OFFSHORE WIND 5: INNOVATION

Welcome

Chair: Mike Blanch, Associate Director, BVG Associates

All-Energy 11 May 2017

- There are no fire alarms scheduled. If an alarm sounds please leave the building in an orderly manner by the nearest available exit as directed by SEC staff.

- Please put phones on silent.

BVGassociates

Welcome

13:00 – 14:30

Programme

- **Offshore Wind Innovation Landscape**
  Mike Blanch, Associate director, BVG Associates

- **Combining offshore wind and wave power technology – what are the challenges and opportunities?**
  Dr Richard Yemm, Director, Quoceant

- **A test of a 500kW kit system in Scotland during 2017/2018**
  David Ainsworth, Business Development Director, Kite Power Systems

- **Multi-rotor devices: what can offshore wind learn from the tidal industry?**
  Tim Baker, Chief Engineer – Marine Energy, Black & Veatch

- **Can a wind turbine learn to operate itself from experience?**
  Dr Maurizio Collu, Senior Lecturer, Cranfield University

- **Q&A and panel discussion**

BEIS's original intension

What the programme used to say

- **Major EU DemoWind and BEIS funded demonstration and innovation projects** by Bart De Leeuw, Innovation Programme Manager, Department for Business, Energy and Industrial Strategy (BEIS)
- Bart had to withdraw from presenting as a result of the general election announcement
- His intension was to announce all the DemoWind projects with grant offers agreed.

Offshore Wind Innovation Landscape

Mike Blanch, Associate Director, BVG Associates
Alun Roberts, Associate Director, BVG Associates
Kate Freeman, Associate, BVG Associates

All-Energy 11 May 2017

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About BVG Associates

BVG Associates

Business advisory

- Analysis and forecasting
- Strategic advice
- Business and supply chain development

Economics

- Cost of Energy
- Technology and project economic modelling
- Policy and local content assessment

Technology

- Engineering services
- Due diligence
- Strategy and R&D support

Selected clients

Public reports: free to download: bvgassociates.com

Mike Blanch

A bit about me

- Leads BVGA's technology strategy, due diligence and R&D support sector - *Selecting best technologies to deliver LCOE reduction*

- 26 years' in wind industry including
  - Practical research working first hand with wind turbine technology
  - FMEA and assessment of the reliability of devices
  - Managing a test site
  - Economic modelling of offshore wind, onshore wind and marine energy sectors including wave and aquaculture including the impact of innovation
  - Technical review, technical monitoring and assessment of R&D programmes

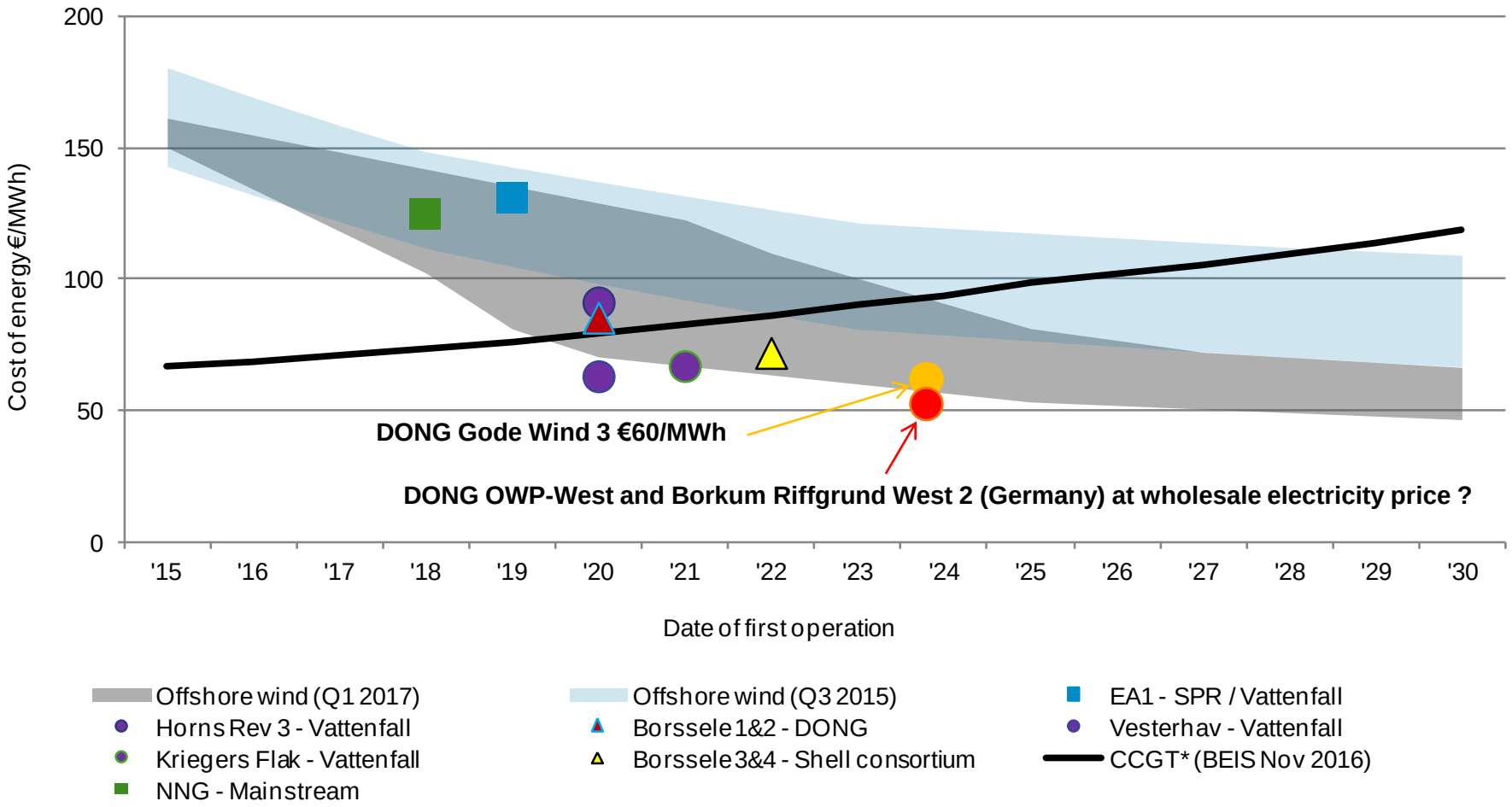
- In 2016, lead the economic modelling for the Marine Investment for the Blue Economy (MARIBE) project, analysing 22 potential commercial combination projects including offshore wind energy (fixed and floating), wave energy, fixed shipping terminal, aquaculture, and desalination including multi-use of space and multi-use platforms.

- In 2013, was seconded into BIS to develop and begin the implementation of the Offshore Wind Industrial Strategy (published August 2013).

Accelerated cost reduction is being delivered

Big step-down in costs during 2016 and 2017

Latest outlook from BVG Associates



Offshore wind is no longer expensive

- In December 2016 Shell and partners won the latest Netherlands auction for an offshore wind farm at Borssele III & IV at a price of €54.5/MWh (25% lower than that achieved by DONG in July 2016 for Borssele I & II). Adding the transmission connection gives a total project LCOE of about €53/MWh – close to the value of the price of electricity.

- The natural advantages of the Borssele sites means their LCOE's are close to the lower end of the range of possible LCOEs so LCOE of €70-80/MWh can be expected at a typical site a government has developed for auction.

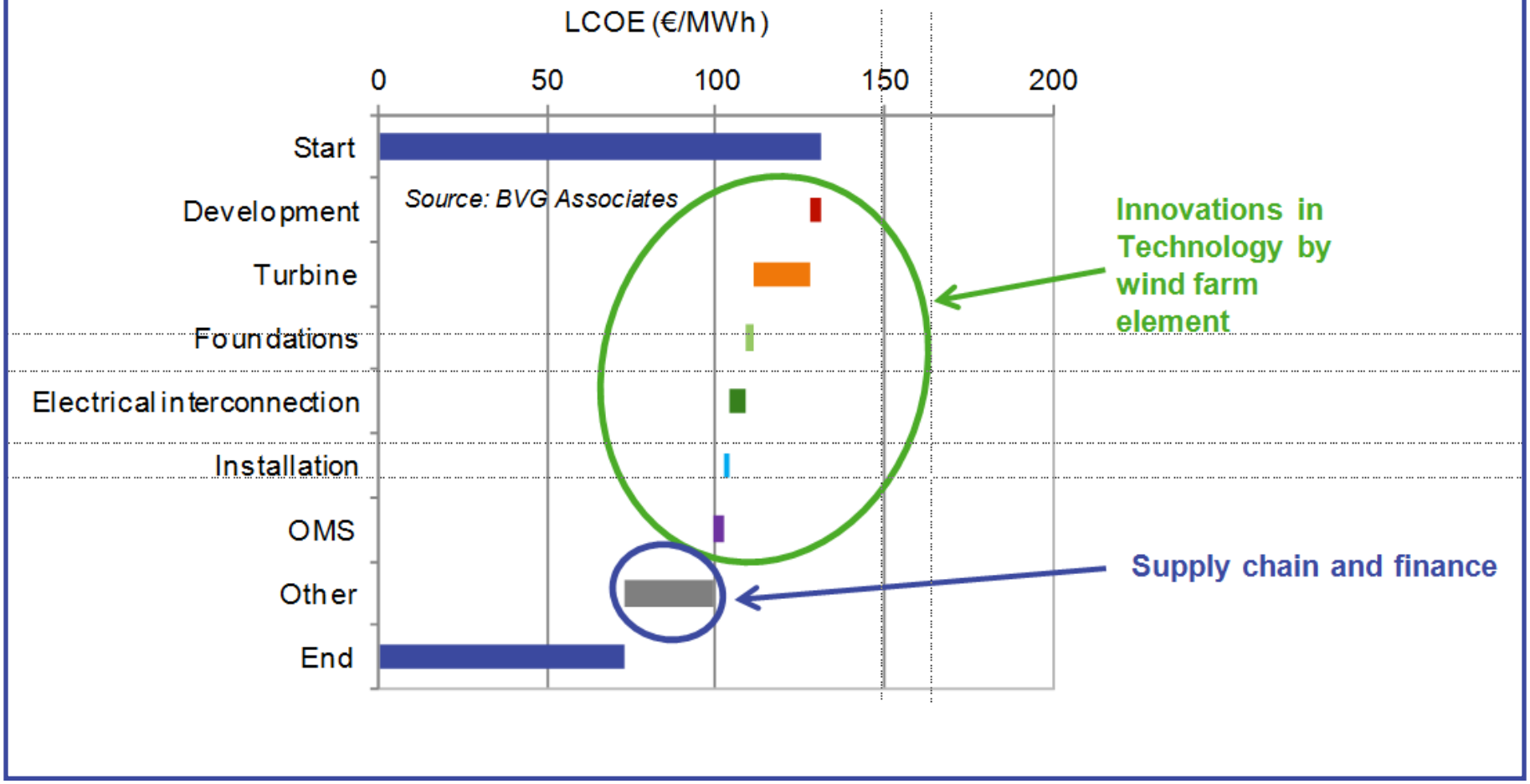
- The current UK CfD round 2 is for sites developers have developed. Winning bids expected to be £$_{2017}$85/MWh or lower? Cheaper than UK nuclear (£$_{2012}$ 92.5/MWh).

Offshore wind test and demo opportunities

- Concern in medium term over supply of enough consented sites in UK to maintain price reduction . The Crown Estate has talked about Round 3.1 but it needs to happen so that the big zone developers maintain their commitment or the UK needs an orderly switch to the Danish/Dutch model where government does more development and then auctions.

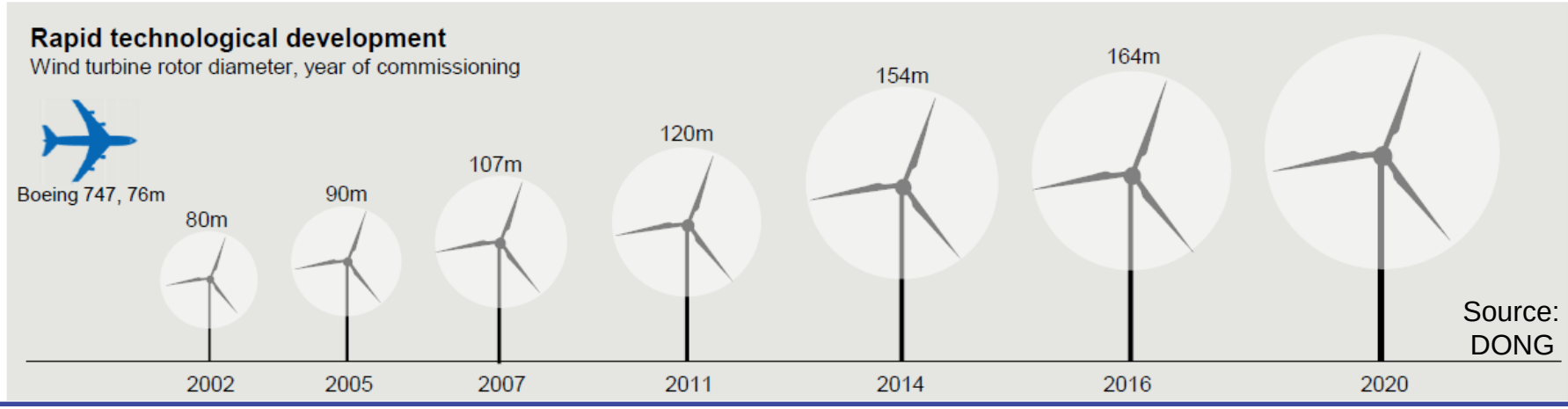
- Need sites in the new wind farms

It’s not just about the technology….



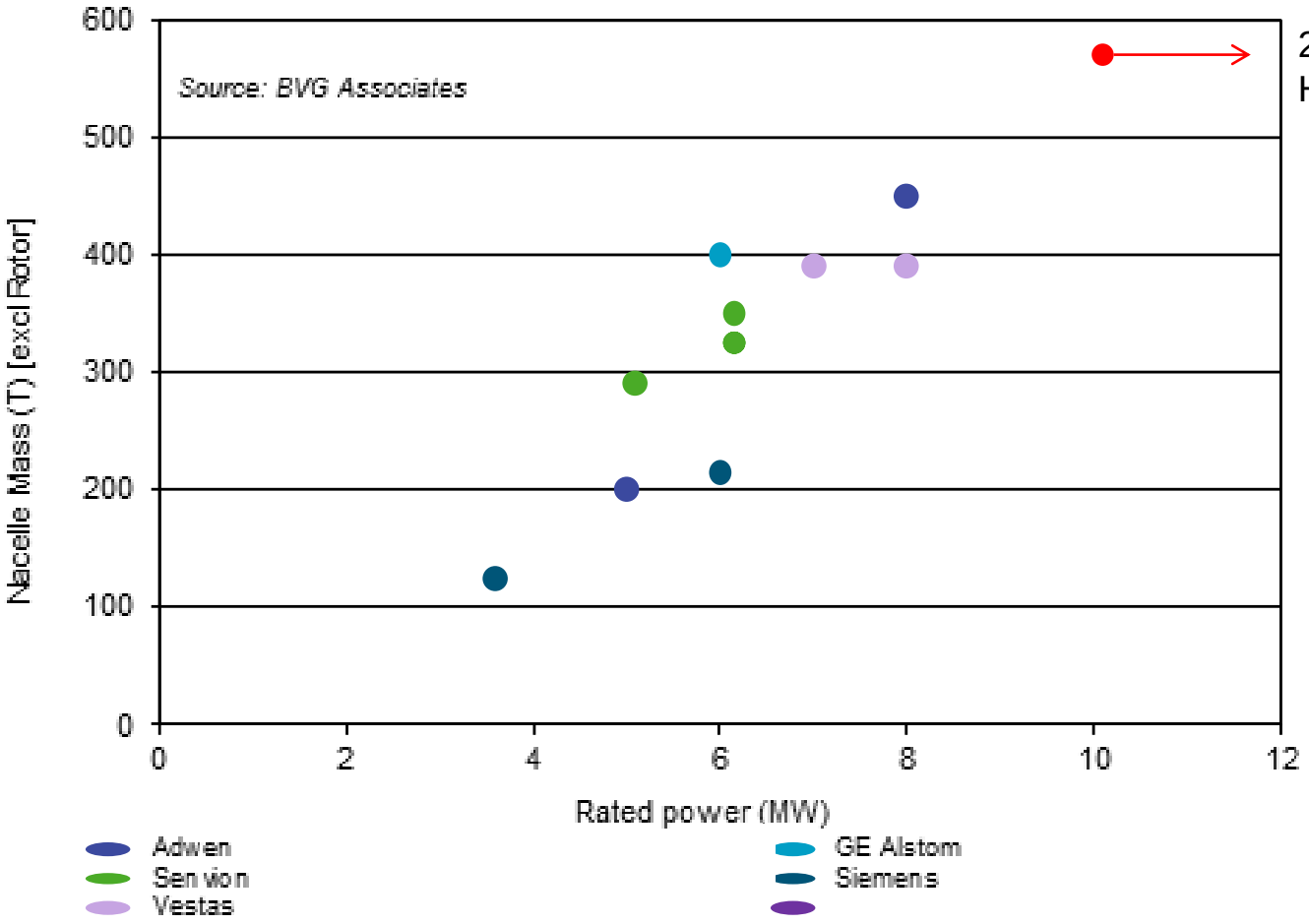
The landscape

- A word of caution. Just because we have had rapid cost reduction, doesn't mean that it will continue at the same pace. Bid price isn't the same as LCOE.
- Recent LCOE reduction a happy coincidence of bigger turbines, cheap steel and cheap finance. Can't assume that the last two will remain favourable.
- **Innovation is essential if offshore wind is to continue to reduce levelised cost of energy (LCOE) and become an increasingly competitive source of new electricity generation.**



How big will turbines get?

What will a 12MW turbine look like?



200m rotor +
Hub height 130m?

What does this mean for vessels?

Collaboration is vital

- Too many were surprised by the rapid introduction of 8MW turbines
- A lot of investment in turbine installation vessels but the fleet no longer looks fit for purpose
- Upgrades to vessels (legs and cranes) can plug the gap in the short term
- Are there any vessels that can install a 10MW+
- When vessel investments were committed in 2010-12, the forecast market was a lot larger
- Is there a business case for a new vessel?
- A manufacturer cannot develop a new turbine if the LCOE benefit is lost through inefficient installation

Seajacks Scylla

- Siemens can make long-term commitment to service operations vessels (SOVs).

What does this mean for vessels?

Do we need a radical re-think?

- Is it asking too much to keep bringing new vessels into service to keep up with turbine developments?
- Integrated turbine installation has been explored but barriers to entry were too high
- Is this still true?
- Will turbine manufacturers need to engage with radical solutions to sustain cost reduction?
- Blyth Offshore Wind Demonstration Ltd and BAM Wind Energy JV constructing 5 ‘float-and-submerge’ gravity based foundations (GBF) due for installation in Blyth Offshore Wind Farm in 2017. The turbines will be installed at the wind farm by a vessel.

Source: EDF ER

What does this mean for foundations?

The demise of monopiles was greatly exaggerated

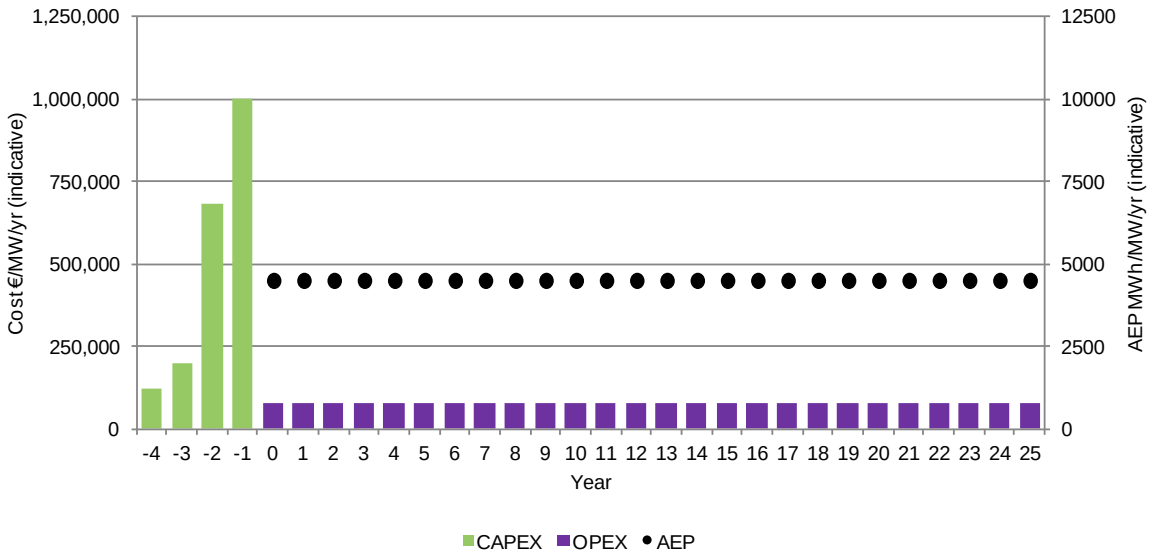
- Even for larger turbines, could monopiles still be used for near-shore sites with 10-12MW turbines (assuming there are no consenting problem?
- Investment in jacket facilities has lagged because of technology/market uncertainties and because fabricators need to amortise over a short period.
- Again, there is a strong case for turbine manufacturers to collaborate with the supply chain
- No point if turbine innovation LCOE gains are lost on suboptimal foundations

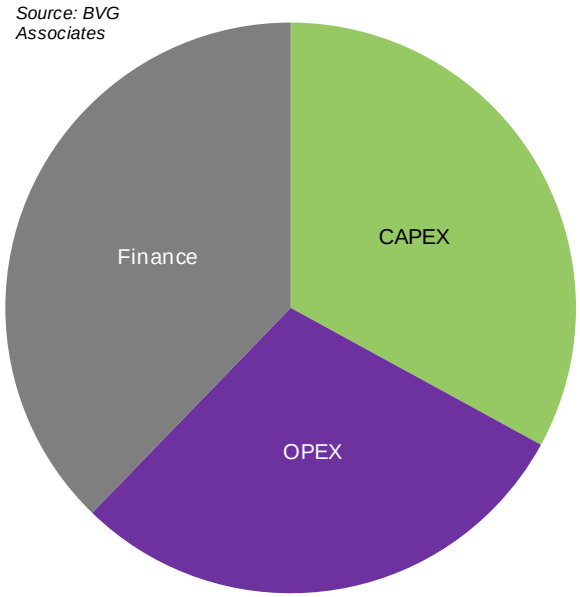
Source: Siemens

Time is money

How speed of installation influences cost; What is LCOE?

- CAPEX spend and OPEX spend including the finance contribution divided by the energy
- Servicing of finance cost is a large part of this.

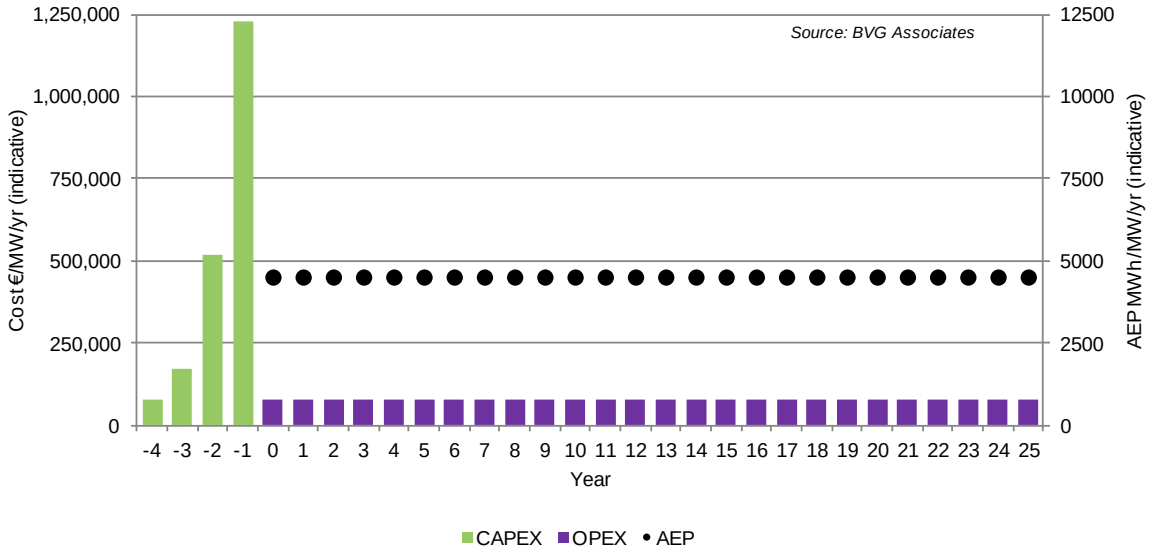


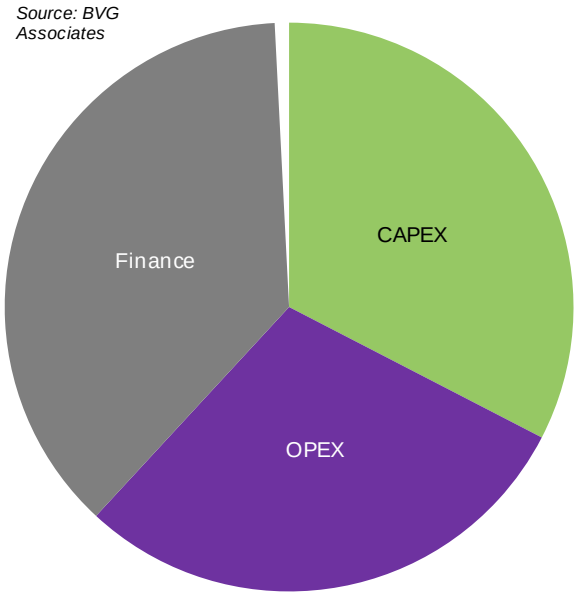


Time is money

How speed of installation influences cost;

- Move CAPEX closer to time at which you pay off the debt
- Brings servicing of finance cost down (even without cheaper vessel charters)





Do combinations reduce levelised cost of output (LCO)?

Multi-use platforms (MUP) and multiple use of space (MUS)

MUP/MUS	Sector 1	Sector 2	Company 1	Company 2	Basin
MUS	Fixed Offshore Wind	Aquaculture	Maribe Combo (from MERMAID)		Baltic and North Sea
MUP	Floating Offshore Wind	Wave	JJ Campbells		Atlantic
MUP	Floating Offshore Wind	Wave	Floating Power Plant		Atlantic
MUS	Floating Offshore Wind	Aquaculture	ACS	Besmar	Atlantic
MUP	Floating Offshore Wind	Desalination	EcoWindWater		Mediteranean
MUP/MUS	Floating Shipping Terminal	Aquaculture	Grand Port Maritime de Guyane		Caribbean
MUP	Floating Shipping Terminal	Wave	Float Inc.		Atlantic
MUS	Wave	Aquaculture	Wave Dragon	Seaweed Energy Solutions & BELLONA	Atlantic
MUS	Aquaculture	Wave	AquaBioTech	Albatern	Mediteranean

This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 652629

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MARIBE Marine Investment for the Blue Economy

.. and the price of fish?

EU Multiuse of space directive means what?

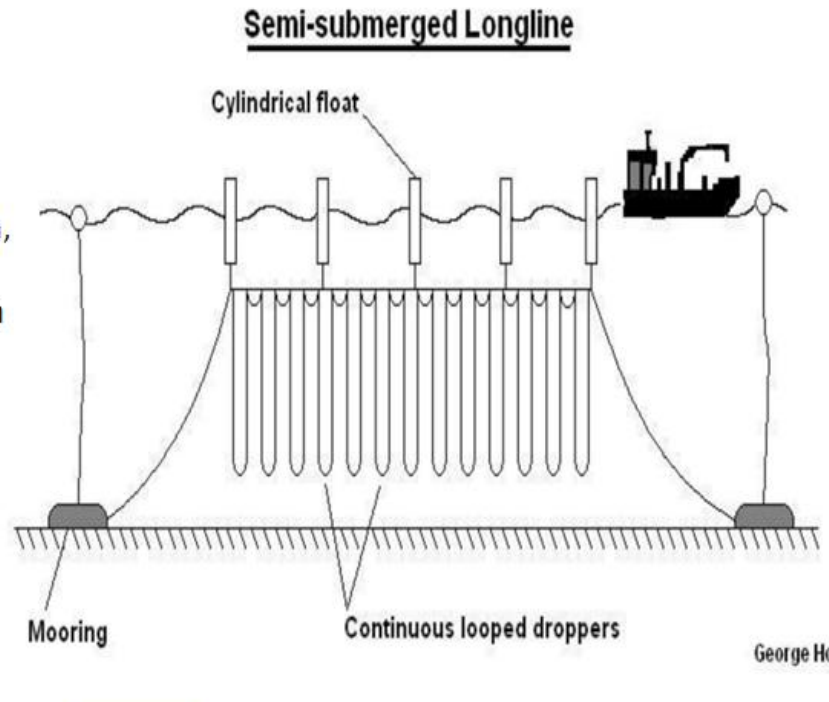
Our analysis showed combination with mussels reduced levelised cost of output (LCO) – looking for partners to trial

MARIBE
Marine Investment for the Blue Economy

AQUACULTURE + FIXED OFFSHORE WIND

Mussel farming and offshore wind

- Multi-use of space – structures are separate allowing turbine access
- Considered feasibility for Dutch Borssele wind farm
  - Development of wind farm is a given, with fixed structures
  - Water depth between 15m and 35m
- Double long lines (continuous) attached to anchors
- Annual production target for mussels: 5.5 million kg of mussel seed



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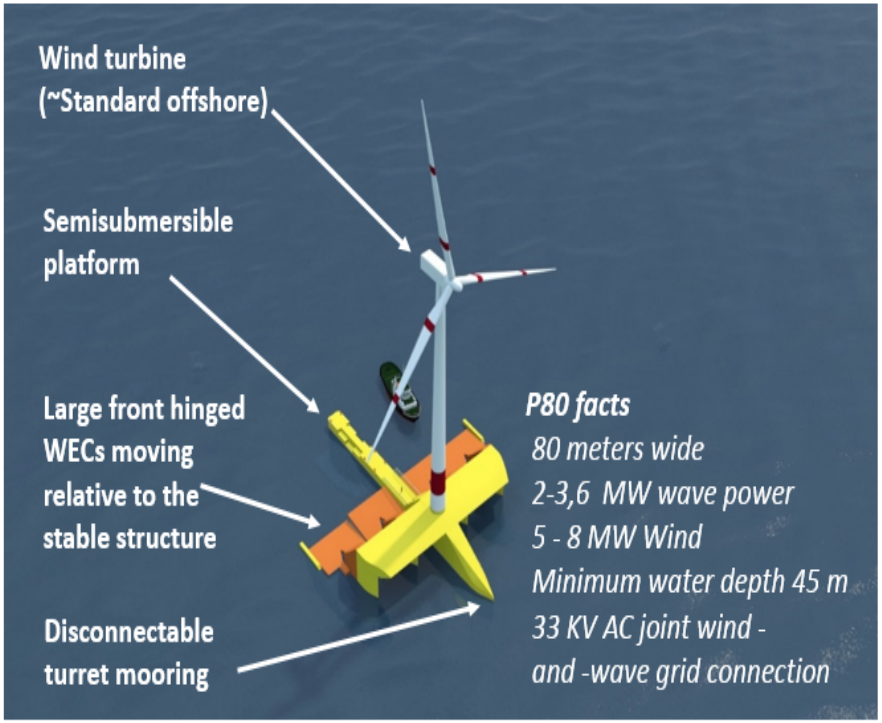
Global Offshore Wind
June 2016

This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 652629

Maribe – floating wind-wave

Floating Power Plant A/S

FLOATING OFFSHORE WIND + WAVE



An unique design combination that passively turns into primary wave direction
=> More wave power
=> Safe access zone

Design based on:

- Stable semi submersible platform **- oil & gas component**
- Build via panel line modules – **standard ship principle**
- Mooring / flexible sub-sea cables - **oil & gas components**
- Disconnetable and vaning turret **- oil & gas components**
- Wind turbine – **offshore wind turbine**
- Power export standards – **offshore wind standards**

- Unique wave device and PTO systems placed on a known stable structure
- Integrated on one platform where all components are placed indoors

- For the +45 meter water depth market segment

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Maribe – wind - desalination

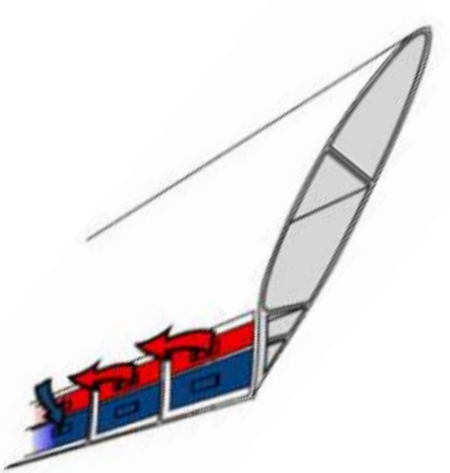
EcoWind Waters' Floating Wind-Desalination MUP

FLOATING OFFSHORE WIND + DESALINATION

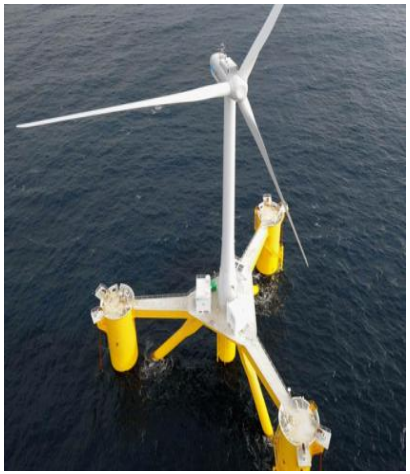
- 35 kW prototype
- Potable water
- 100% RES
- No chemical pre-treatment of sea water
- Away from the coast, without any impact on the island
- Scalable
- Autonomous , Unmanned
- Low installation and maintenance costs
- Transportable

And what else is coming …

Plenty more evolution but also disruption



Aero control
Huge blades need better control



Floating
Access new areas

Multi-rotor
Better use of foundations

Kites
Aim higher

Main per MW benefits

Increased AEP Decreased OPEX	Increased AEP or Lower transmission CAPEX and OPEX	Decreased CAPEX Decreased OPEX	Decreased CAPEX

What does this mean for innovation?

- Innovation is needed
- Rest of industry needs to keep up with turbine manufacturers whose development of larger turbines has shown huge faith in the potential for cost reduction
- Anticipate
    - Bigger, larger, and heavier turbines
    - Fewer foundations, cables and installations needed per MW
    - ‘Float-and-submerge’ including turbine is successfully demonstrated
    - More pressure for multi-use of space especially in Belgium waters
- Disruptive technology (kites, floating etc) need to demonstrate greater LCOE reduction

Funded innovation – DECC OWTC

- DECC Offshore Wind Technology Programme finished in 2016 and gave grants support to 7 innovations for turbines, 8 for foundations, 1 in operations and maintenance, and 3 in electrical infrastructure.

Turbine

- Blade Dynamics: Composite wind turbine hub for a 6MW offshore wind turbine
- David Brown Gear Systems: Powertrain gearbox solution for large scale offshore wind energy production
- NGenTec: Permanent magnet generator technology which can reduce turbine costs
- Ricardo: Offshore wind drivetrain for turbines of 5MW and beyond
- SSE: Development of a National Offshore Wind Turbine Test Facility (NOWTTF)
- Sgurr Control: Control system that will reduce the stress placed on turbine blades
- Wind Technologies: 5MW medium-speed drive train concept

Operations and maintenance

- OSBIT Power: MaXccess-HBS offshore wind turbine access system

Funded innovation – DECC OWTC (continued)

Foundations

- 2B Energy: Demonstrate the 2-B truss foundation structure
- Aquasium: RapiFab - Rapid, cost-effective fabrication of offshore wind support structures
- Gravitas: Pre-production demonstration of concrete gravity foundation demonstrator
- MEES: Articulated Wind Column - buoyant foundation
- Ocean Resource: SeaBreeze - a self-installing gravity base foundation
- OGN North Sea: Triton Wind Turbine Generator Foundation – a steel jacket foundation for large offshore wind turbines, to be installed at water depths in excess of 30m
- Principle Power: UK Pilot WindFloat Design and Industrialisation Study
- TetraFloat: Floating tetrahedral structure for offshore wind turbines

Electrical infrastructure

- High Voltage Partial Discharge (HVPD) Ltd: Integrated Offshore High Voltage Network Monitoring System (OHVMS) For Renewable Networks;
- JDR Cable Systems: Lead-Free HVAC Array Cables
- Power Cable Services: Hi-Cab – cable jointing technology for high voltage offshore wind farm array and export subsea power cables

Funded innovation – DemoWind

- Lead by UK Department for Business, Energy and Industrial Strategy, BEIS, DemoWind 1 and 2 are ERA-NETs funded under the European Union's Horizon 2020 research and innovation programme under grant agreement numbers 646517 and 691732.

- Enabling industry to push technologies mainly from Technology Readiness Levels (TRL) 5-6 up to TRL 6-8 through collaborative, trans-national offshore wind demonstration of or in .
    1. Turbine components
    2. Floating offshore turbines
    3. Foundation structures
    4. Electrical networks/multi-terminal DC networks
    5. Metocean data measurement and forecasting
    6. Installation and decommissioning practices, and
    7. Operations and maintenance.

- The total maximum Call Budget for
    - DemoWind 1 2015 was €31.6 million
    - DemoWind 2 2016 was €24.6 million …….. to be continued

Funded innovation – DemoWind

- In the public domain is that Blyth-based ORE Catapult is testing an 88m blade fabricated for Adwen's new 8MW offshore wind turbine as part of DemoWind.

Source: ORE Catapult

Funding to be aware of

- BEIS Energy Entrepreneurs Fund – last round had no successful wind projects
- Innovate UK – Energy Catalyst
- Innovate UK – Infrastructure
- EU SME instrument

- We flag things in our newsletter so do sign up for that.

Thank you and any questions

BVG Associates Ltd
The Blackthorn Centre
Purton Road
Cricklade, Swindon
SN6 6HY UK
tel +44(0)1793 752 308

BVG Associates Ltd
The Boathouse
Silversands
Aberdour, Fife
KY3 0TZ UK
tel +44(0)1383 870 014

BVG Associates LLC
Green Garage
Second Avenue
Detroit, MI
48201 USA
tel +1 (313) 462 0673

imjb@bvgassociates.co.uk
@bvgassociates
www.bvgassociates.co.uk

CfD timetable

Milestone	Scenario 1 Non-qualification reviews and qualification appeals	Scenario 2 Non-Qualifying Applicants after review; No appeal raised	Scenario 3 Non-Qualifying Applicants after application assessment; Review raised	Scenario 4 Non-Qualifying Applicants after application assessment; No review raised	Scenario 5 All Qualifying Applicants after application assessment
The CFD Allocation Application window when applicants submit CFD Application and pre-qualification information.	3 April 2017 to 21 April 2017	3 April 2017 to 21 April 2017	3 April 2017 to 21 April 2017	3 April 2017 to 21 April 2017	3 April 2017 to 21 April 2017
Applicants informed of the status of their applications. If **all** applicants meet the qualification criteria then the process will continue on shortest timeline otherwise.	15-May-17	15-May-17	15-May-17	15-May-17	15-May-17
Window for BEIS Secretary of State to consider a budget increase.	4 August 2017 to 10 August 2017	15 June 2017 to 21 June 2017	8 June 2017 to 14 June 2017	24 May 2017 to 31 May 2017	17 May 2017 to 23 May 2017
Inform applicants if auction is required and invite sealed bids (if auction).	11-Aug-17	22-Jun-17	15-Jun-17	01-Jun-17	24-May-17
Sealed bid window.	14 August 2017 to 18 August 2017	23 June 2017 to 29 June 2017	16 June 2017 to 22 June 2017	2 June 2017 to 8 June 2017	25 May 2017 to 1 June 2017
CFD Notification: Delivery Body notifies all Qualified applicants of allocation outcome and notifies LCCC and successful applicants only.	11-Sep-17	20-Jul-17	13-Jul-17	29-Jun-17	22-Jun-17
Contracts processed and distributed.	12 September 2017 to 25 September 2017	21 July 2017 to 3 August 2017	14 July 2017 to 27 July 2017	30 June 2017 to 13 July 2017	23 June 2017 to 6 July 2017
Sign contracts and return to Low Carbon Contracts Company.	26 September 2017 to 9 October 2017	4 August 2017 to 17 August 2017	28 July 2017 to 10 August2017	14 July 2017 to 27 July 2017	7 July 2017 to 20 July 2017