

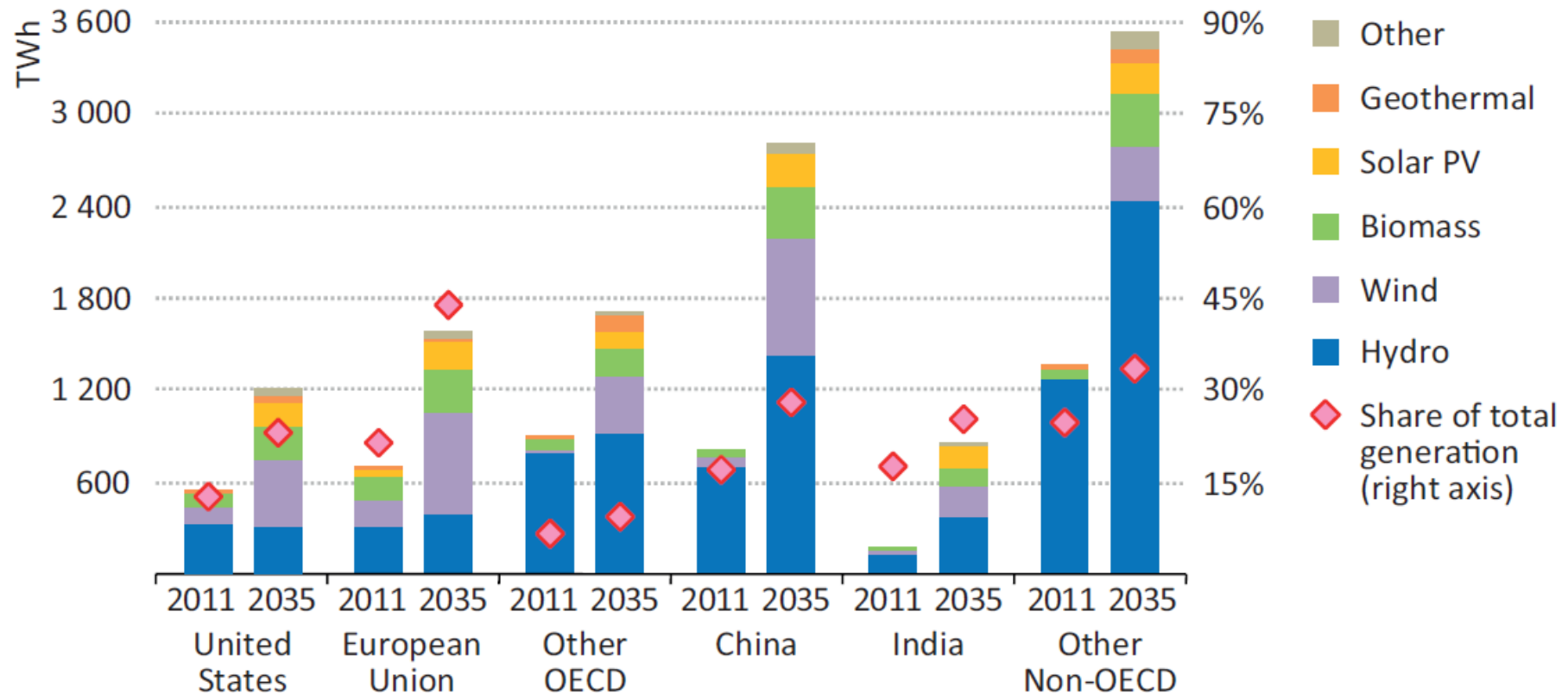
Is floating offshore wind turbines an option?

The history of Hywind and the way forward.

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

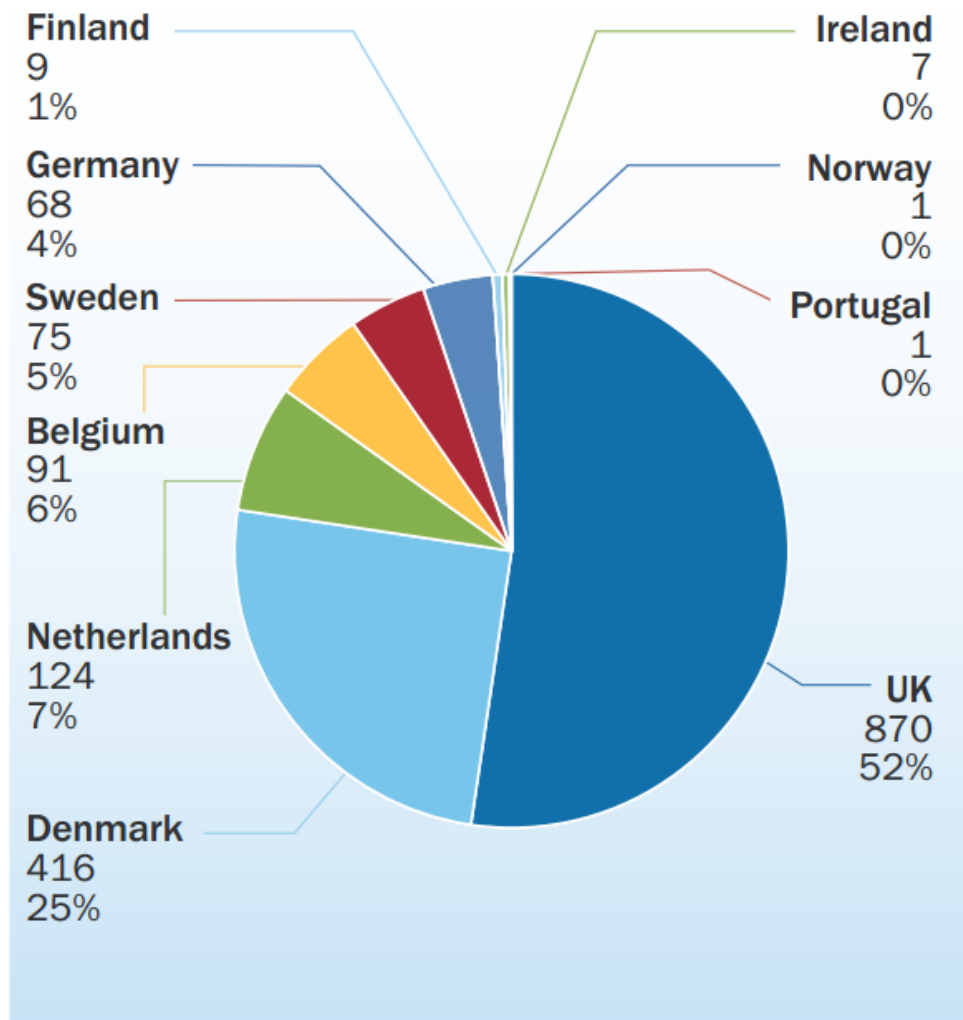
The role of renewables

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



Source: IEA Energy Outlook 2013

Installed offshore wind turbines – by country



Globally Land + offshore,
end 2013:

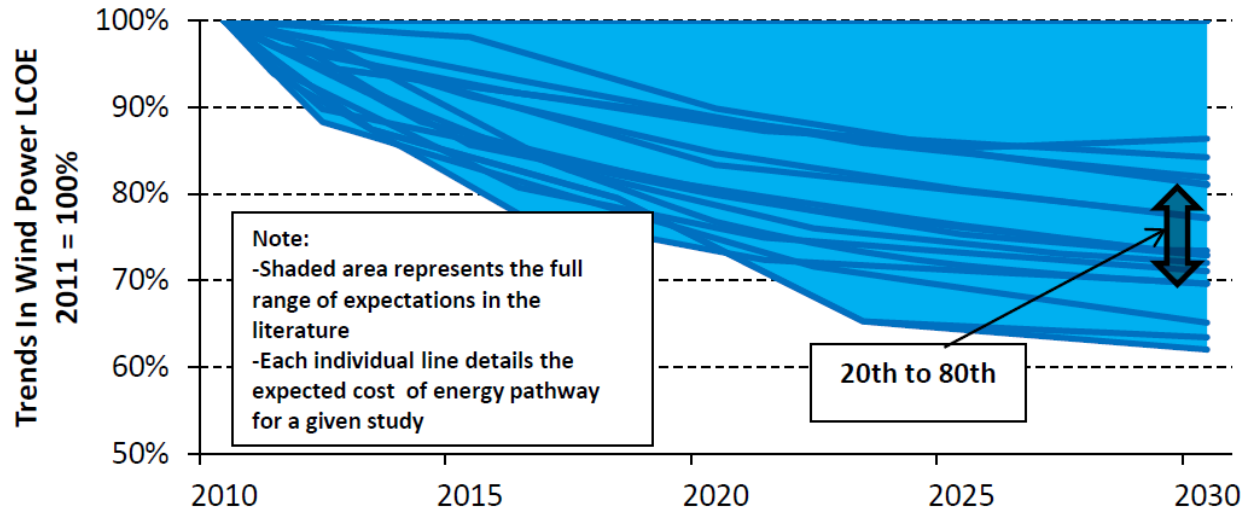
318 GW installed (+11%)

Offshore:

7.0 GW (+30%)

Source: EWEA 2013 /14

Trends in cost of wind energy



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

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

Where we are coming from:

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



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?*

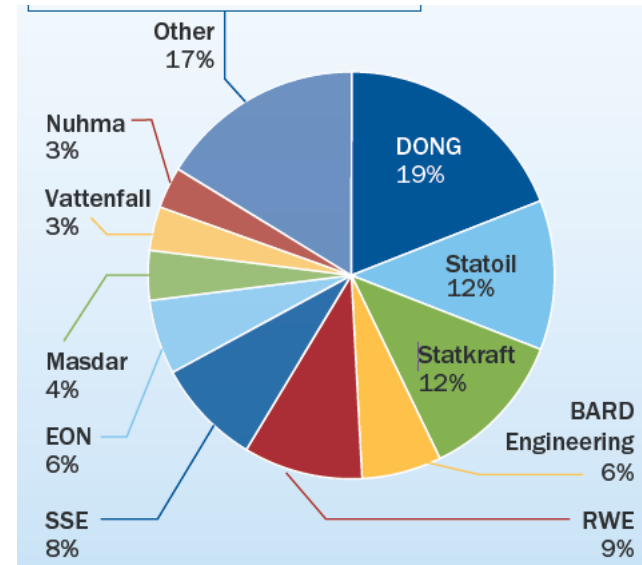
2009-

2012-

2012-

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

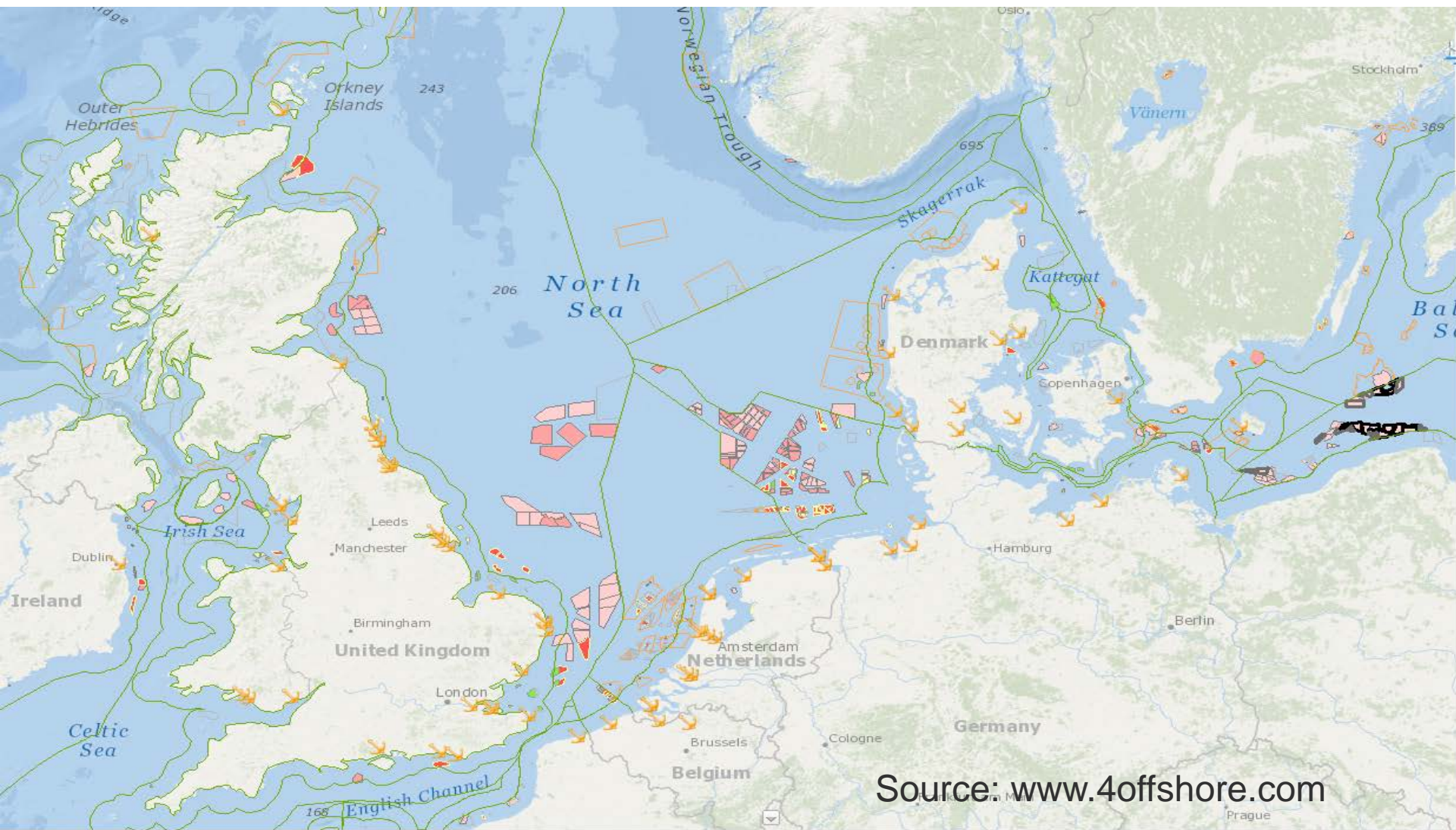


Share of 2012 installations



Location of offshore wind farms.

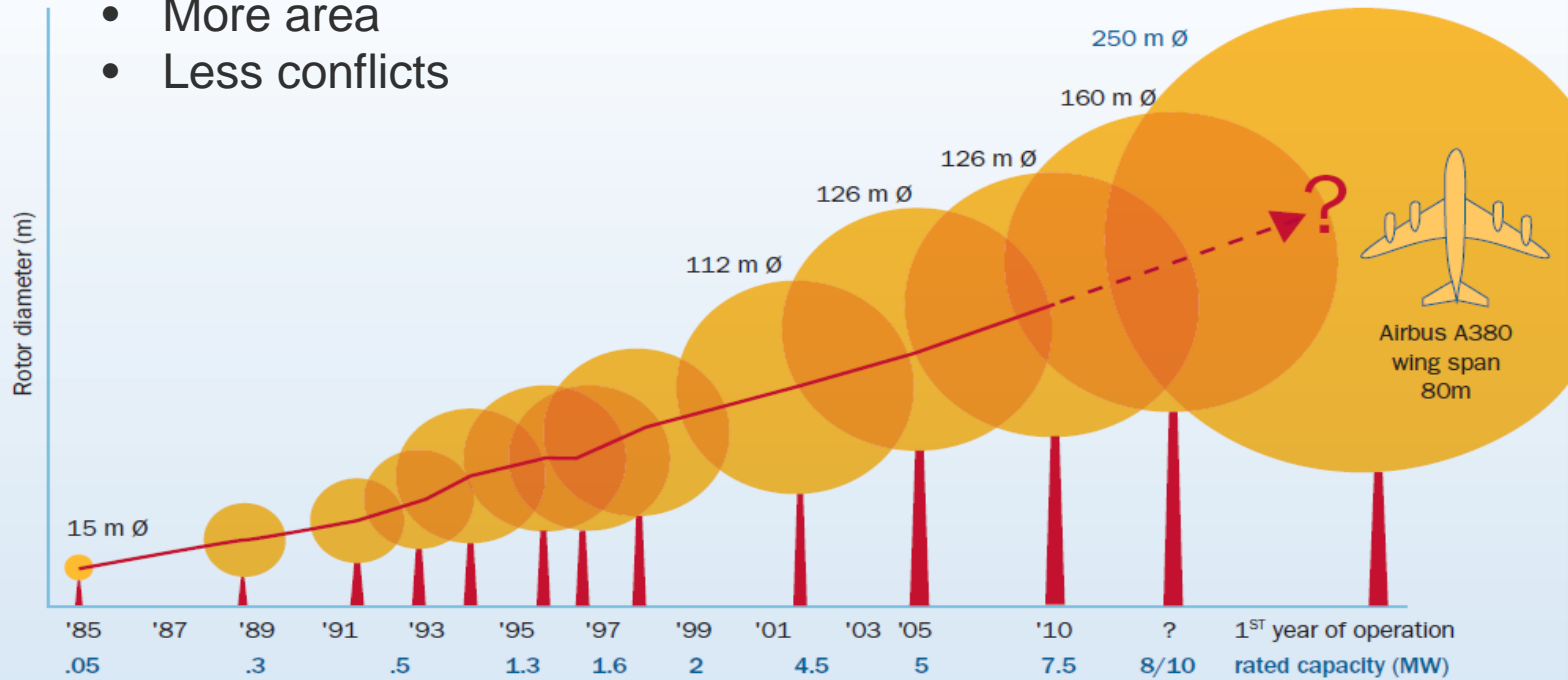
Present and future



Source: www.4offshore.com

Why offshore?

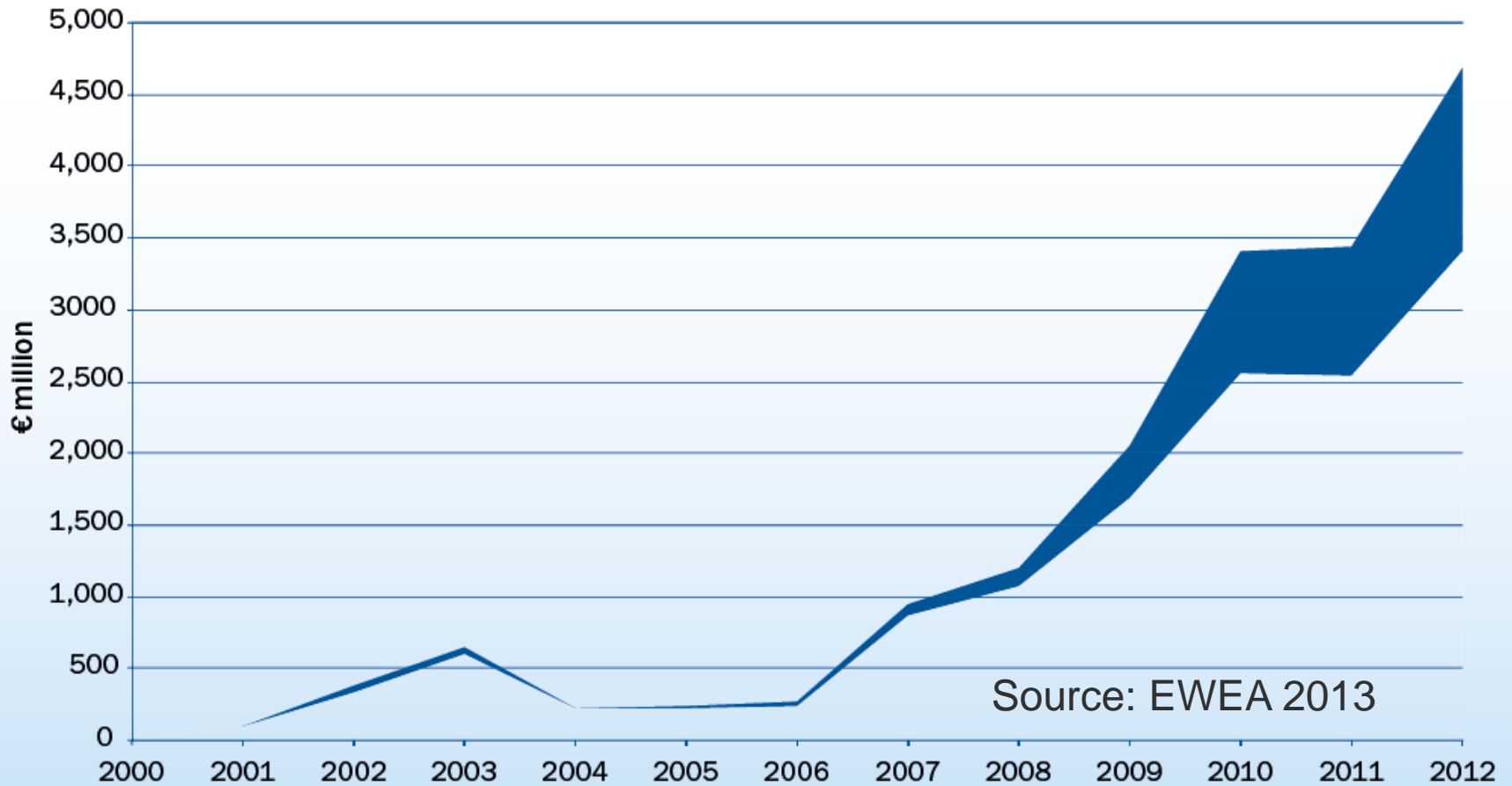
- More wind, $P = kU^3$
- More area
- Less conflicts



Source: EWEA



Annual investments in offshore wind farms (Europe)



Two National centres for offshore wind

Home | Contact | About the centre | Vacancies | News | Norwegian Motion Lab | CMR.MO | Login ProjectPlace



norcowe

Norwegian Centre for Offshore Wind Energy

>>> | FOCUS AREAS | VISION | PARTNERS | ANNUAL REPORTS/NEWSLETTERS | VIDEOS



NORCOWE-Day
Bergen hosted the internal meetings for the members of NORCOWE
[read more >>](#)



FAST workshop
NORCOWE and NREL hosted FAST workshop in Bergen
[read more >>](#)



Acting Centre Coordinator
Trygve Tøft-Eriksen has now been the acting Centre Coordinator in NORCOWE since August
[read more >>](#)



SMI Bergen
Presentations and posters from Science Meets Industry Bergen are now available.
[read more >>](#)



Operation and maintenance decision analysis for Dudgeon wind park
A decision methodology based on simulation modelling and analysis was selected to analyse different vessel solutions for O&M.
The model was first configured to fit the O&M and marine logistics system of Dudgeon Wind Park, a task performed in collaboration with Statoil Wind O&M department.
[read more >>](#)

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NOWITECH

Norwegian Research Centre for Offshore Wind Technology

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NOWITECH Annual Report 2013
[NOWITECH Annual Report 2013 - print version](#)

EERA DeepWind'2015 - First announcement and call for papers

REGISTRATION

The objective of NOWITECH is pre-competitive research laying a foundation for industrial value creation and cost-effective offshore wind farms. Emphasis is on "deep-sea" (>30 m) including bottom-fixed and floating wind turbines.

Work is focused on technical challenges including a strong PhD and post doc programme:

- Integrated numerical design tools for novel offshore wind energy concepts.
- Energy conversion systems using new materials for blades and generators.
- Novel substructures (bottom-fixed and floaters) for offshore wind turbines.
- Grid connection and system integration of large offshore wind farms.
- Operation and maintenance strategies and technologies.
- Assessment of novel concepts by numerical tools and physical experiments.

Total budget (2009-2017) is + NOK 320 millions / M€ 41 / MUSD 55 cofunded by the Research Council of Norway and NOWITECH partners.

The application to the Research Council of Norway as approved February 2009 gives the basis for the activities of NOWITECH.

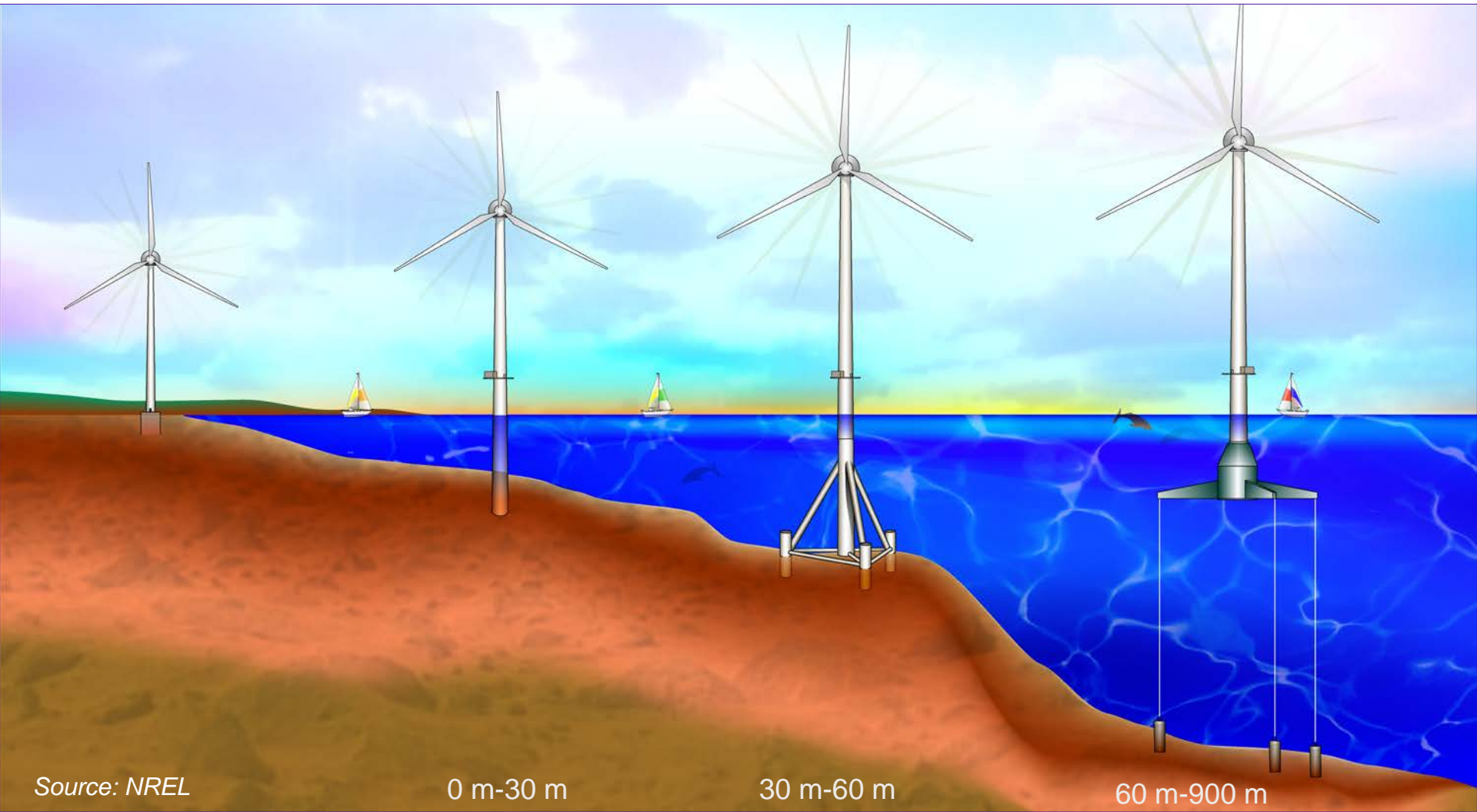
Winds of change: NOWITECH in International Innovation
International Innovation is the leading global dissemination resource for the wider scientific, technology and research communities; www.researchmedia.eu

NOWITECH Leaflet
[NOWITECH internal pages \(requires a password\)](#)
[NOWITECH Scientific Committee internal pages \(requires a password\)](#)

NEWS

- Oljekrise kan gi flere grønne jobber (18. september)
- The peer-reviewed papers from the EERA DeepWind'2014 Conference are now published online in Energy Procedia
- PhD disputas torsdag 14. august - Kevin Bain Cox
- NOWITECH Newsletter July 2014
- EERA DeepWind'2015 - First announcement and call for papers
- Well accomplished NOWITECH Day 2014 (19 June)

Wind power. On the move from land to deep water



The marine industry entered the scene.

New concepts to handle the marine environment

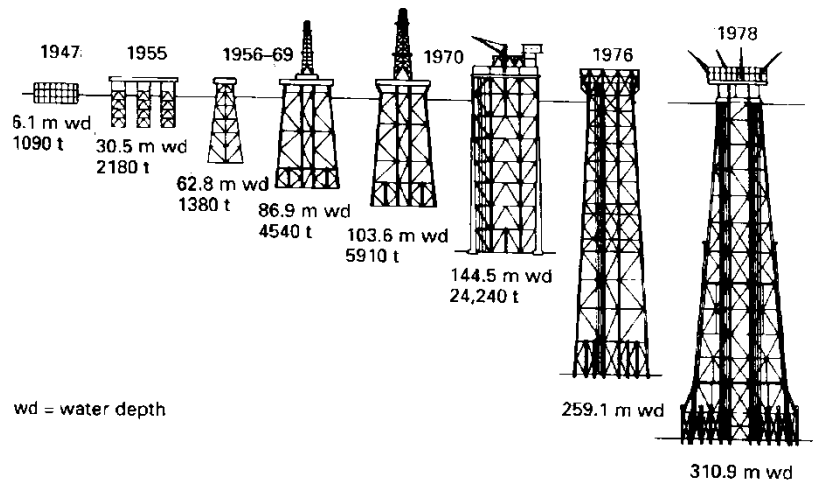
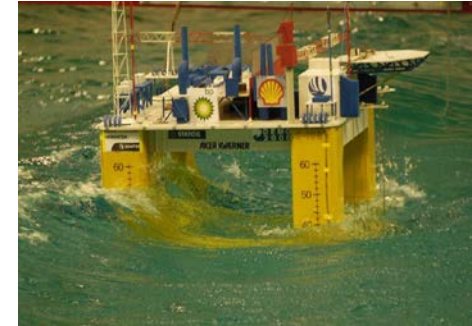


Figure 2.5 Evolution of deep water production capability (from Lee 1980)



Tahiti
TAH-MUS-PIP-XD-TZZ-05-0145
Rev. C
August 16, 2008

Floating wind turbine concepts

SPAR-BUOY



HyWind



Njord



HIPRWIND



Sway



Sasebo



Nautica AFT



Deepwind

TLP



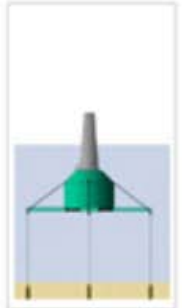
DIWET



MES



PelaStar



NREL

SEMI-SUBMERSIBLE



Windfloat



WinFlo



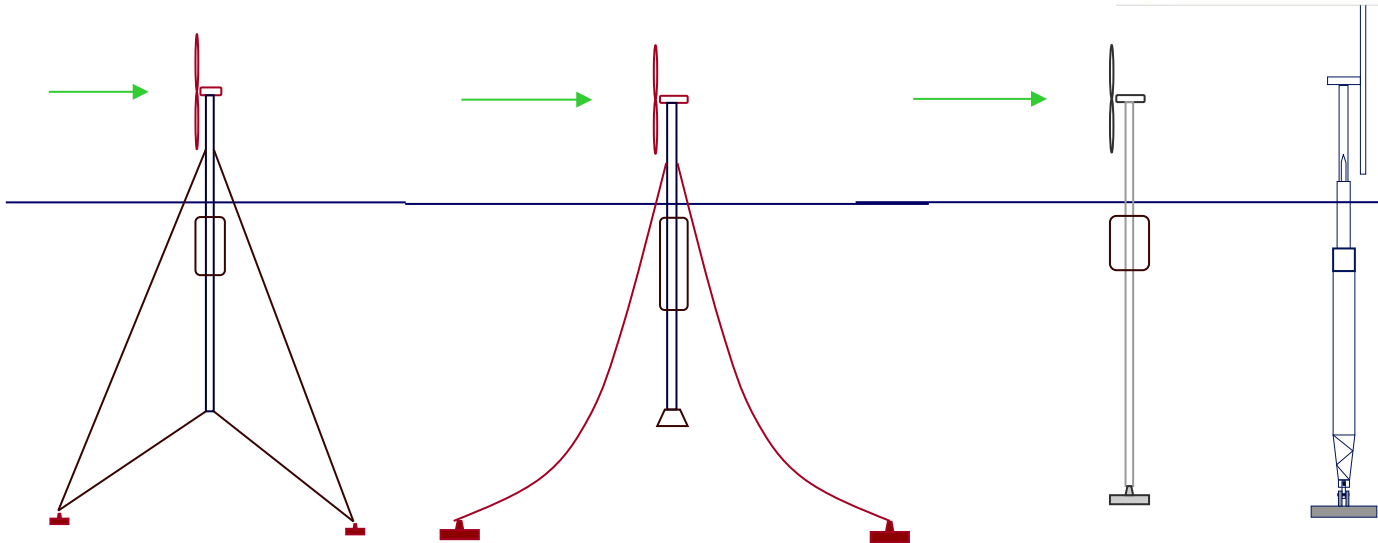
WindSea



Vertiwind

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?



The Hywind concept

Key features

Combines known technologies

Designed for harsh environment

"Standard" offshore turbine

Water depth >100 m

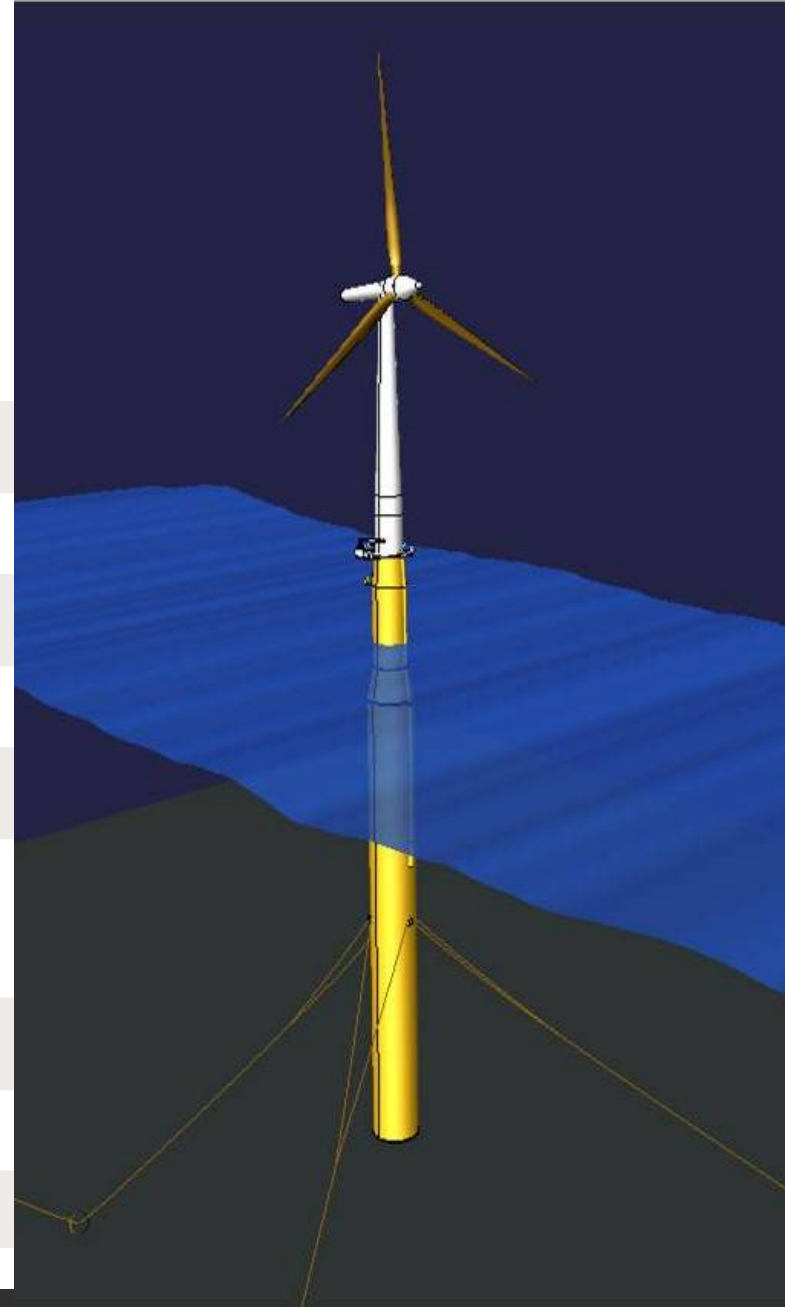
Assembled in sheltered waters, towed to field

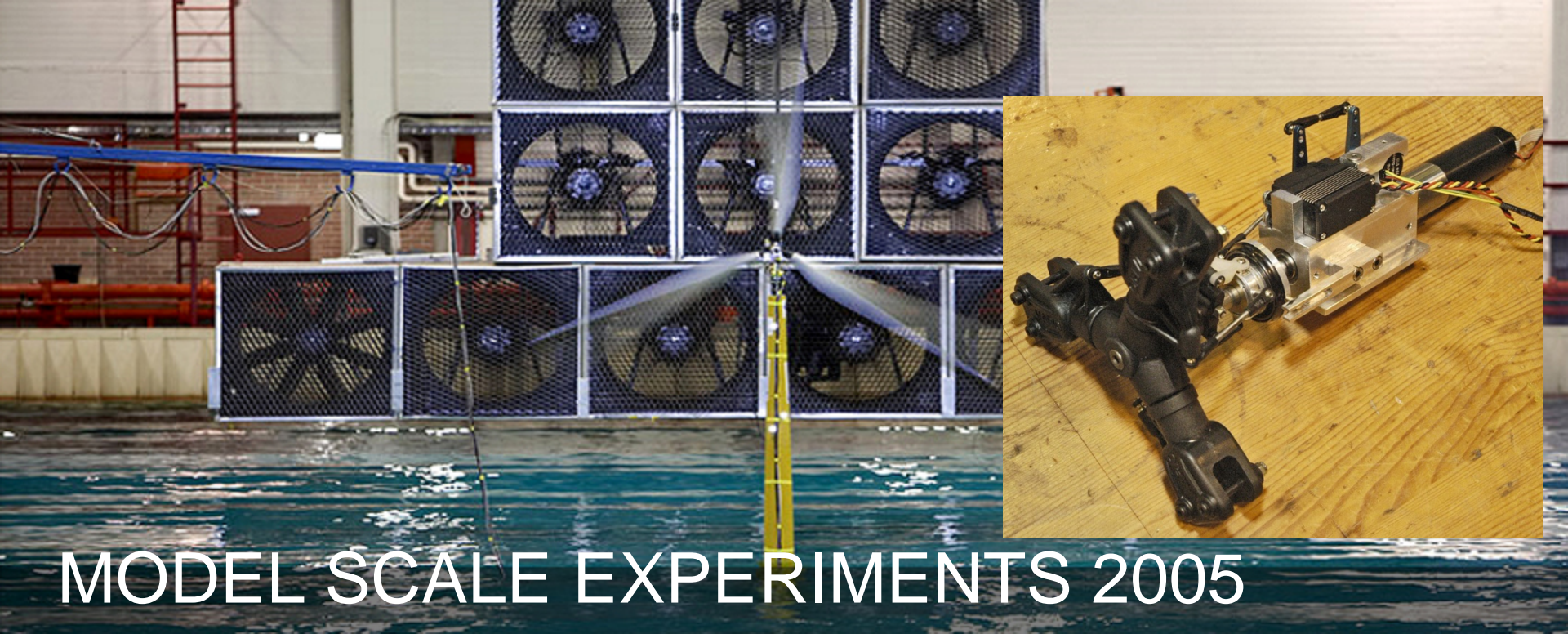
Relies upon experience from :

Floating platforms

Electrical power production

Onshore wind turbines

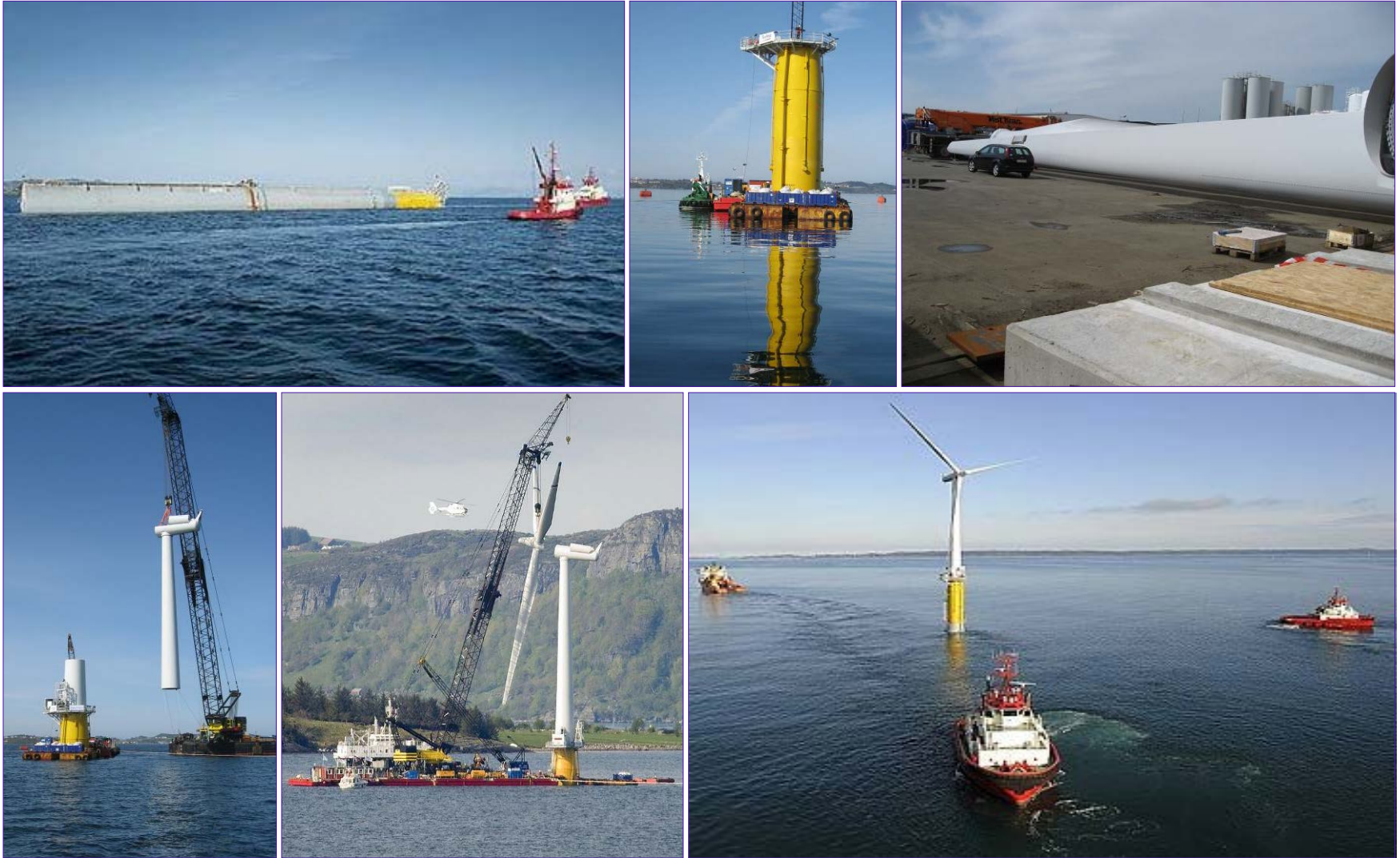




MODEL SCALE EXPERIMENTS 2005

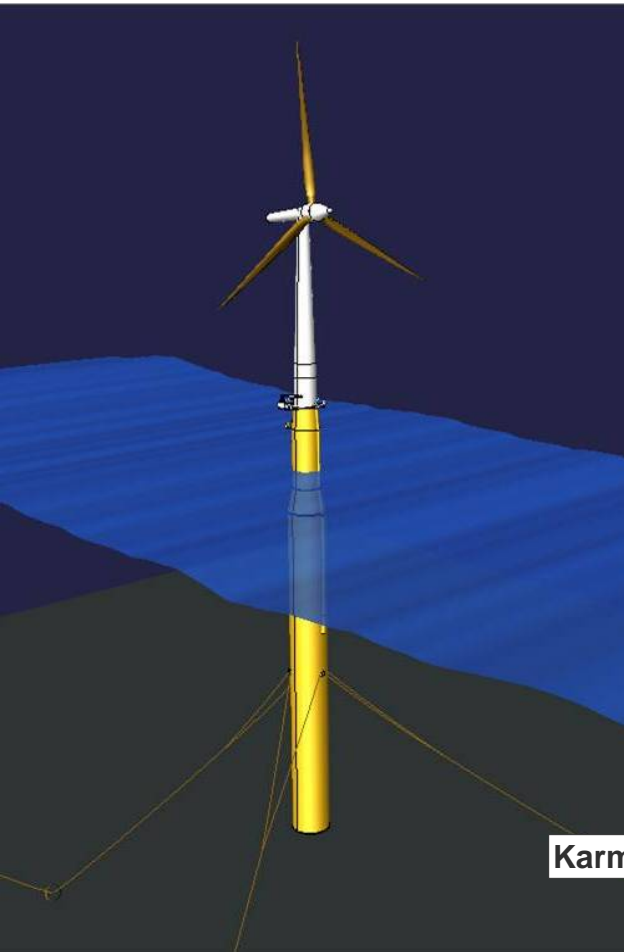
- Demonstration of system behaviour
- Validation of numerical tools
- Model scale 1:47
- Irregular waves, turbulent wind, and various control strategies

Assembly and installation of Hywind Demo Summer 2009

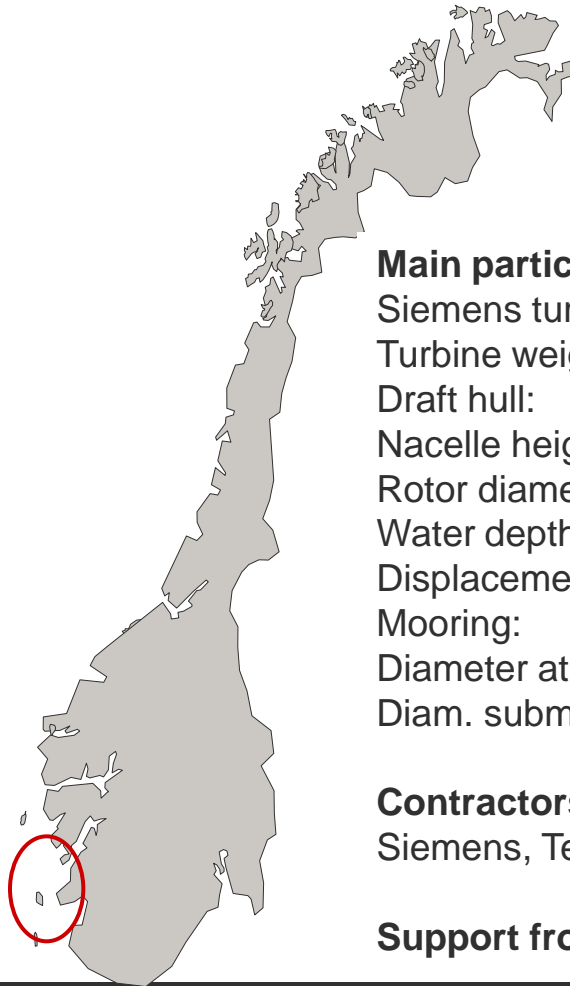


Hywind demonstration unit. Installed June 2009

Located 10 km West of Karmøy



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:

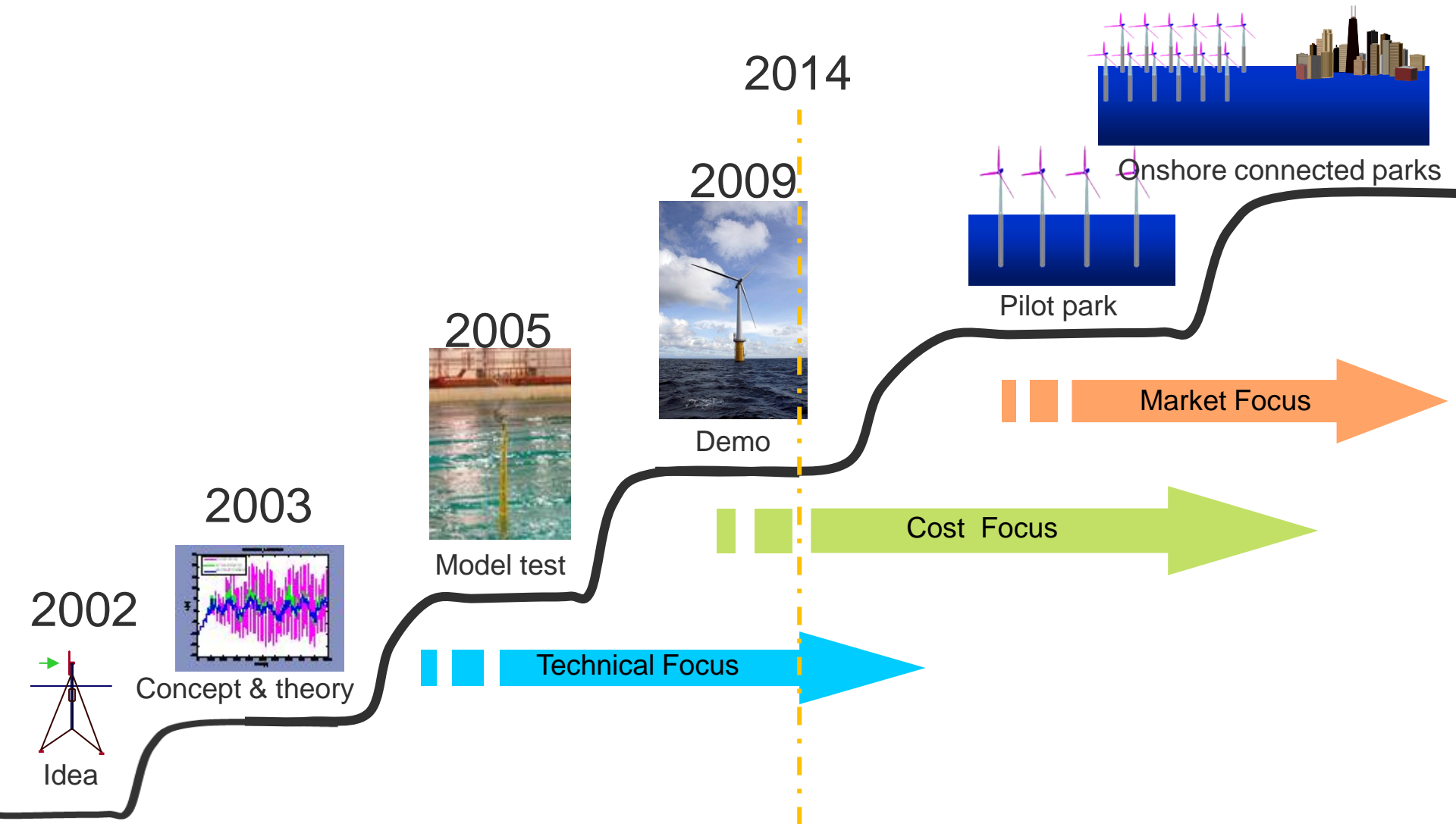
Siemens, Technip, Nexans, Haugaland kraft.

Support from Enova.

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

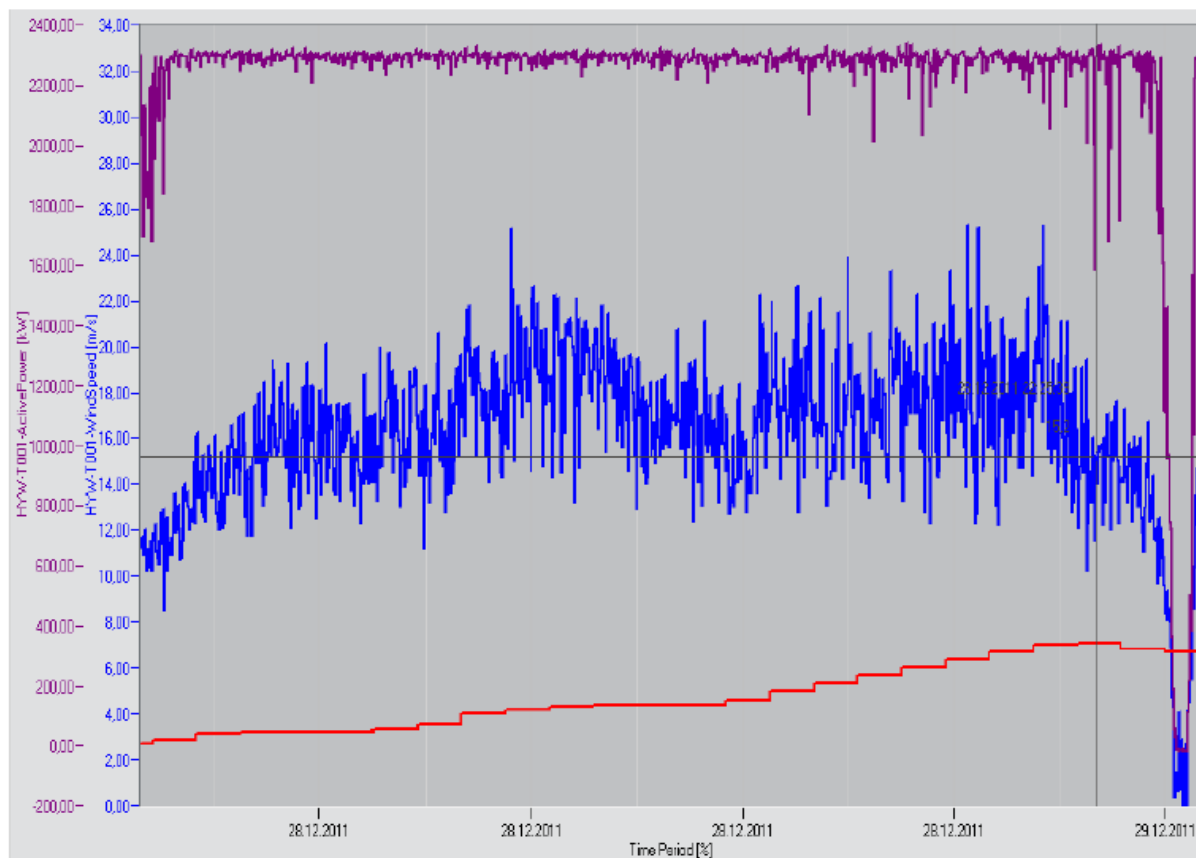


Operation in harsh environment

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

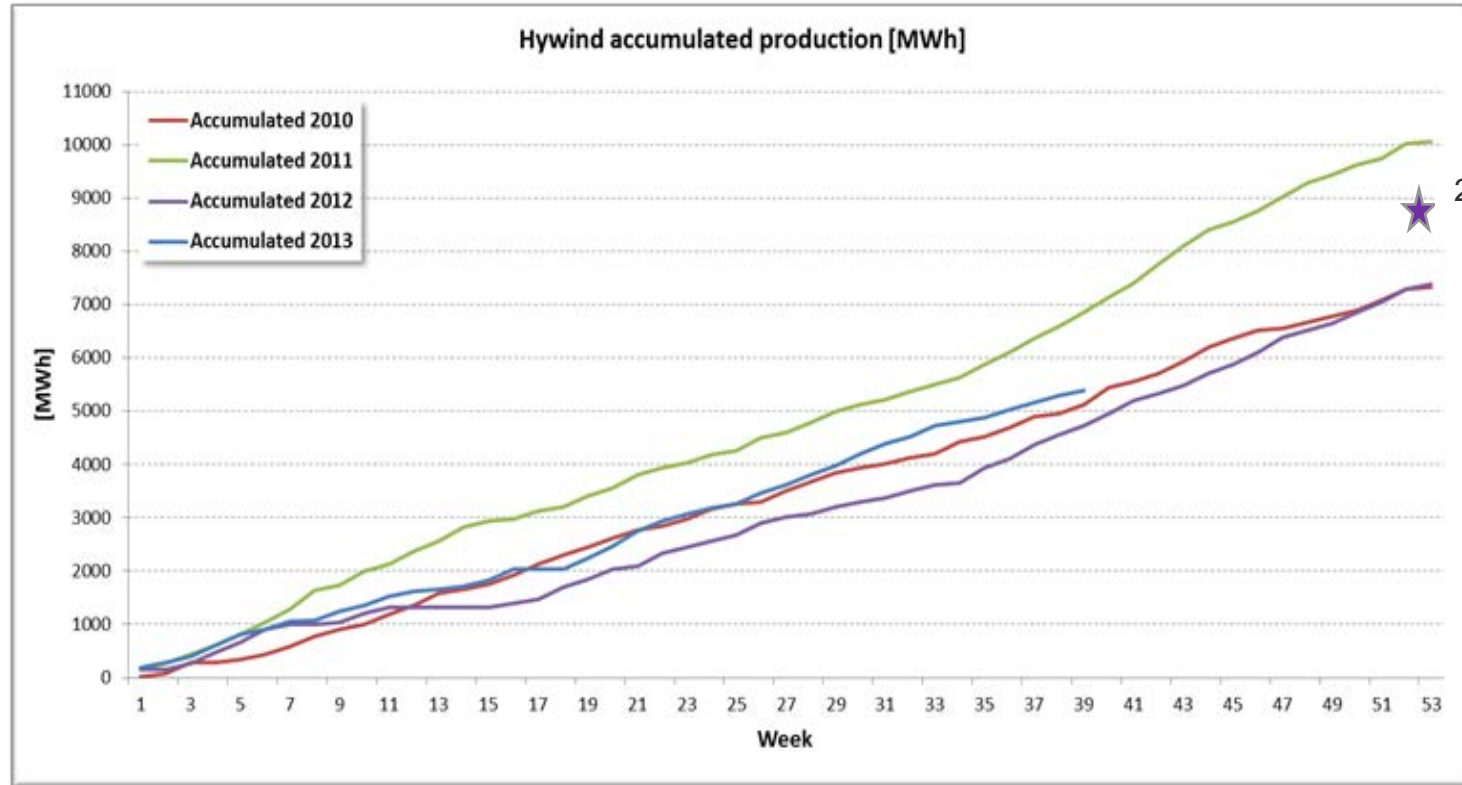


Production during a storm condition



- 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

Hywind performance 2010 – 2013



2010: Testing

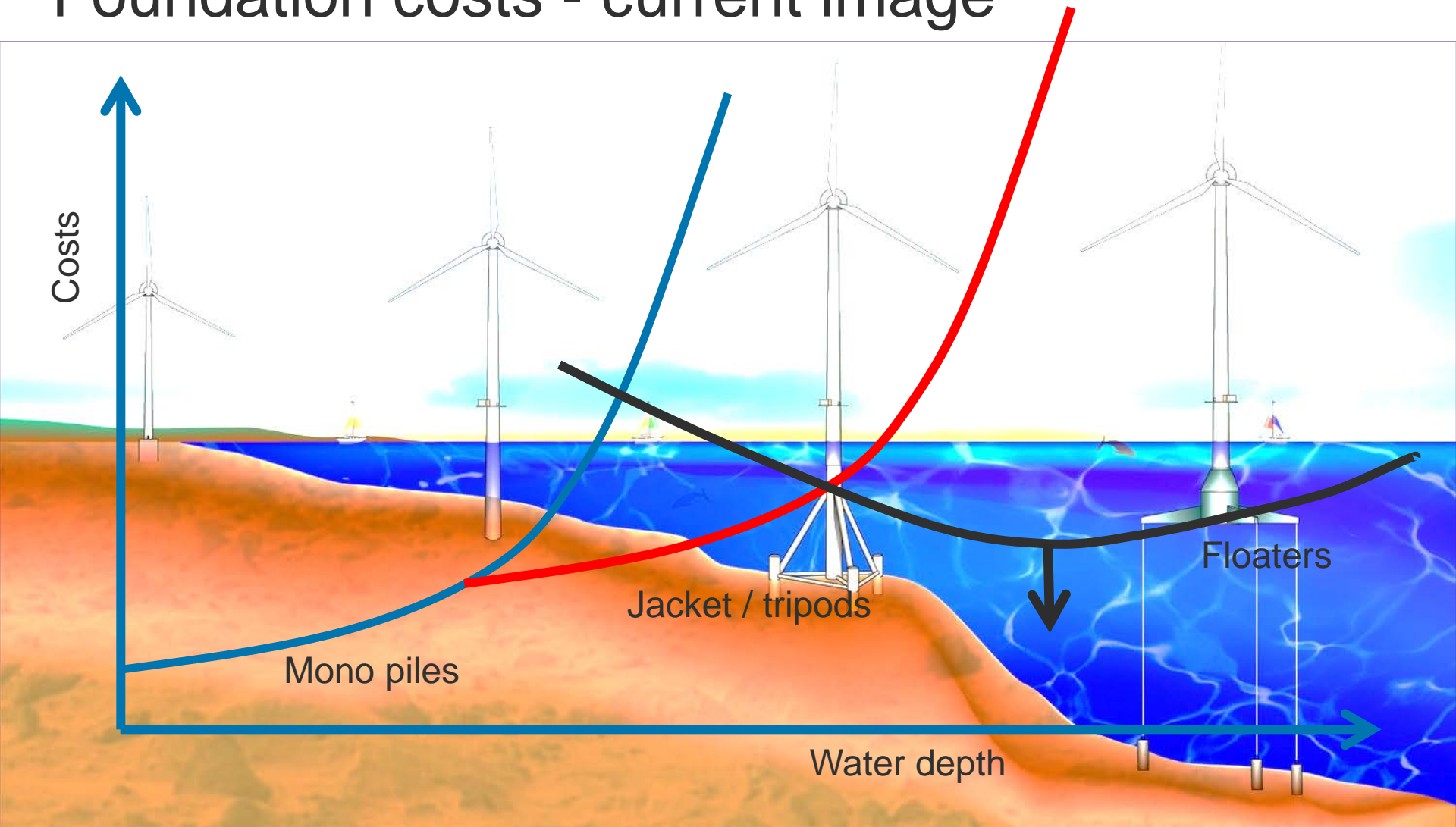
2011: Excellent wind

2012: Unschedule shut down (External grid fault / WoW)

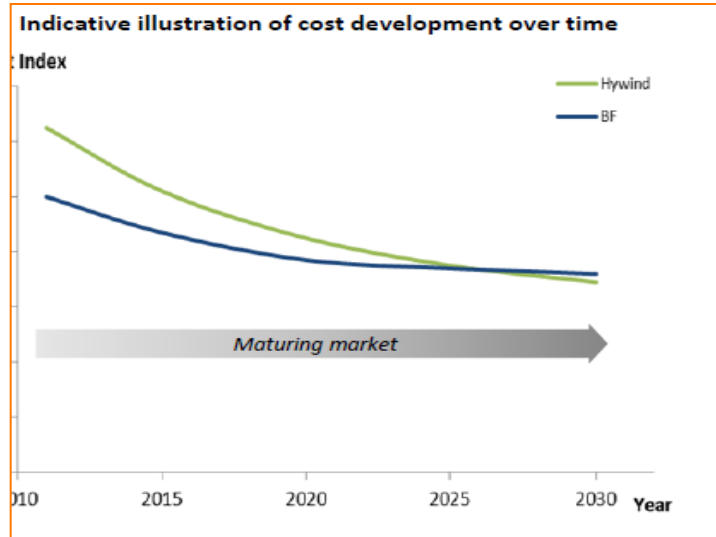
2013: Less than average wind

Expected yearly capacity factor: 0.40 – 0.52

Foundation costs - current image



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



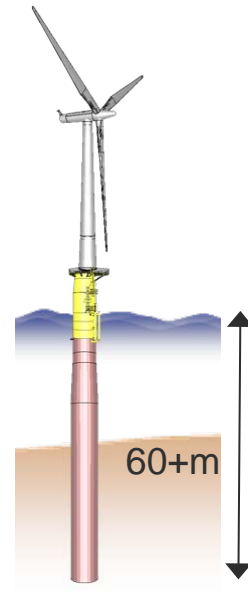
Hywind
Demo



Hywind II
Benign
conditions



Hywind III
Harsh
conditions

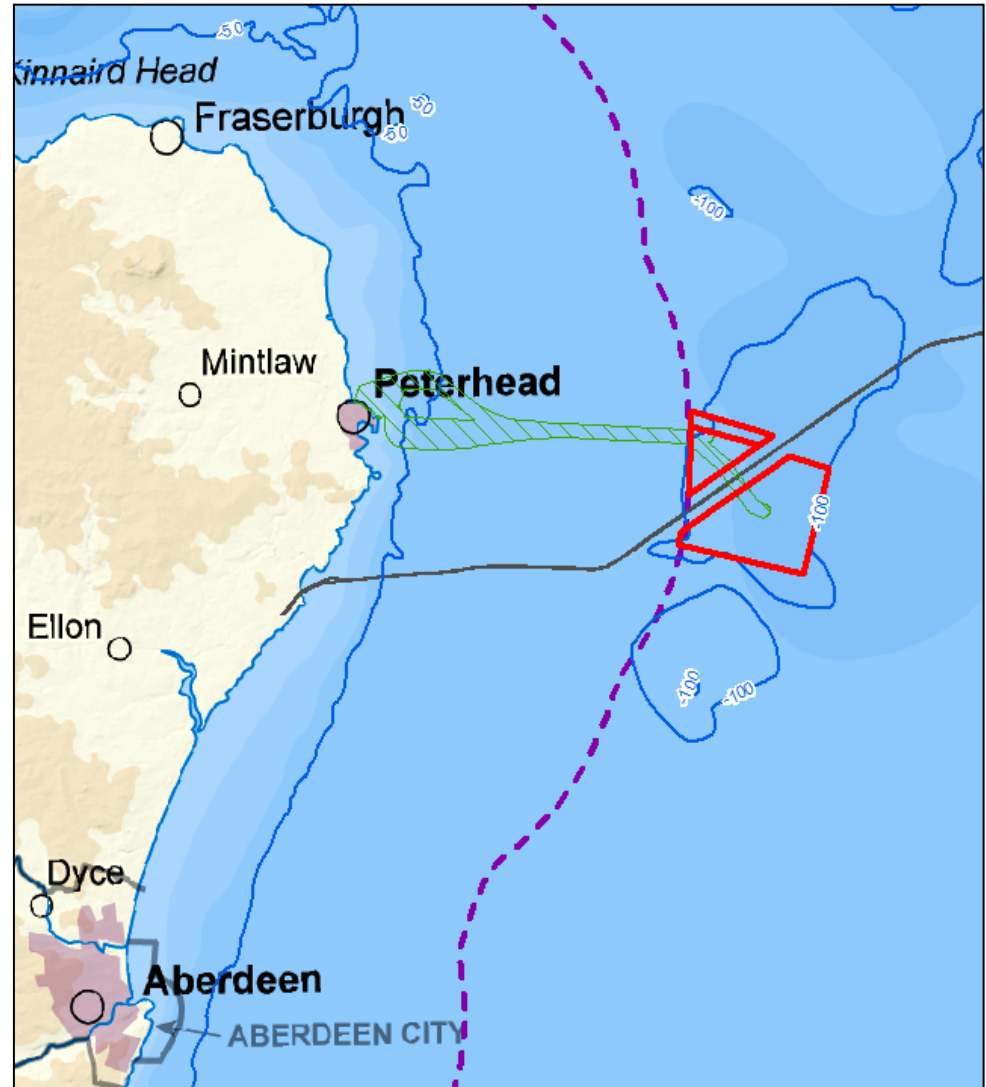


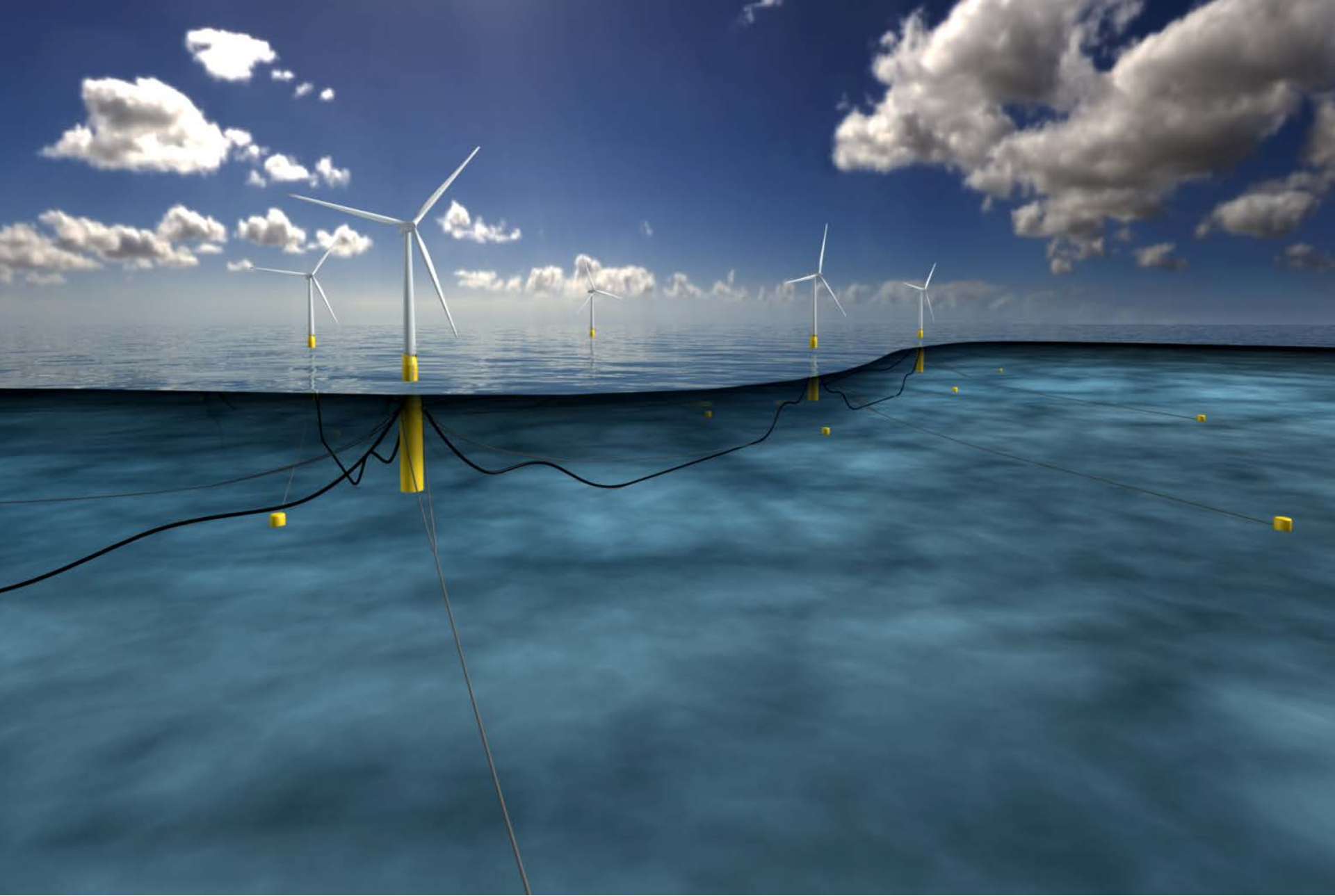
Monopile

The next steps



Hywind Scotland - Buchan Deep





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

