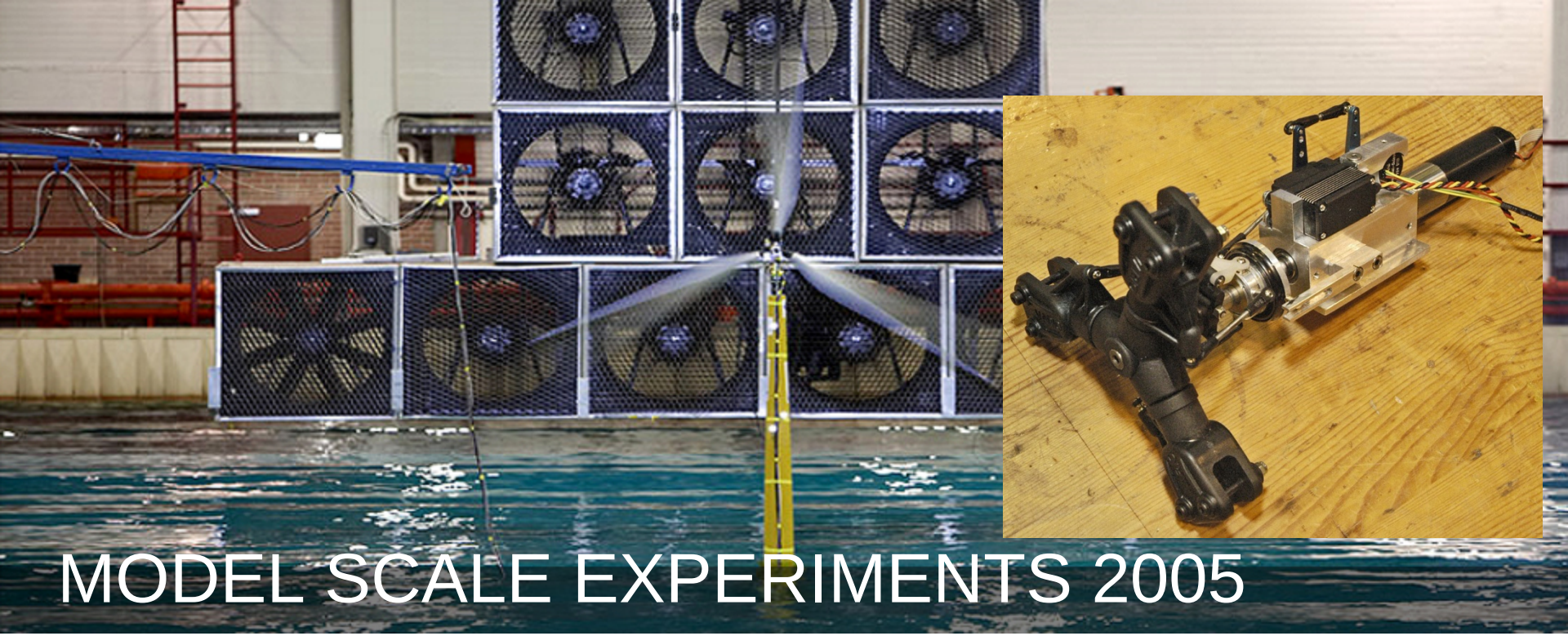

MODEL SCALE EXPERIMENTS 2005

- Demonstration of system behaviour
- Validation of numerical tools
- Model scale 1:47
- Irregular waves, turbulent wind, and various control strategies

Assembly and installation of Hywind Demo Summer 2009






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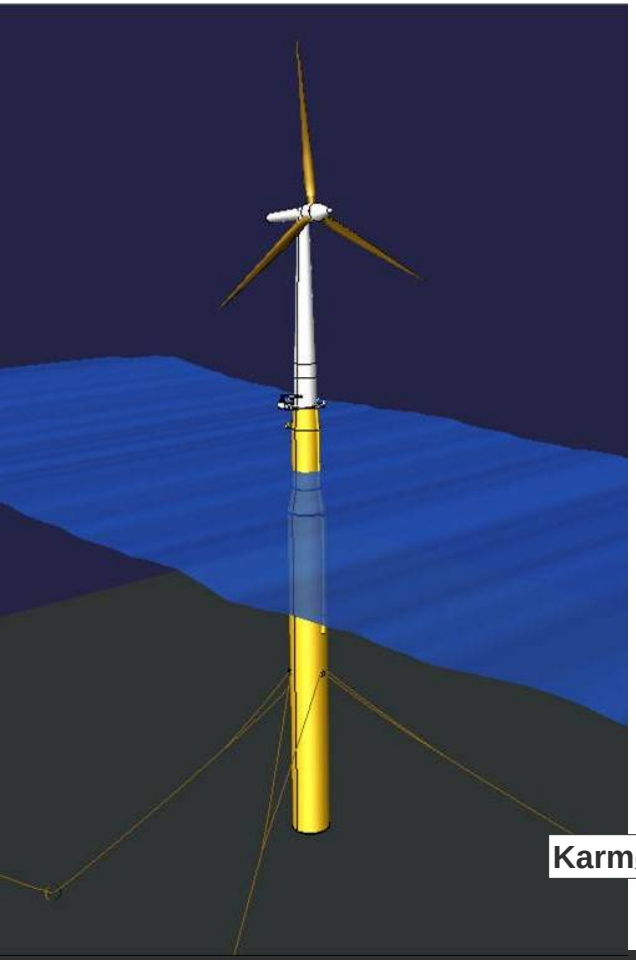
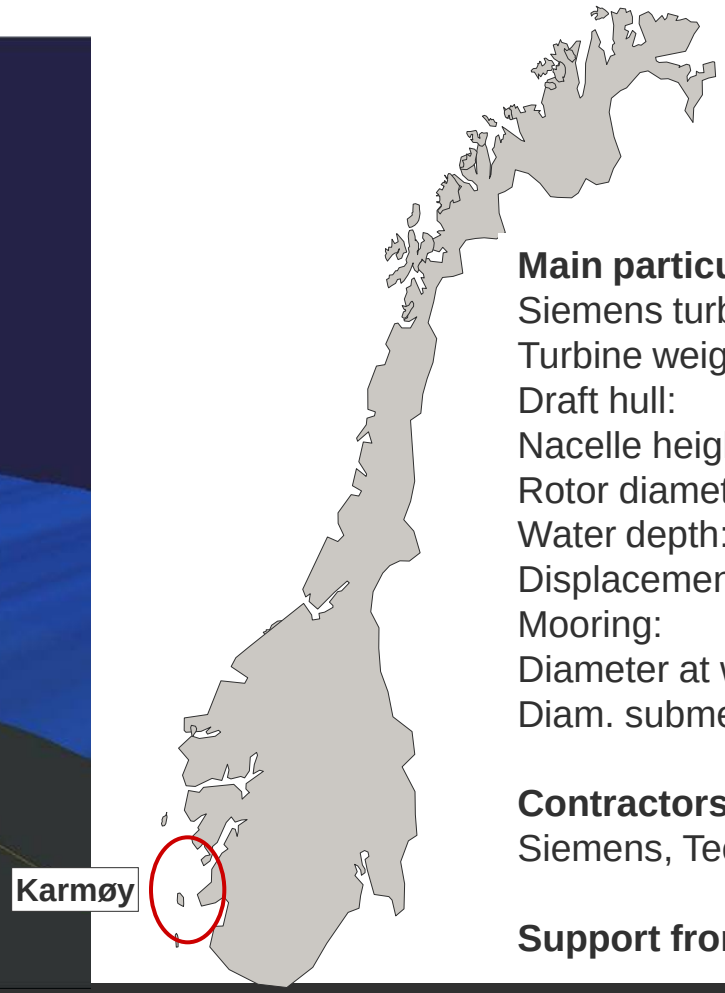
Hywind demonstration unit. Installed June 2009
Located10 km West of Karmøy





Main particulars

Siemens turbine:	2.3 MW
Turbine weight:	138 tons
Draft hull:	100 m
Nacelle height:	65 m
Rotor diameter:	82.4 m
Water depth:	150–700 m
Displacement:	5300 t
Mooring:	3 lines
Diameter at water line:	6 m
Diam. submerged body:	8.3 m

Contractors:
Siemens, Technip, Nexans, Haugaland kraft.

Support from Enova.

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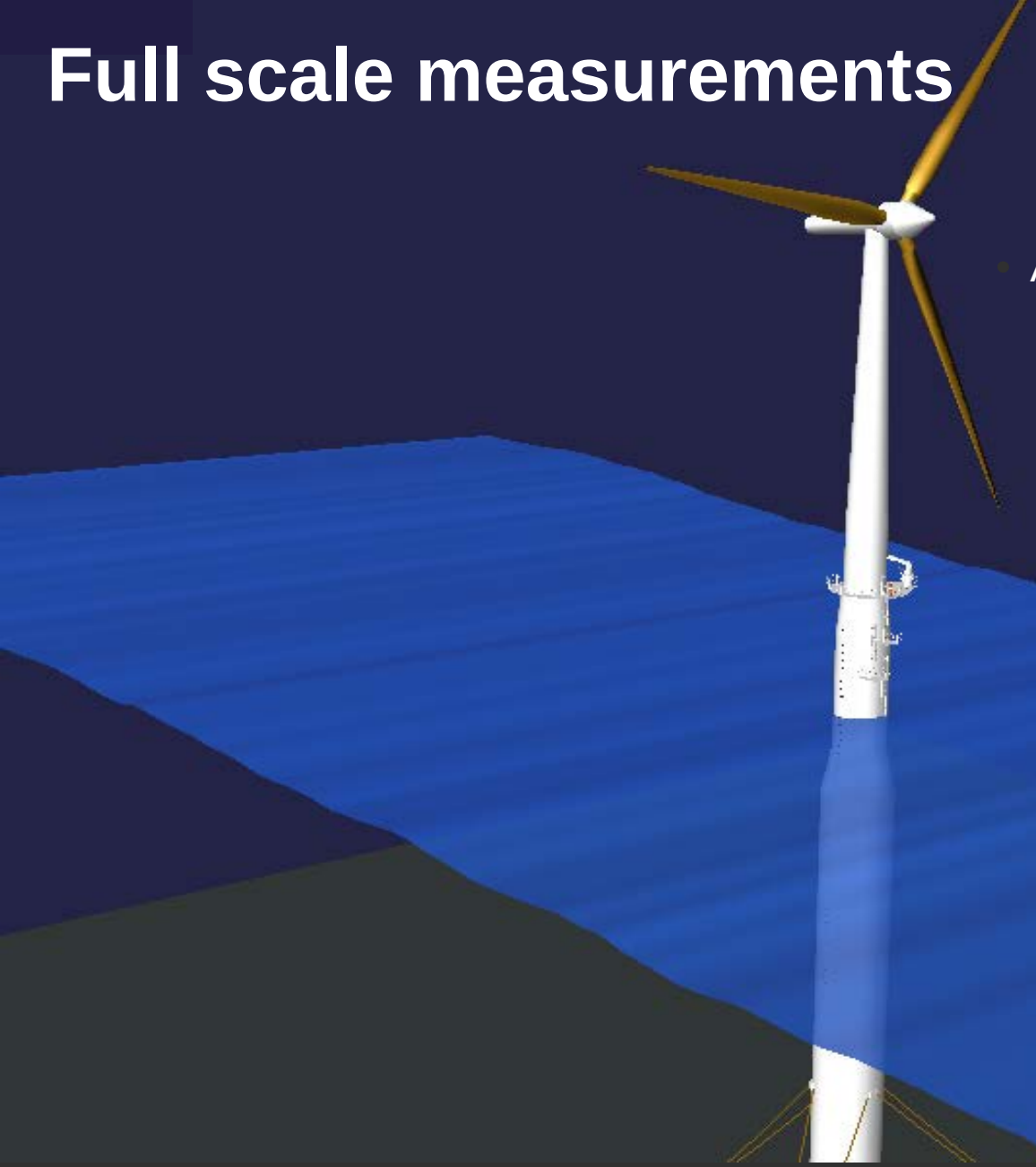
Full scale measurements



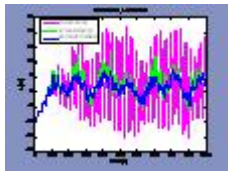
- A total of more than 200 sensors:
  - Waves wind and current (magnitude and direction)
  - Motion (6 DOF) and position of floater
  - Mooring line tension
  - Strain gauges at tower and hull (4 levels – bending moments and axial force)
  - Rotor speed, blade pitch and generator power
  - Flap- and edgeways rotor bending moments
  - Motion (tower pitch) / blade pitch controllers

From idea to commercial concept

2002

Idea

2003



Concept & theory

2005

Model test

2009

Demo

2014

Pilot park

Onshore connected parks

Technical Focus

Cost Focus

Market Focus

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Operation in harsh environment

- Start of operation Sept 2009.
- Production > 30GWh.
- Max wind velocity: >40 m/sec.
- Max sign wave height: 10.5 m, Max wave 19m.

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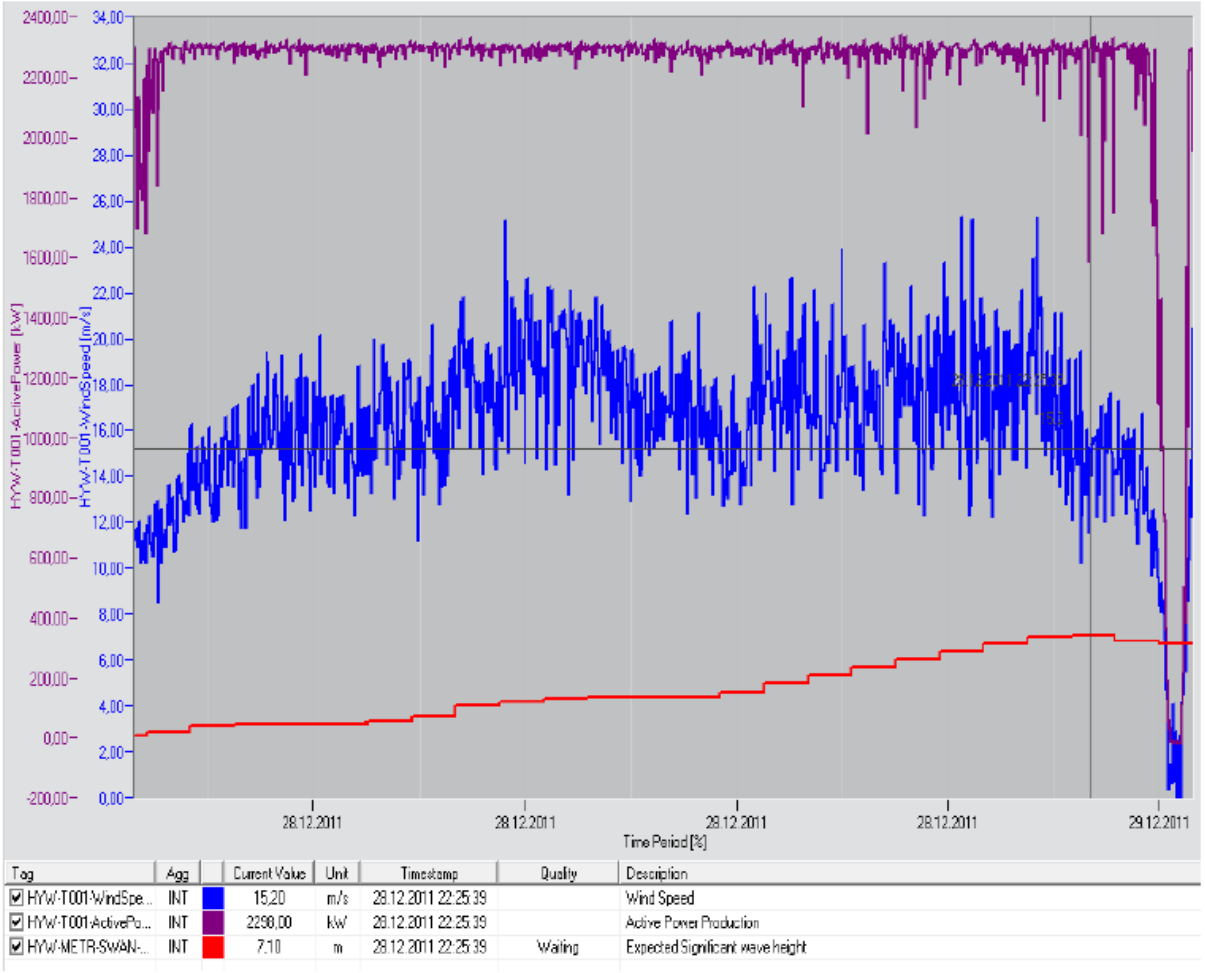
Production during a storm condition



Tag	Agg	Current Value	Unit	Timestamp	Quality	Description
HYW-T001-WindSpe...	INT	15,20	m/s	28.12.2011 22:25:39		Wind Speed
HYW-T001-ActivePo...	INT	2298,00	kW	28.12.2011 22:25:39		Active Power Production
HYW-METR-SWAN-...	INT	7,10	m	28.12.2011 22:25:39	Waiting	Expected Significant wave height

- 24 hour period during storm “Dagmar”, Dec 2011
- Avg. wind speed 16 m/sec
- Max wind speed 24 m/sec
- Max significant wave height 7.1m
- Power production 96.7% of rated

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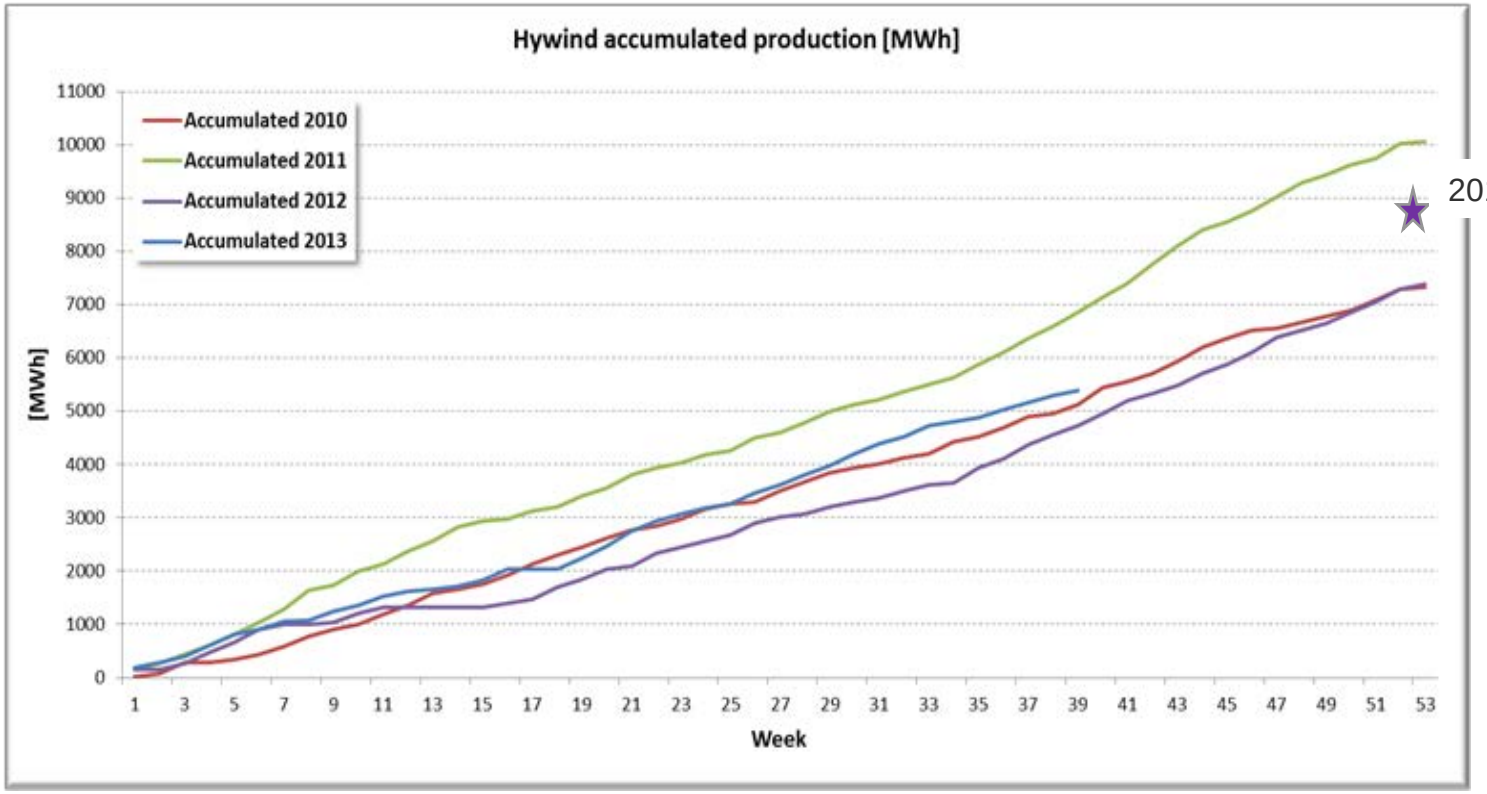
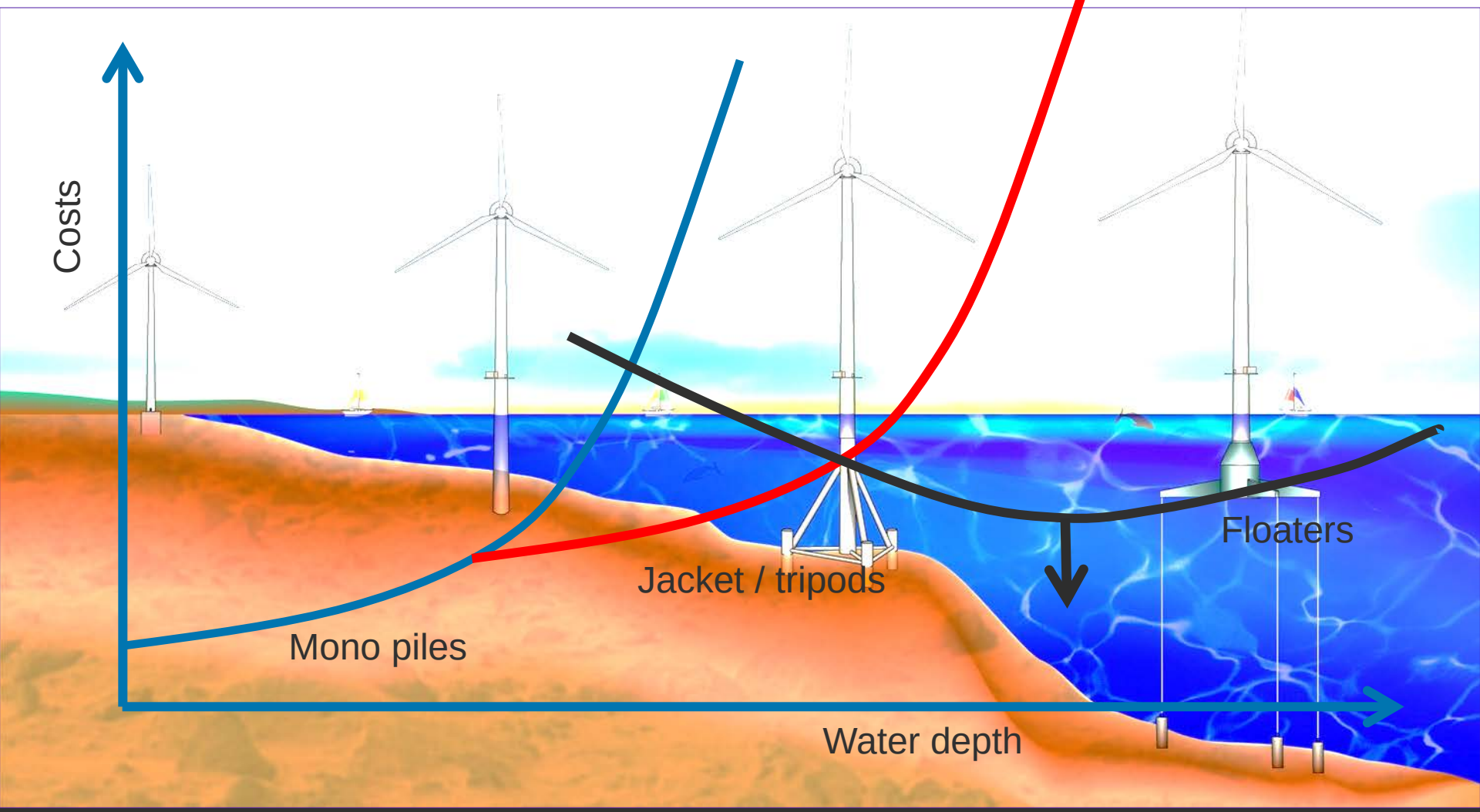
Hywind performance 2010 – 2013



2010: Testing
2011: Excellent wind
2012: Unschedule shut down (External grid fault / WoW)
2013: Less than average wind
Expected yearly capacity factor: 0.40 – 0.52

Foundation costs - current image



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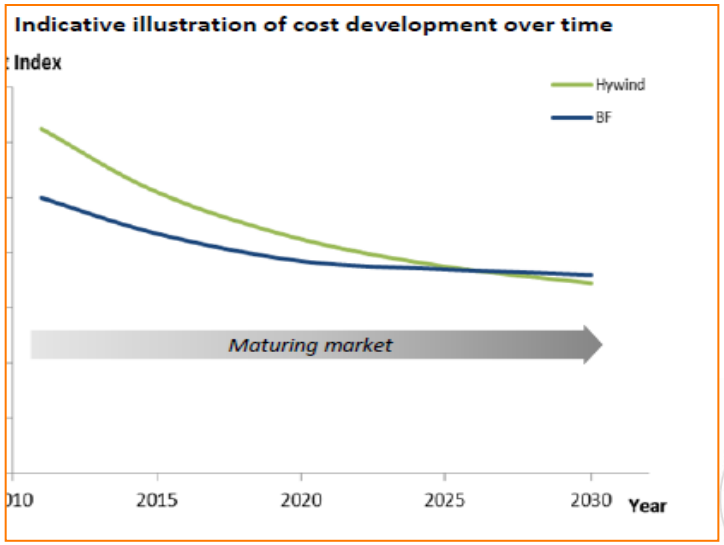
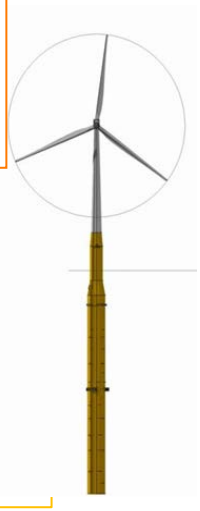
FOW will compete with bottom-fixed offshore wind in a mature market



Optimised design:
Support structure and mooring
Larger turbines
Control system
Higher energy yield

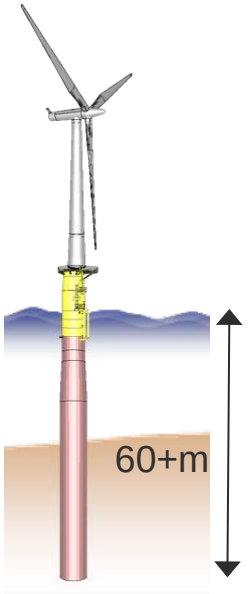
Reduced production costs:
Large volume
Improved supply chain
Simplified assembly and installation



Hywind
Demo

Hywind II
Benign
conditions

Hywind III
Harsh
conditions



Monopile

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The next steps

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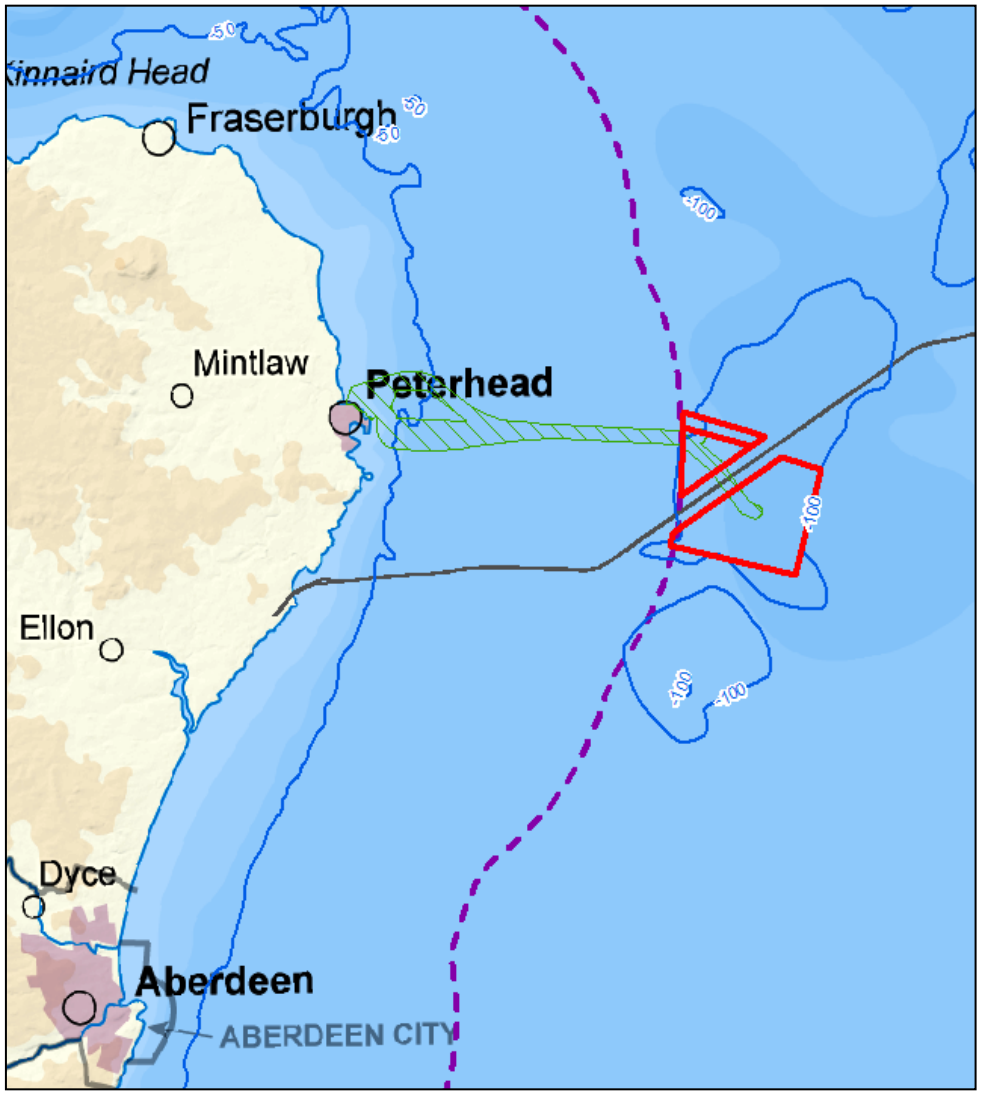
Hywind Scotland - Buchan Deep



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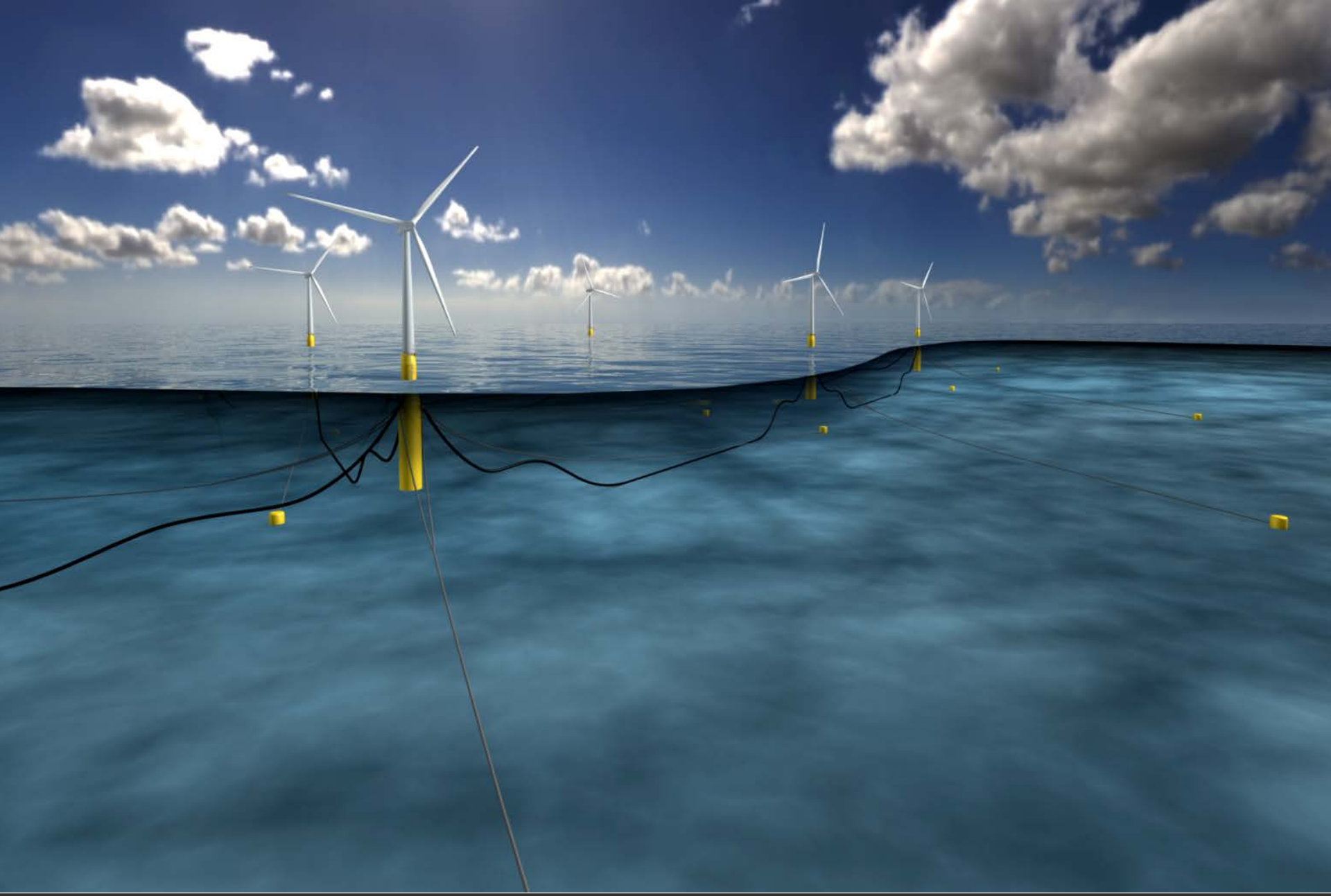

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There's never been a better time for good ideas

Is floating offshore wind turbines an option?
The history of Hywind and

Finn Gunnar Nielsen
Senior Advisor / professor
E-mail address fgn@statoil.com

www.statoil.com

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