



# **The Crown Estate - Cost Reduction Pathways Project**

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# **BVG Associates**

## **Market analysis & business development**

- **Supply chain development**
- **Economic impact assessment**
- **Support to industrialisation**
- **UK ports**

## **Technical innovation & engineering analysis**

- **Support to investment in technology**
- **R&D programme management**
- **Design and engineering services**

## **Project implementation**

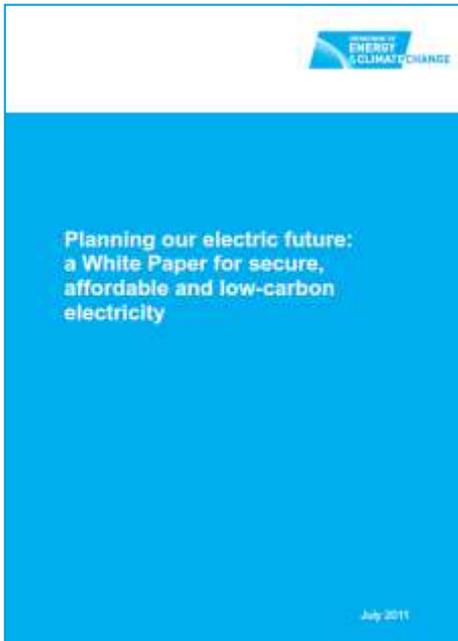
- **SCADA & condition monitoring**
- **O&M technical support**

## **Technical education**





# The Crown Estate Offshore Cost Reduction Pathways Project



## THE CROWN ESTATE




## It's a game of numbers

- 3** • Work streams; **Technology, Supply chain, Finance**
- 4** • Time periods; 2011, 2014, 2017, 2020
- 4** • Site Types; Covering different water depths, distances from shore and wind speeds
- 4** • Turbine sizes; 3-5MW-Class, 5-7MW-Class, 7-9MW-Class, 9-11MW-Class
- 4** • Industry stories; Slow progression, Technology efficiency, Supply chain acceleration, Rapid growth
- 7** • Workshops involving about 50 companies
- 20** • Key organisations interviewed from a cross section of industry

# Technology work stream: methodology

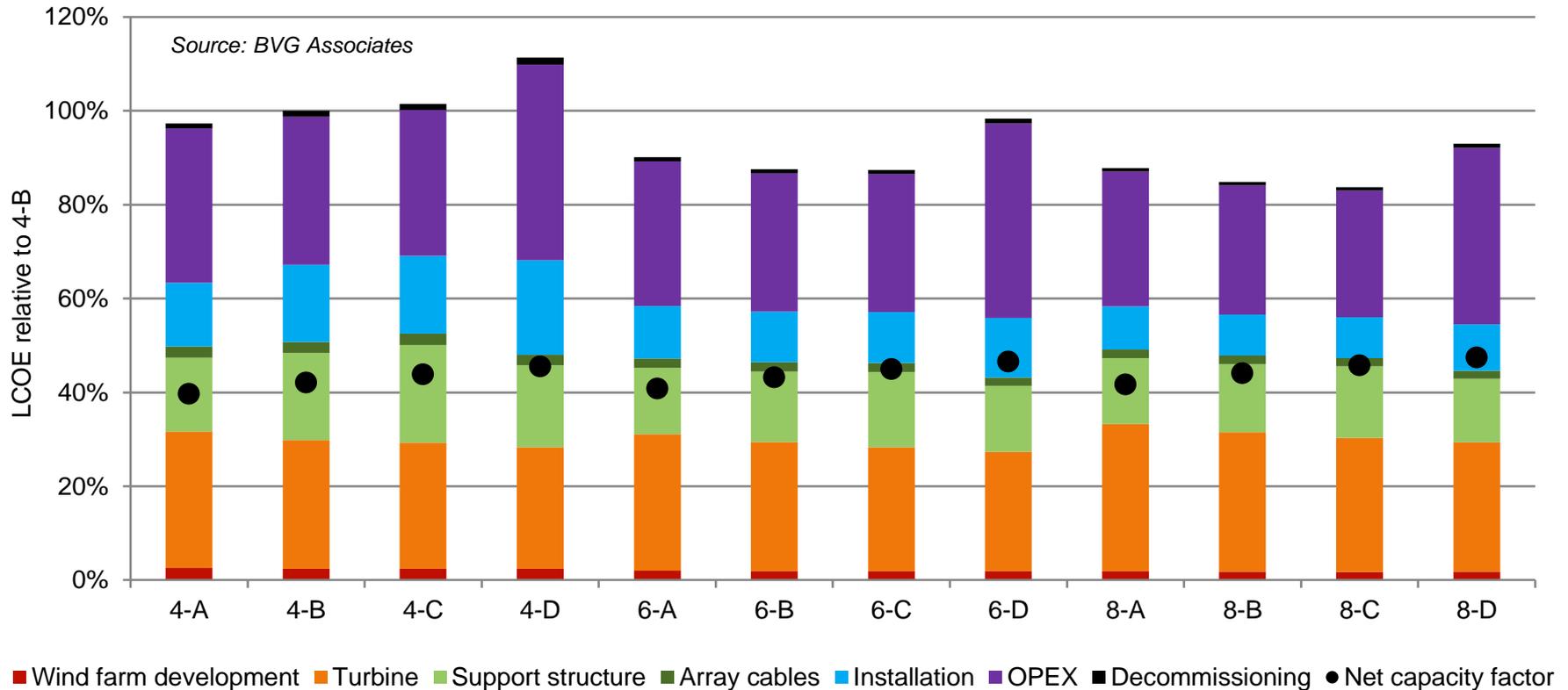
**+1% change ~ +0.7% LCOE**

**~ +0.3% LCOE**

$$\text{LCOE} = \frac{\text{Annualised CAPEX} + \text{OPEX}}{\text{AEP}}$$

**~ -1% LCOE**

## 1. Created baselines



# Technology work stream: methodology

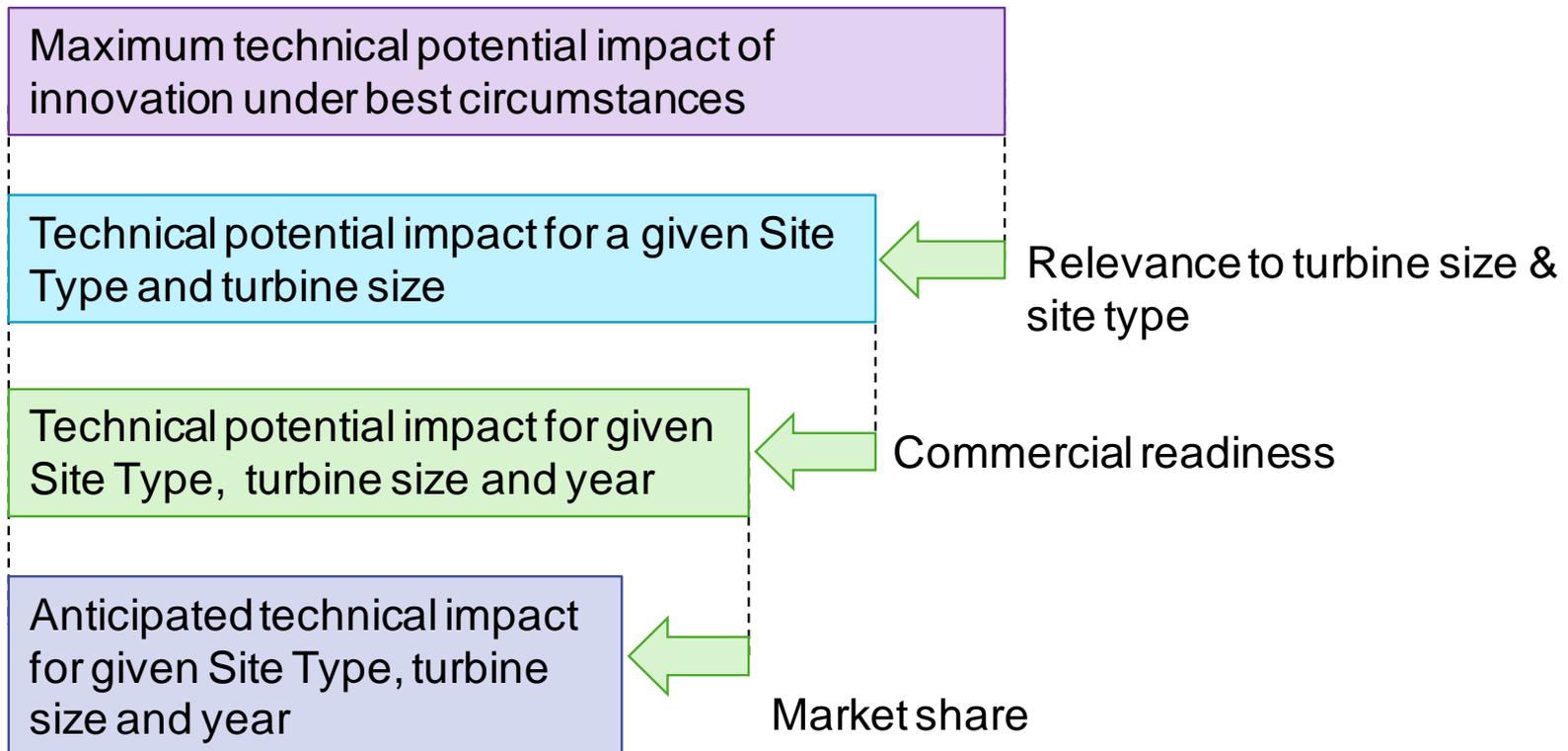
## 2. Considered (many) innovations

**Technology menu: Support Structure X-11-X-X to X-14-X-X**

Relative change in...																
Sub-element	#	Innovation	Wind Farm Development	Wind Turbine Rotor	Wind Turbine Nacelle	Support Structure	Array Electrical	Installation	Operation and planned maintenance	Unplanned service	Other OPEX	Increase in Gross AEP	Relative decrease in other turbine losses	Relative decrease in WF aerodynamic array losses	Relative decrease in WF electrical array losses	Relative decrease in WF unavailability
Main structure	5	Improvements in monopile design				3.0%		1.0%								

# Technology work stream: methodology

## 3. Moderated impact of each innovation



# Aggregated impact of technology innovations

Element	4-11-B-X	6-20-B-X	Change	Impact of change in element on LCOE	Impact of innovation in element on LCOE
Wind farm development (£/MW)	84,657	80,096	-5.4%	-0.1%	-1.8%
Wind turbine rotor (£/MW)	392,760	507,478	29.2%	2.8%	-5.6%
Wind turbine nacelle (£/MW)	631,714	702,969	11.3%	1.7%	-11.7%
Support structure (£/MW)	690,399	538,370	-22.0%	-3.7%	-3.6%
Array electrical (£/MW)	81,380	67,629	-16.9%	-0.3%	-0.5%
Installation (£/MW)	611,325	323,382	-47.1%	-6.9%	-3.0%
Construction phase insurance (£/MW)	40,000	38,000	-5.0%	0.0%	N/A
Contingency (£/MW) (Story 2)	249,223	155,895	-37.6%	-2.3%	N/A
CAPEX (£/MW)	2,781,458	2,413,319	-13.2%	-8.9%	-23.9%
Operation and planned maintenance (£/MW/yr)	26,896	21,225	-21.1%	-1.1%	-1.5%
Unplanned service (£/MW/yr)	55,053	34,049	-38.2%	-4.0%	
Other (£/MW/yr)	2,101	1,723	-18.0%	-0.1%	
Annual transmission charges (£/MW)	68,537	62,885	-8.2%	-1.1%	N/A
Operating phase insurance (£/MWh)	14,000	14,000	0.0%	0.0%	N/A
OPEX (£/MW/yr)	166,588	133,883	-19.6%	-6.2%	-1.5%
Gross AEP (MWh/MW/yr)	4,520	5,118	13.2%	-	N/A
Net AEP (MWh/MW/yr)	3,691	4,280	16.0%	-13.8%	N/A
DECEX (£/MW)	397,361	210,198	-47.1%	-0.6%	N/A
Simple LCOE (T only) (£/MWh)			-27.3%	-27.3%	-27.3%

- Chosen as current and most likely technical solution in 2011, 2020 – not a product mix
- LCOE figures do not include supply chain levers, variable WACC, and exclude developers contingency so cannot be interpreted as an holistic LCOE impact
- Still subject to continuing work – will change

## Innovation #1: Increase in turbine rating

**What:** Move from 4MW-class turbines today to 6MW turbines installed 2016 onwards

**Impact:** Turbine CAPEX + 11%  
Wind farm CAPEX -5%  
Wind farm OPEX -8%  
Net AEP + 3%  
LCOE -9%



## Innovation #2: Improvements in jacket manufacturing

**What:** Automation of welding & selective standardisation  
**Impact:** Support structure CAPEX -10%  
Wind farm CAPEX -3%  
LCOE -2%



## Innovation #3: Optimised rotor diameter

**What:** At 6MW scale, going to optimum instead of just scaling up 4MW today

**Impact:** Turbine CAPEX +12%  
Wind farm CAPEX +8%  
OPEX +0.3%  
Net AEP + 7%  
LCOE -1.2%



## **Top dozen innovations (anticipated impact on LCOE by 2020 for 6MW-scale turbines)...**

- 1. Increase in turbine rating**
- 2. Improvements in jacket manufacturing**
- 3. Optimised rotor diameter**
- 4. Improvements in blade pitch control**
- 5. Improvements in blade aerodynamics**
- 6. Improvements in range of working conditions for support structure installation**
- 7. Introduction of direct-drive drive trains**
- 8. Greater level of optimisation during FEED**
- 9. Introduction of multi-variable optimisation of array layouts**
- 10. Introduction of mid-speed drive trains**
- 11. Improvements in installation process for jackets**
- 12. Improvements in AC power take-off system design**

## And largest potential impact to 2020 & beyond (for range of turbine sizes, ignoring previous)...

1. Introduction of float out and sink installation of turbine and support structure (likely CGB)
2. Introduction of direct-drive superconducting drive trains
3. Improvements in jacket manufacturing
4. Introduction of DC power take-off (inc. impact of DC array cables)
5. Introduction of buoyant concrete gravity base foundations
6. Introduction of mid-speed drive trains
7. Introduction of multi-variable optimisation of array layouts
8. Introduction of direct-drive drive trains
9. Introduction of continuously variable transmission drive trains
10. Improvements in blade aerodynamics
11. Introduction of holistic design of the tower with the rest of support structure
12. Improvements in range of working conditions for support structure installation

## Summary

- 1. Plenty of technology innovations out there**
- 2. Progress relies on confidence to invest**
- 3. Not all about CAPEX reduction**
- 4. Combined with supply chain & finance innovations, much potential for cost reduction**
- 5. Crown Estate report will be published next few months**
- 6. Detailed and supportive engagement from industry with lots of ambition for growth**
- 7. Useful input to inform areas where governments could help catalyse innovation**
- 8. Helped us build really good modelling capability & understanding of how costs of different technologies are anticipated to evolve**



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**Thank you**