Offshore wind technology cost reduction: one year on from the biggest industry study to date

All Energy

Aberdeen, 21 May 2013

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Offshore wind technology cost reduction: one year on

Introduction

Contents

Selected clients

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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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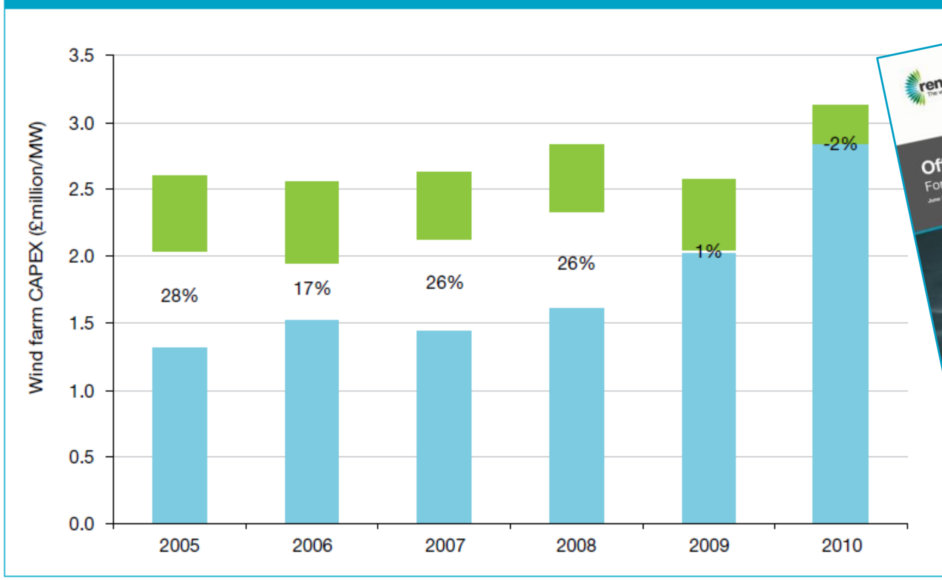
Offshore wind technology cost reduction: one year on

Health warning

CAPEX has been going up, not down

- Need to understand the past before talking about cost reduction in the future
- Between 2003 and 2010, CAPEX increased (blue bars)
- Much can be explained by change of site conditions
- Much of the rest can be explained by market conditions
- Due to increases in site wind speeds and use of larger turbines, LCOE decreased during period despite CAPEX increase
- CAPEX stabilised 2010-12

Figure 8: Gap between quoted costs and estimated and compensated CAPEX based on 2010 costs



Cost reduction pathways study

Overview

Context

- 2011 UK Government 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

- Published summer 2012

Methodology in numbers: 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)

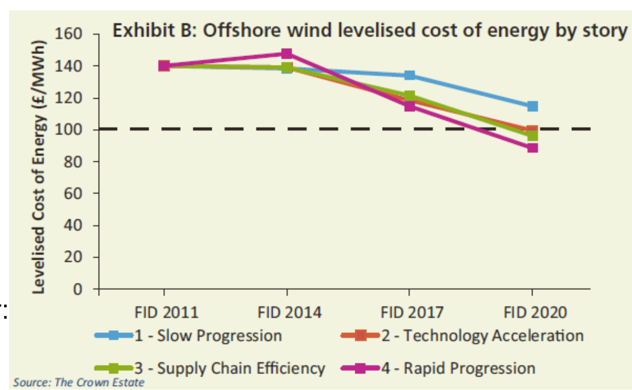
20 Deep industry interviews (4 hours +)

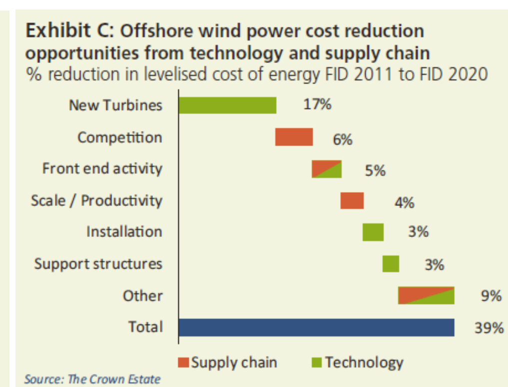
125 Industry individuals directly involved

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

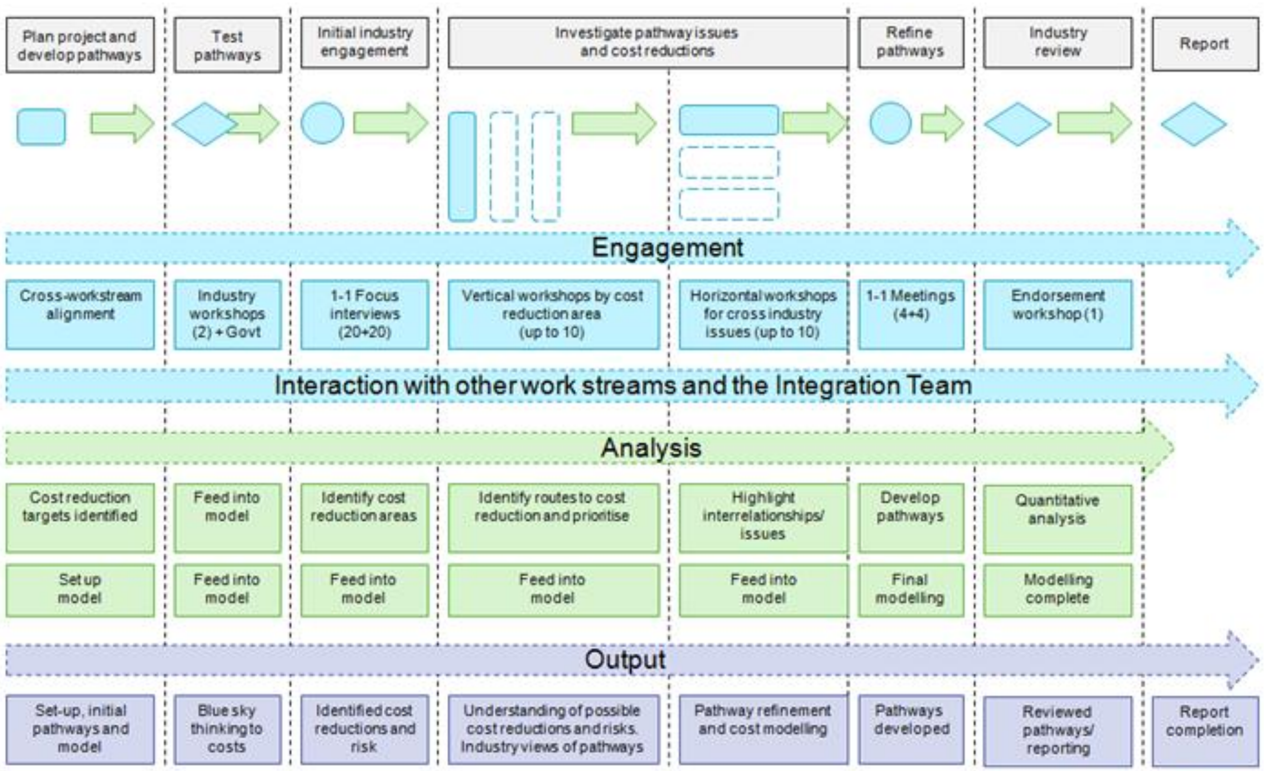




Methodology

Robust modelling and significant industry consultation

9 month process



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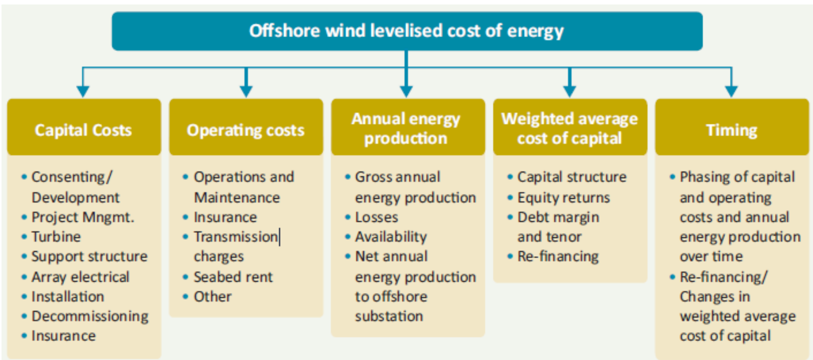
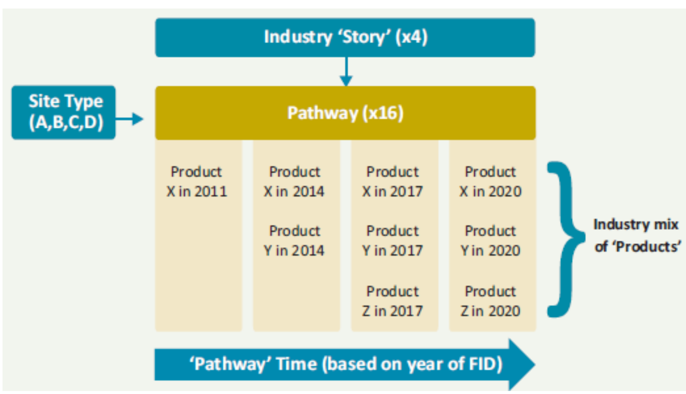
Methodology

Robust cost model and industry-supported baselines

Cost Model



- Models changes in risk, with resulting impact on financing cost
- Numerous other stated assumptions, agreed with industry



Baselines

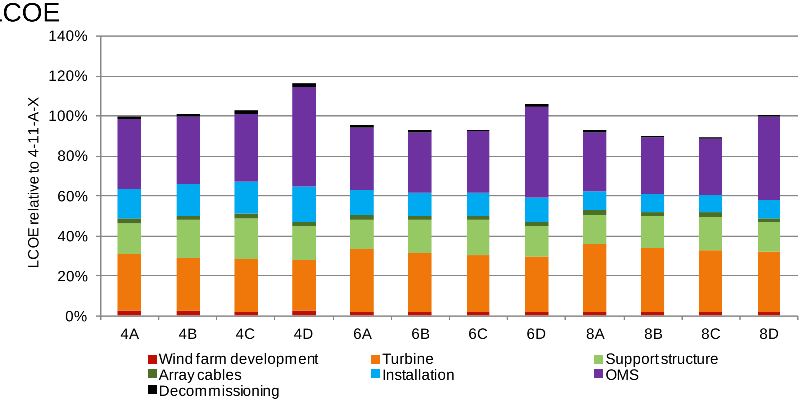
Wind turbines

Turbine MW-Class	Nominal range of power rating (MW)	Typical range of rotor diameter (m)	Diameter modelled (m)	Example current and future turbines
4MW	3 to 5	up to 145	120	AREVA M5000-116 and 135, REpower 5M and 6M, Siemens SWT 3.6-107 and 120, Vestas V112-3.0
6MW	5 to 7	145 to 162	147	Alstom Haliade 150-6MW, Siemens SWT-6.0-154
8MW	7 to 9	162 to 180	169	MPSE Sea Angel, Samsung S7.0-171 Vestas V164-8.0MW

Wind farm sites

Site Type	Average water depth (MSL) (m)	Distance to nearest construction and operation port (km)	Average wind speed at 100m above MSL (m/s)
A	25	40	9
B	35	40	9.4
C	45	40	9.7
D	35	125	10

LCOE



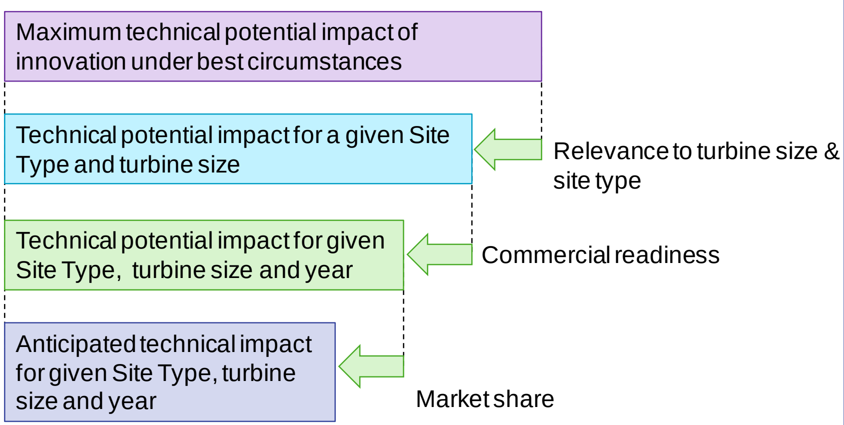
Methodology

For each independent innovation (60+ covered)

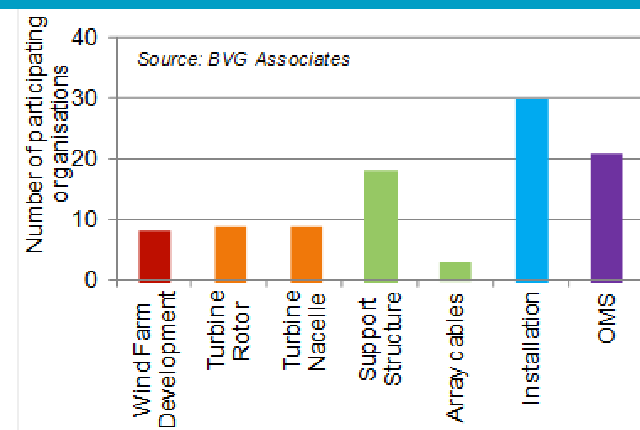
Maximum potential impact of innovation

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
Introduction of DC power take-off (incl impact of DC array cables)			4.0%		10.0%	0.5%		5.0%		1.2%			10.0%	1.0%

Impact of innovation in real world



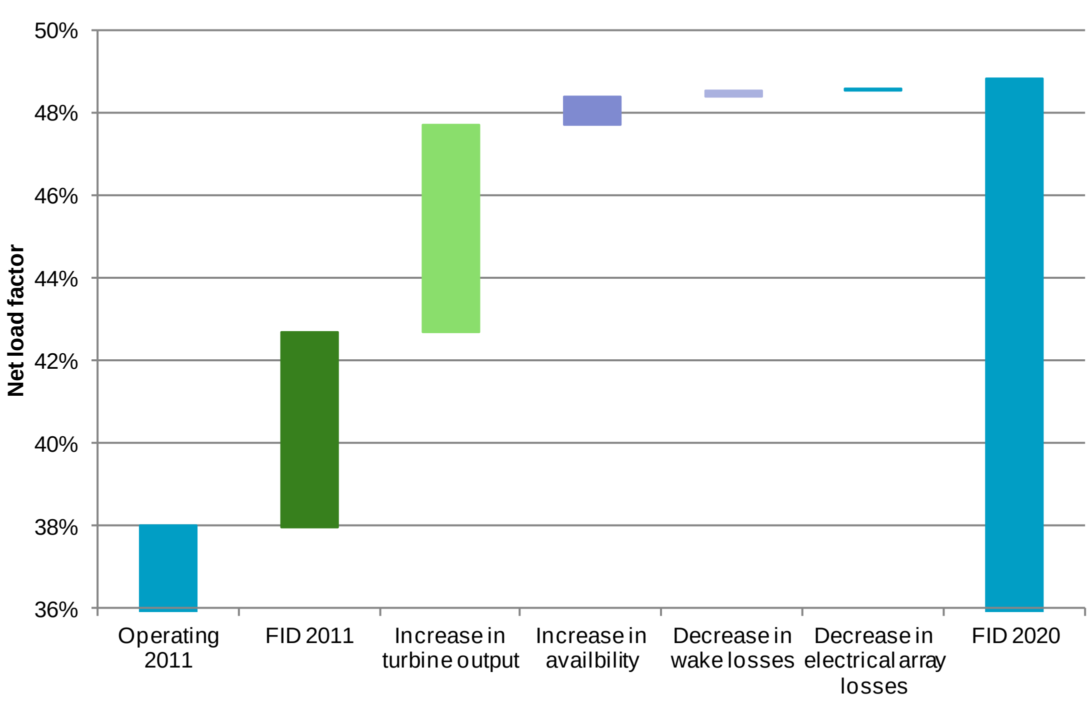
Thorough peer review (4 stages)



Example output

Increase in load factor gained mainly through improvements in turbine technology

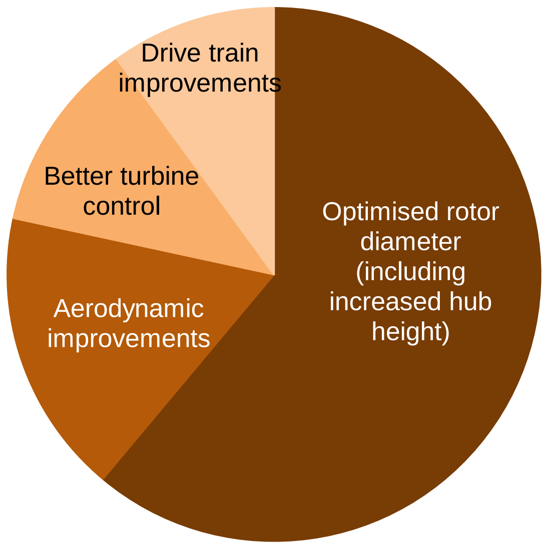
6MW-Class turbine on Site Type B



Explanation

- Majority of load factor improvement coming from developments in turbine technology.
- More than 60 per cent of this benefit comes from optimisation of rotor diameter to minimise cost of energy.

Impact from turbine improvements



Progress

one year on

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:
  - Green: Sufficient progress visible to keep on track*
  - Amber: Insufficient progress
  - Red: Little or no progress

* For £100/MWh target by FID in 2020

Development

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

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Progress

one year 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 S7.0-171 & Siemens SWT-4.0-130 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 Volatility of PM material costs
Advanced drive trains [30, 47, 59]	-9%	-0.4%		MHI trialed hydraulic solution at 2.4MW; full-scale in 2013; Samsung mid-speed solution DC generation 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 of active areodynamics	Long time / expensive for thorough verification on turbine
Improvements in blade design, manufacture and materials [19, 21, 26]	-2%	-1%		Vestas announced change in blade concept Blade Dynamics / ETI £15m project announced	Low quantity production for offshore for some time

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Progress

one year 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 developing new facility	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 TSB funded holistic tower-foundation project	Single-section towers need suitable portside facilities
Introduction of suction bucket technology [29]	-2%	-0.3%		Met stations deployed Fred Olsen progressing demonstrators	Installation not gone as planned Availability and economics 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 established Supplier-installer-developer dialogue increasing	Long lead time to implement due to typical wind farm project processes

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Progress

one year on

Installation

	Potential	Anticipated	Progress	Evidence	Challenges
Improvements in range of working conditions for installation [7, 32, 42]	-2%	-1%	Green	Areva blade lift solution one of many Access solutions for OMS progressing	
Greater levels of optimised installation vessels, processes, tooling and strategies [12, 24, 28, 33, 34, 40, 51]	-3%	-2%	Amber	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%	Green	New investment in Seatower Gov funding for concrete demo Scottish Enterprise SIFT call	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%	Green	Access solutions for higher waves progressing Higher focus on mother ship arrangements	
Improvements in OMS strategies [14, 41, 46, 48]	-2%	-1%	Amber	Slow progress on condition-based maintenance Some progress on integrating ops management tools	Across-organisation collaboration and data sharing

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Summary and reflections

one year on

Wind farm

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

Summary

- Overall, from technology perspective, starting to slip behind course to reduce LCOE to £100/MWh
- Cost of energy reduction does not simply mean CAPEX reduction. CAPEX will rise for some time; OPEX and AEP will drive reduction

1. Confidence in European markets is weaker
2. Significant investment is needed to implement cost reductions
3. Breakdown of zonal approach to UK Round 3 is meaning less action
4. Need clear governmental support to industry (UK and elsewhere)
   - Market scale
   - Industrial strategy
   - Technology support
5. Need industry to help itself where it can
   - Communication
   - Collaboration
   - Courage to back itself to succeed

Reading material

Cost of energy reduction

All free from our website

- Long and detailed analysis of cost reduction opportunity
- Part of trilogy from The Crown Estate
- Published June 2012

- Celebrating opening of our Scottish office
- Opportunities for Scotland from cost reduction
- Published November 2012

- Summary cost of energy breakdown now and in 2020
- Industry's key innovations to reach £100/MWh
- Published today