Offshore wind technology cost reduction: six months on

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now in Scotland
BVGassociates

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Customers

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- Market analysis and business development
  - Supply chain development
  - Economic impact assessment
  - Support to industrialisation
- Technical innovation & engineering analysis
  - Support to investment in technology
  - R&D programme management
  - Design and engineering services
- Project implementation
  - FIT project development (UK only)
  - SCADA & condition monitoring
  - O&M technical support

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Cost reduction pathways study

Overview

Context

- 2011 Energy white paper:
  - Central scenario 13GW by 2020
  - Minded to support to 18GW if cost of energy reduced – target £100/MWh

- The Crown Estate cost reduction pathways study established to evidence what industry thinks could be done
  - Supply chain, finance and technology work streams

- Cost Reduction Task force established to address how to make it happen

Methodology: technology work stream

4 Dimensional cost model: Time, types of wind farm site, turbine sizes, industry scenarios

6 Industry day-long workshops (in UK, DK, DE)

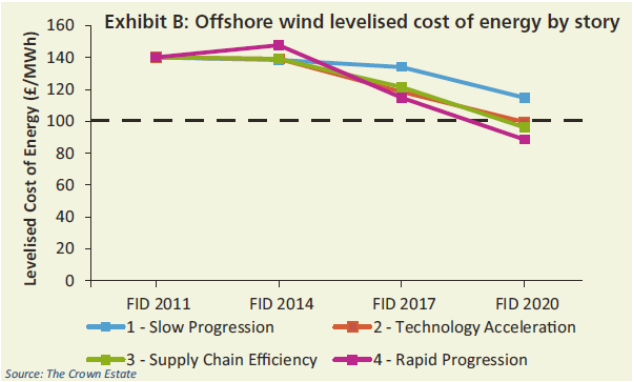
20 Deep industry interviews (4 hours +)

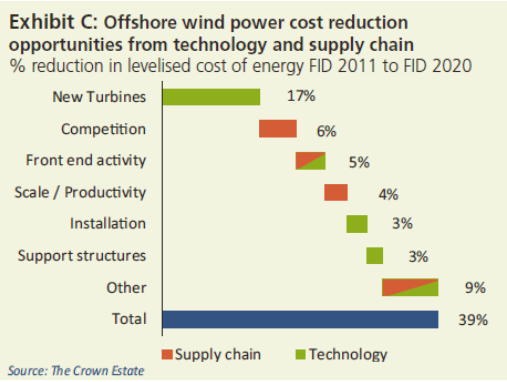
125 Industry individuals directly involved

215 Pages – available for download from our website

Cost reduction pathways study: results

- Given right external conditions, industry can meet target:
  - Confidence in market size to beyond 2020
  - Smooth and timely transition under EMR
  - Planning consent timelines reliably met
  - Clear and predictable offshore grid regulatory framework
  - Facilitation of new technology introduction
- To deliver, industry also needs to work together:
  - Best practice, standardisation, risk management, accessing new finance





Progress

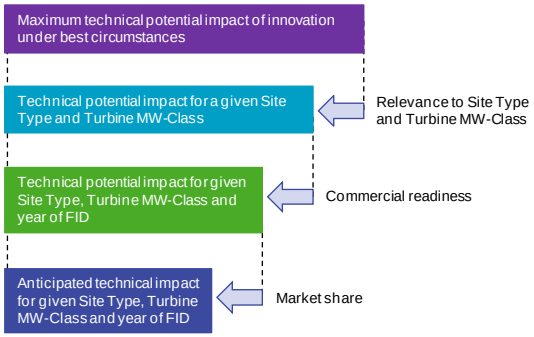
Six months on

Development

	Potential	Anticipated	Progress	Evidence	Challenges
Greater level of array optimisation and feed [9, 10, 22, 52]	-4%	-2%		More early-stage collaboration Recognition of benefit (Little extra site investigation or progress with array optimisation)	Increasing project (rather than zone) approach Increased risk on early spend, especially if delays later

Definitions

- LCOE: Levelised cost of energy – income required from whatever source to give 10% rate of return to project owner
- Innovations listed [nn] reference Table B.2 in report.
- Changes are compared to a baseline wind farm of 4MW turbines, in 35m water depth, FID 2011
- Potential: Maximum technical potential impact on LCOE of innovation under best circumstances
- Anticipated: Anticipated technical impact on LCOE for project:
  - 35m water depth
  - 6MW turbines
  - FID in 2020
  - Takes into account:
    - Relevance of innovation to given conditions
    - Commercial readiness
    - Anticipated market share
- Progress:
  - More than sufficient progress visible to keep on track*
  - Sufficient progress
  - Insufficient progress
  - Little or no progress



* For £100/MWh target by FID in 2020

Progress

Six months on

Turbine

	Potential	Anticipated	Progress	Evidence	Challenges
Increase in turbine power rating [2]	-9%	-9%		Most new development in 7-8MW range 1st 6MW project operating 2 other 6MW prototypes up	Lack of market confidence slowed progress for some
Optimisation of rotor diameter and aerodynamics [5, 6, 25]	-4%	-3%		Samsung rotor diameter over 170m Delays to some rotor extension projects	Lack of market confidence slowed progress for some Lack of test site has delayed one project
Introduction of next generation drive trains [8, 11, 13, 15, 49]	-7%	-3%		In-house and open-access drive train test rigs progressing Increased focus on mid-speed solutions and reliability	High cost of thorough verification / high risk to change Uncertainty on PM material costs
Advanced drive trains [30, 47, 59]	-9%	-0.4%		MHI hydraulic at 2-3MW proto in 2012; 7MW in 2013; Vestas DC generation players progressing	Insufficient evidence from some smaller players to get traction from turbine manufacturers
Improvements in aerodynamic control [4, 23, 31, 50]	-5%	-2%		Number of in-house teams strengthening Vestas announced trial	Long time / expensive for thorough verification on turbine
Improvements in blade design, manufacture and materials [19, 21, 26]	-2%	-1%		Incremental steps being taken Vestas announced change in blade concept Increased focus on carbon	Low quantity production for offshore for some time

Progress

Six months on

Support structure

	Potential	Anticipated	Progress	Evidence	Challenges
Improvements in jacket design and manufacturing [3, 16, 36]	-4%	-3%		At least one JIP established Industry extending monopile use Tata mass-production tubulars OGN with RGF grant	Challenging environment for future investment Uncertainty about technology usage – eg. jacket / concrete
Introduction of tower design improvements [18, 20]	-2%	-1%		Benefits recognised – relatively easy to implement 2-B Energy progressing with holistic space frame design	Single-section towers need suitable portside facilities
Introduction of suction bucket technology [29]	-2%	-0.3%		Two suppliers deploying for met stations Fred Olsen progressing demonstrators	Availability of suitable test sites

Array cables

	Potential	Anticipated	Progress	Evidence	Challenges
Introduction of array cables with higher operating voltages [35]	-0.4%	-0.2%		Strong demand and innovative solutions being developed	Long lead time to develop and certificate solutions
Improvements in array cable standards and client specification and design [38, 44, 53]	-0.5%	-0.3%		More than one JIP being established Supplier-installer-developer dialogue increasing	Long lead time to implement due to typical wind farm project processes

Progress

Six months on

Installation

	Potential	Anticipated	Progress	Evidence	Challenges
Improvements in range of working conditions for installation [7, 32, 42]	-2%	-1%		Blade lift solutions being developed Access solutions for OMS progressing	
Greater levels of optimised installation vessels, processes, tooling and strategies [12, 24, 28, 33, 34, 40, 51]	-3%	-2%		Slow progress on optimised jacket installation vessels Better progress on cable installation	Foundation concepts still evolving
Introduction of radical installation strategies [27, 39, 45]	-9%	-0.6%		New investment in Seatower Gov funding for concrete demo More interest in floating for deeper Round 3 projects	Long time to commercial sales at wind farm scale

OMS

	Potential	Anticipated	Progress	Evidence	Challenges
Improvements in base, transport and access solutions [17, 37, 55]	-2%	-0.7%		Access solutions for higher waves progressing Higher focus on mother ship arrangements	
Improvements in OMS strategies [14, 41, 46, 48]	-2%	-1%		Slow progress on condition-based maintenance Some progress on integrating ops management tools	Across-organisation collaboration and data sharing

Summary and reflections

Six months on

Wind farm

	Potential	Anticipated	Progress
Turbine	-31%	-17%	
Balance of plant	-9%	-5%	
Installation	-14%	-4%	
OMS	-3%	-2%	
Development	-4%	-2%	
Overall			But…

Summary

- Overall, from technology perspective, currently on course to reduce LCOE to £100/MWh
- Supply chain and finance position not reconsidered
- Cost of energy reduction does not simply mean CAPEX reduction. CAPEX will rise for some time; OPEX and AEP will drive reduction

But…

1. Confidence in market is weakening
2. Significant investment is needed to implement cost reductions
3. Breakdown of zonal approach to Round 3 is meaning less action
4. Need clear government response back to industry
   - Market scale
   - Electricity market
   - Industrial strategy
   - Ongoing technology support
5. Need industry to help itself where it can
   - Communication
   - Collaboration
   - Courage to back itself to succeed

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