Offshore cost of energy: Forecasts based on the European Story so far…

NREL 3rd WESE Workshop

Boulder

Bruce Valpy

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Agenda

Contents

- Cost of Energy calculation
- EU CAPEX trend to date
  - Reported
  - Modelled
  - Differences
  - Causes
- EU LCOE trend to date
- Future
  - The Crown Estate study and beyond
  - System engineering opportunities

Selected clients

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- Market and supply chain
  - Analysis and forecasting
  - Strategic advice
  - Business and supply chain development
- Economics
  - Socioeconomics and local benefits
  - Technology and project economic modelling
  - Policy and local content assessment
- Technology
  - Engineering services
  - Due diligence
  - Strategy and R&D support

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Cost of energy

Basics

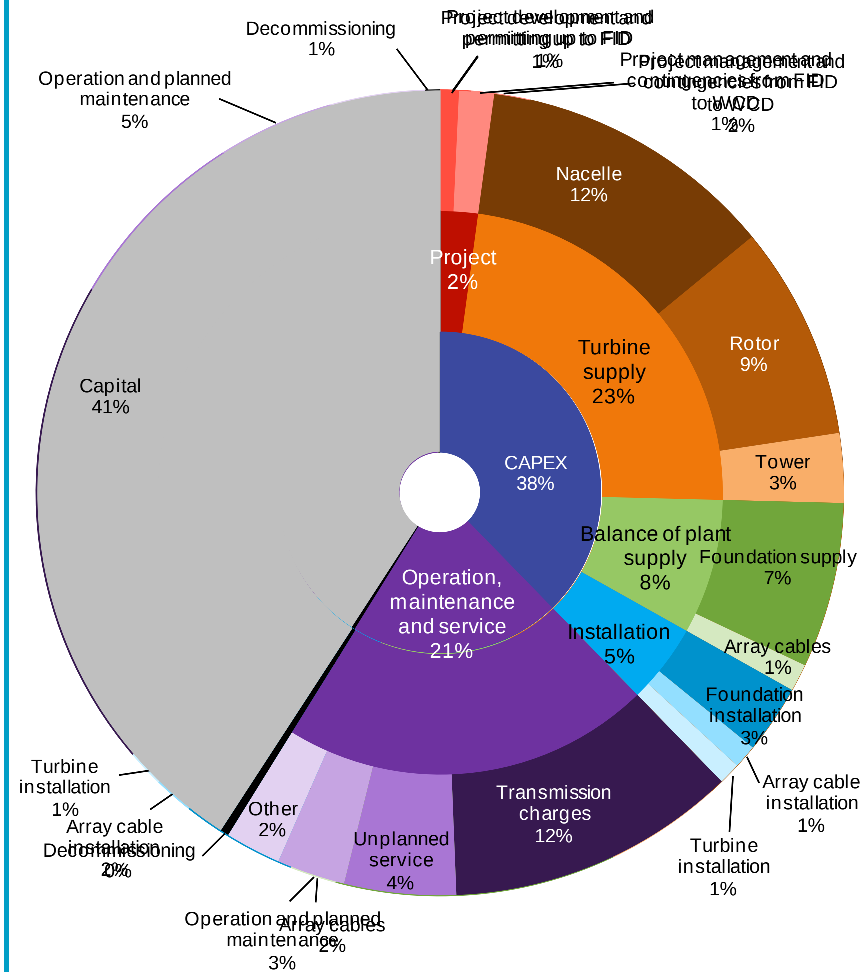
LCOE

$$LCOE = \frac{\sum_{i=-m}^{n} \left((C_i + O_i + D_i) \ / \ (1+W)^i \right)}{\sum_{i=-m}^{n} \left(E_i \ / \ (1+W)^i \right)}$$

Where:

LCOE	Levelised cost of energy in £/MWh = revenue needed (from whatever source) to obtain rate of return W on investment over life of the wind farm (tax, inflation etc. not modelled)
C_i	Capital expenditure in £ in year i
O_i	Operational expenditure in £ in year i
D_i	Decommissioning expenditure in £ in year i
E_t	Energy production in MWh in year i
W	Weighted average cost of capital in % (real) = (cost of debt x % dept) + (return on equity x equity portion)
n	Operating lifetime of wind farm (baseline 20 years)
m	Years before start of operation when expenditure first incurred
i	i year of lifetime (-m, ..., 1, 2, …n)

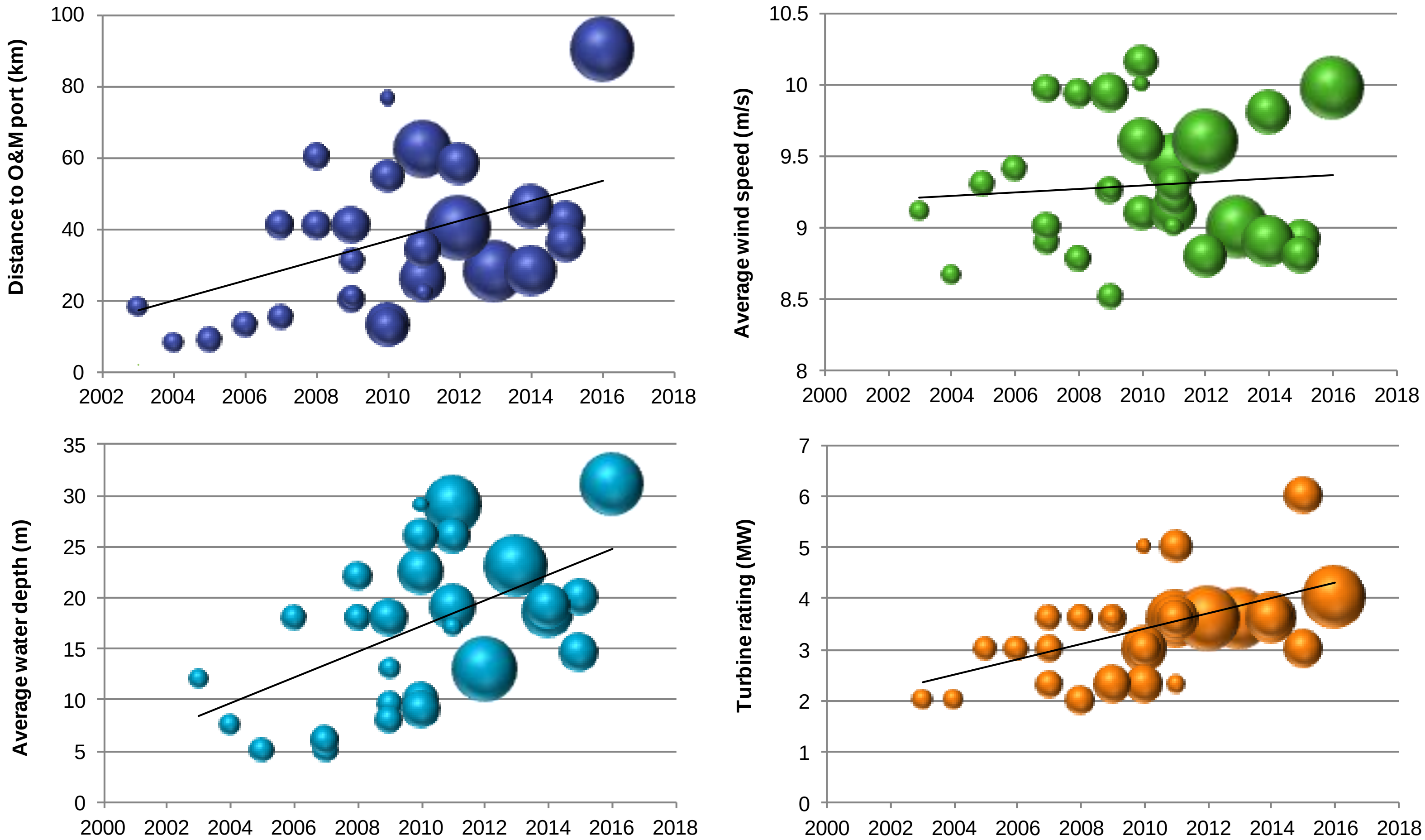
LCOE breakdown – for specific US site; FID in 2020



EU Sites

33 projects across Northern Europe

Significant variation, but upward trends in difficulty and turbine size

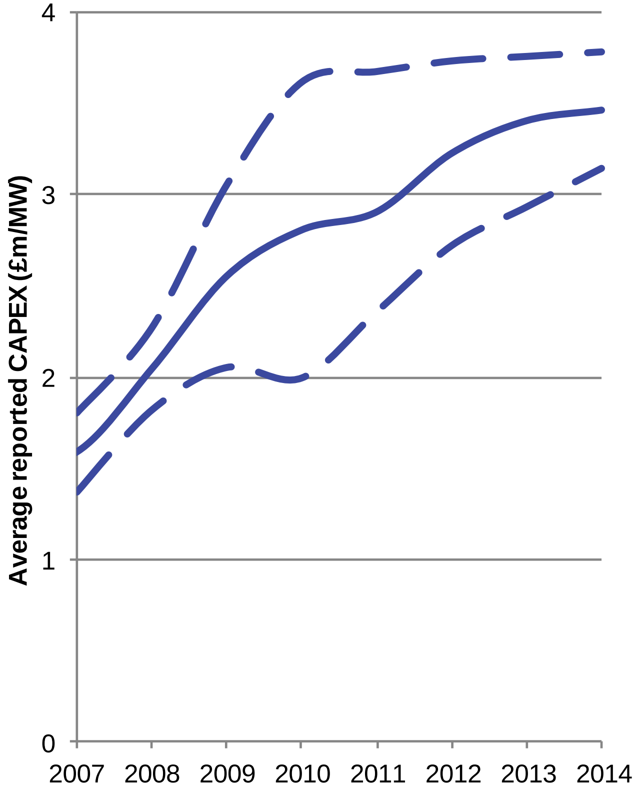


CAPEX

33 projects across Northern Europe

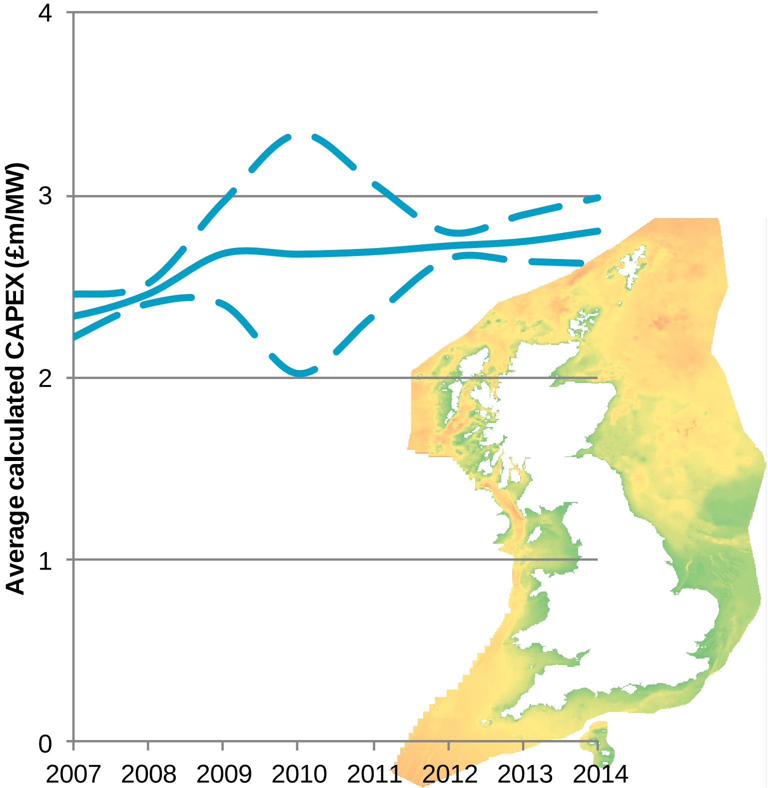
Average reported CAPEX

- Little logic in trends between bubbles – wide scatter
- Sensitivity about the use of bubbles - confidentiality
- Averaged over 5 years
- Derived a smoothed ±1SD range
- Slope due to changes in site conditions and other effects
- Not sure reached point of inflection



Average calculated CAPEX

- Used in-house spatial, multi-variable module-based LCOE model
- Assumed 2011 technology, costs and 4MW turbines (selectable)
- Difference with reported should remove effect of site conditions
- Average matches to 2%
- Period of widest variation in CAPEX matches
- Gradient quite different



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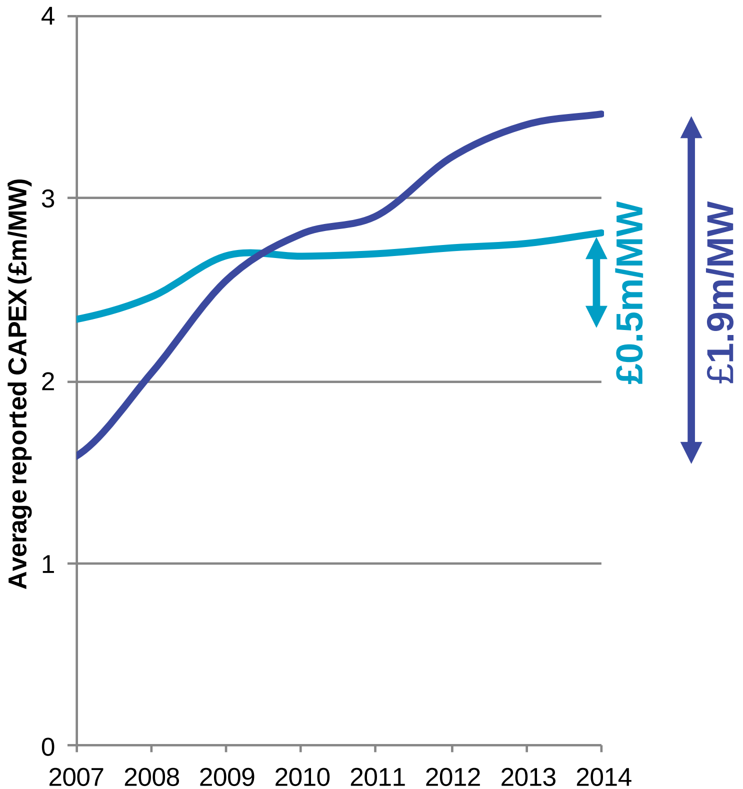
CAPEX

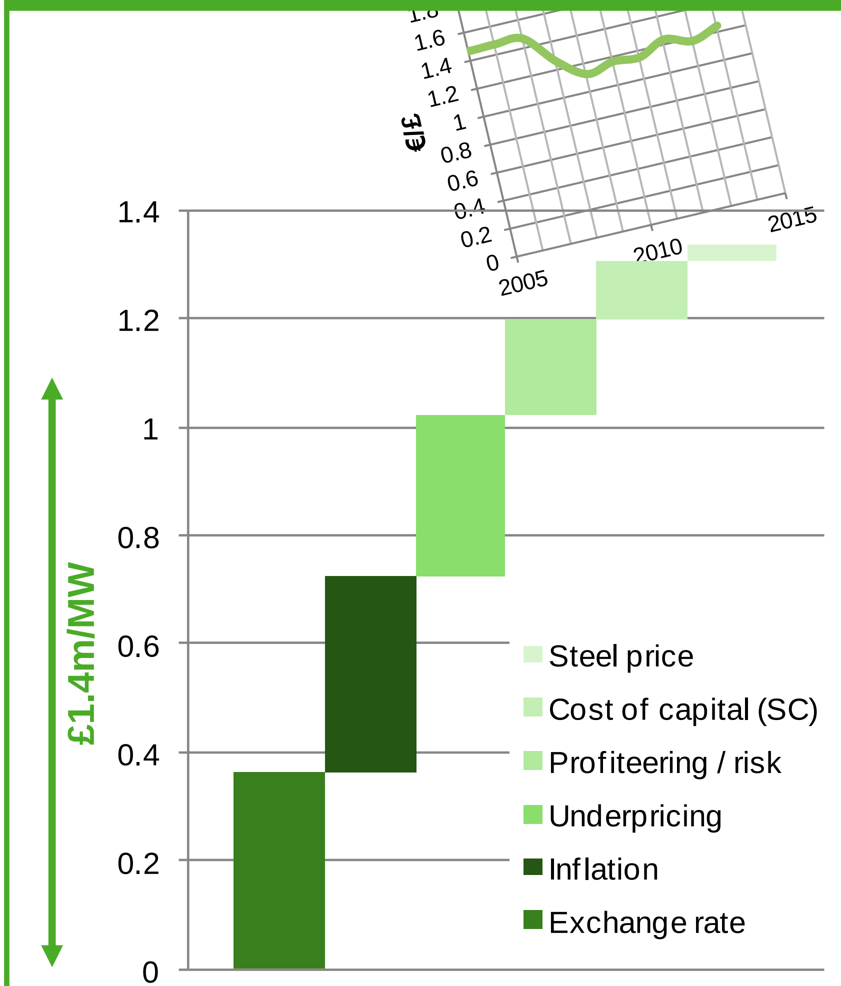
Much steeper increase in CAPEX than modelled

Much steeper increase in CAPEX than modelled

- Change in site conditions only explains about 25% of change in CAPEX
- Still £1.4m/MW gap



6 main causes of the £1.4m/MW gap?

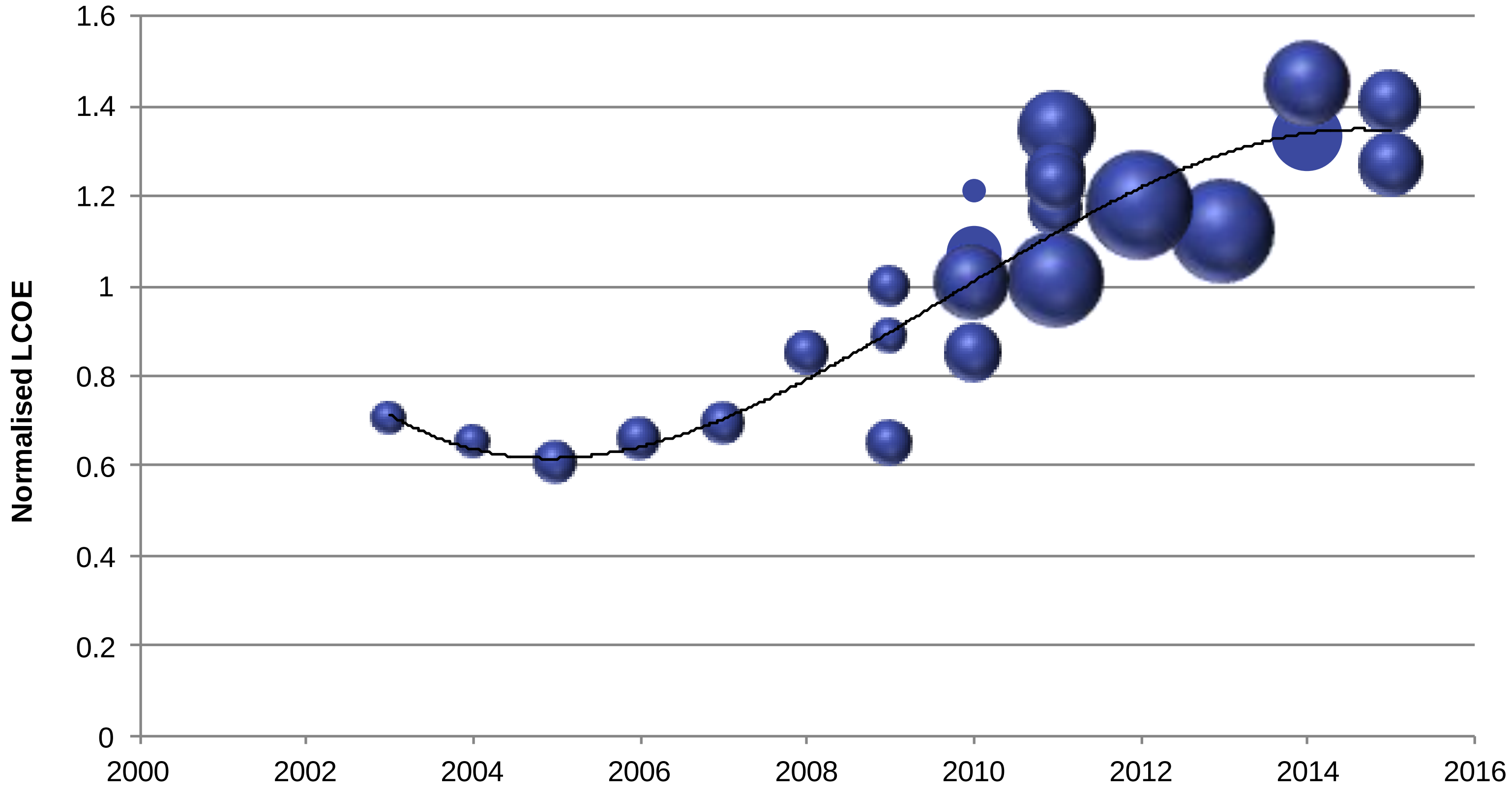


Cost of Energy

Raw trend could have levelled off

Normalised LCOE for 33 projects

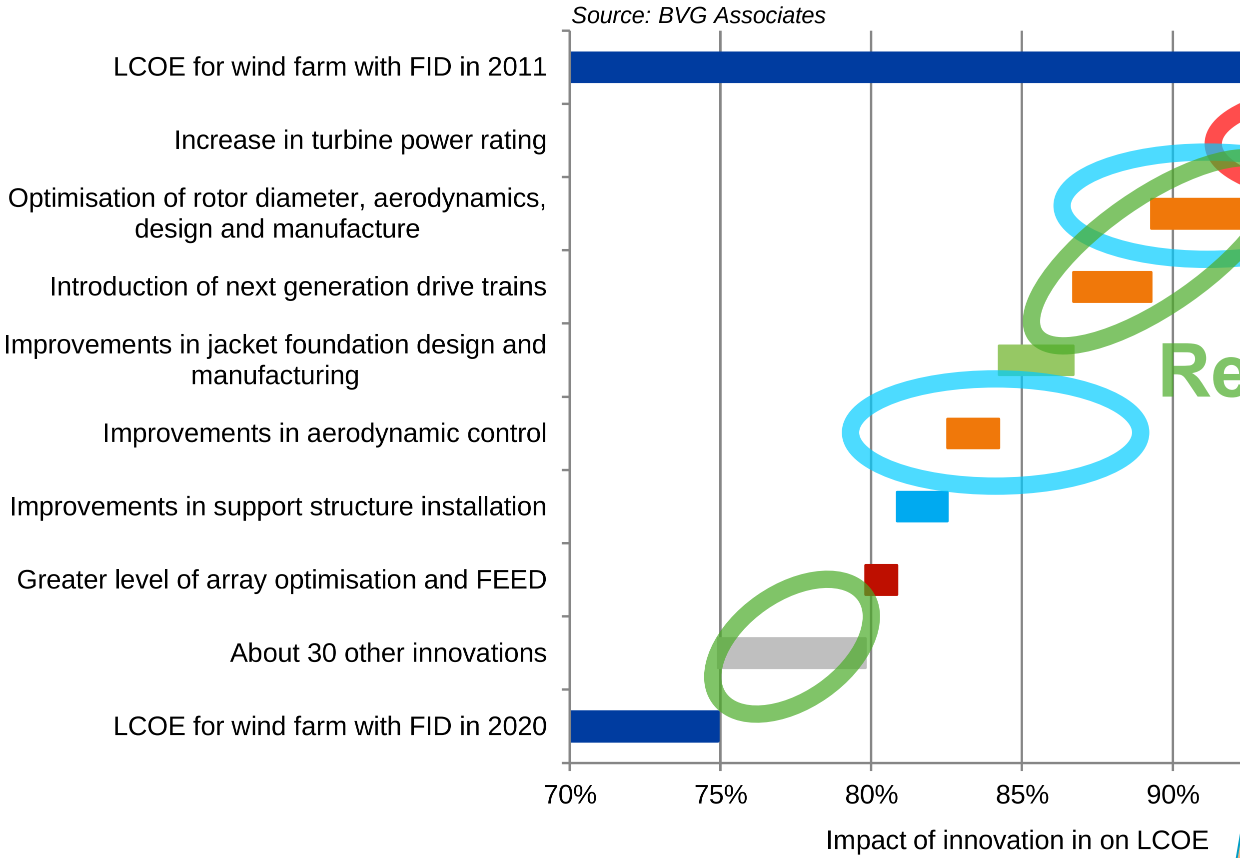
- Combines reported CAPEX with modelled OPEX and AEP
- All in 2011 terms; constant WACC



Forecast 1: to 2020

The Crown Estate Offshore Wind Cost Reduction Pathways study

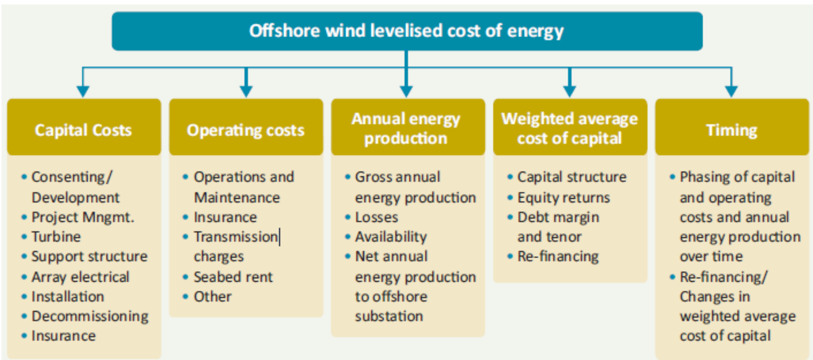
Technology



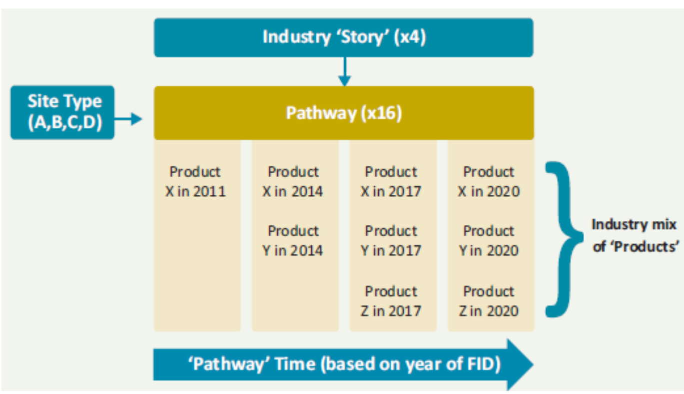
Methodology

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

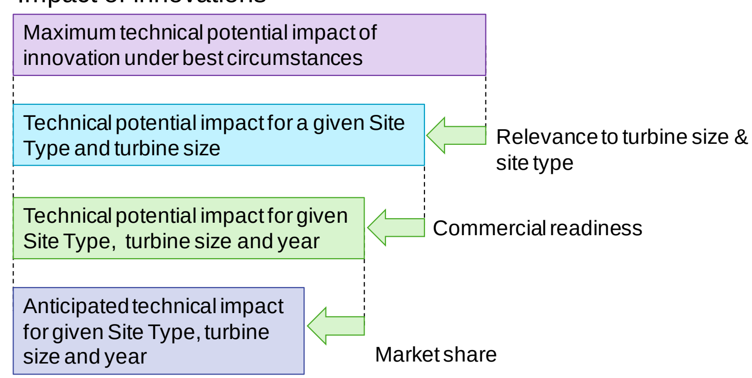
Wind turbines

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

Impact of innovations

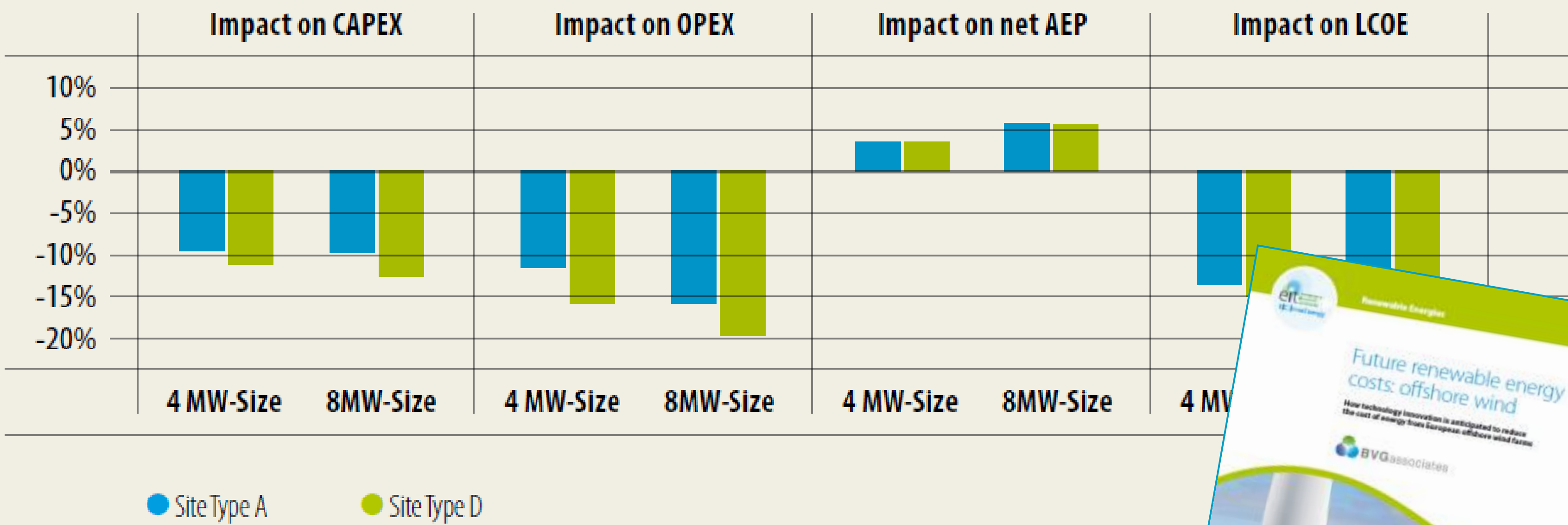


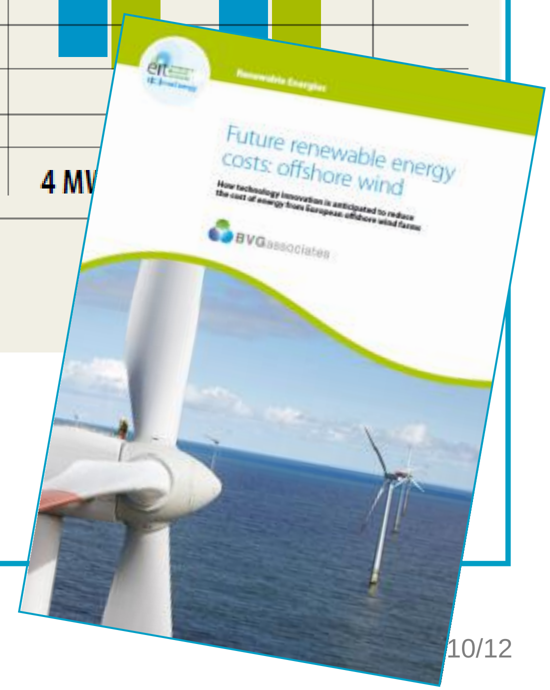
Forecast 2: to 2025

KIC InnoEnergy Future Renewable Energy Costs: Offshore Wind (June 2014)

Technology

Figure 0.1 **Anticipated impact of all innovations by Turbine Size and Site Type with FID in 2025, compared with a wind farm with the same MW-Size Turbines on the same Site Type with FID in 2014.**[1]

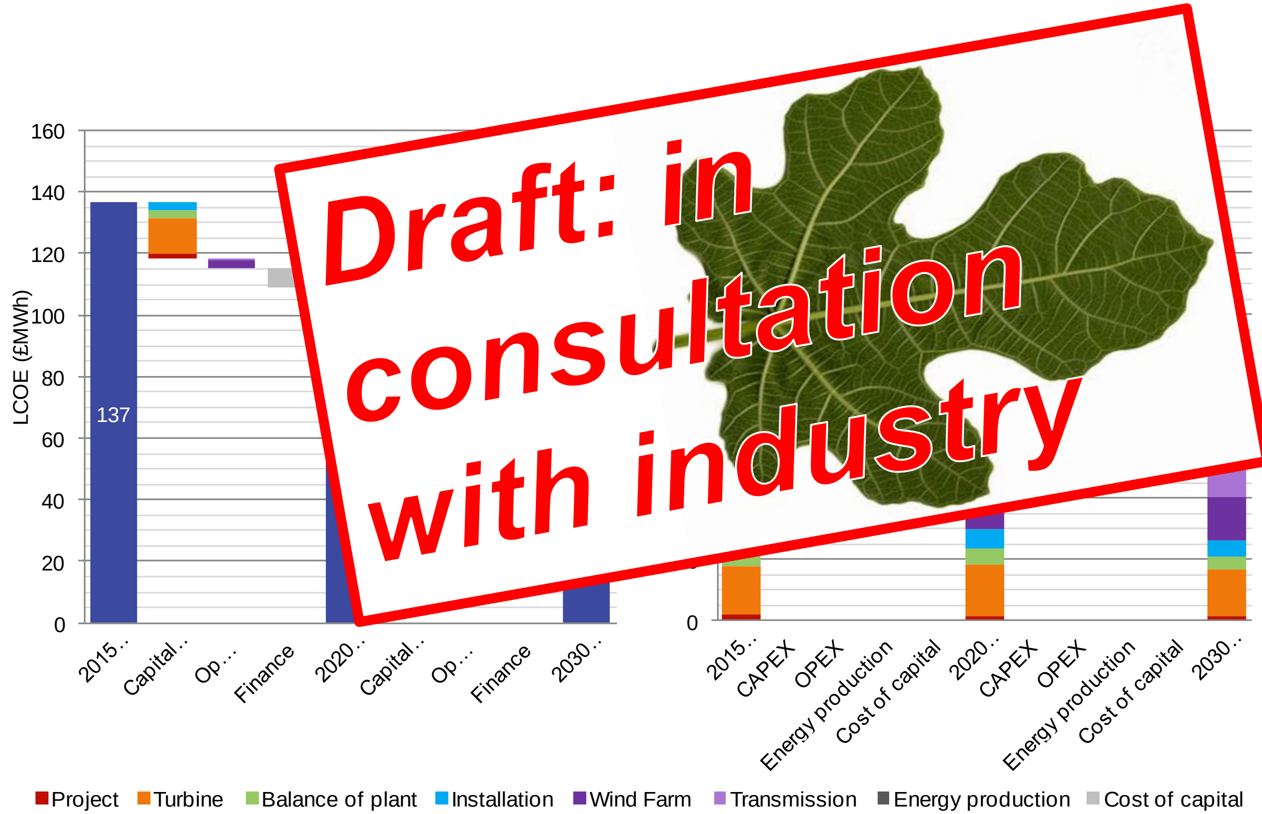




Forecast 3: to 2030

The Committee on Climate Change (*May 2015)*

Technology, supply chain and policy drivers

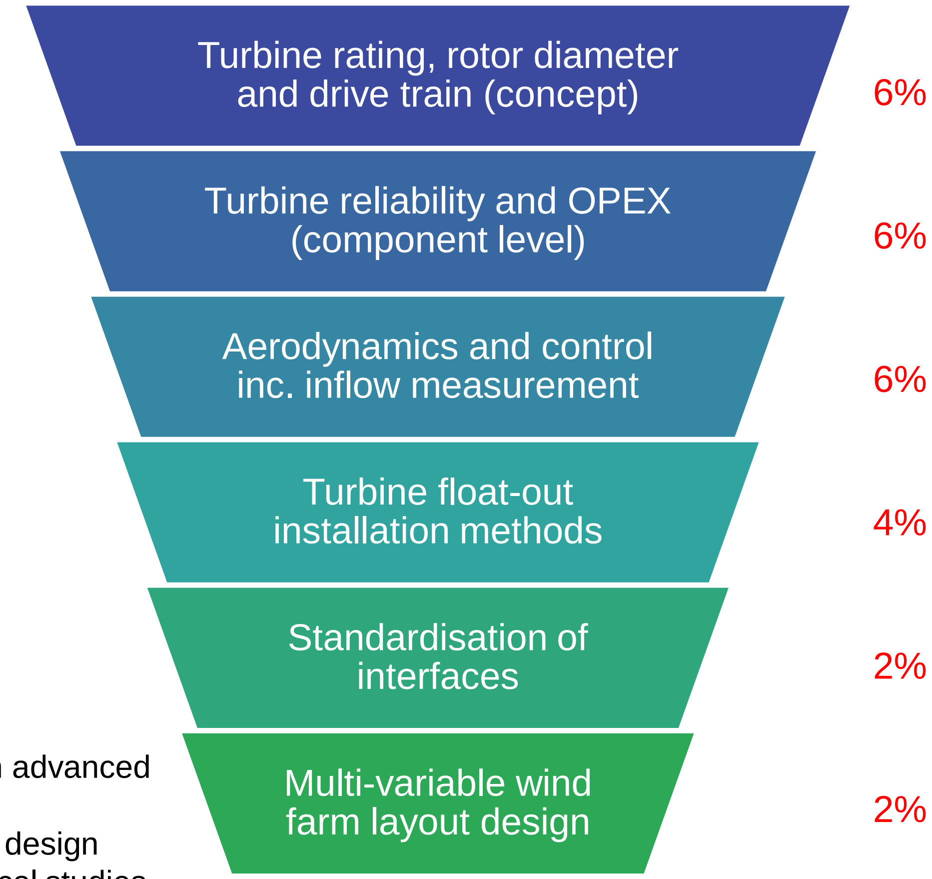


- Market scale, visibility and confidence
- Confidence in future levels of own supply
- Public funded RD&D and skills development
- De-risked investment in projects
- A well-structured supply chain
- A c…
- A…
- Strategic transmiss…

Future

System engineering approach

Systems engineering opportunities with largest remaining potential LCOE impact (to 2030)



Plus:

- Operations management with advanced weather forecasting
- Holistic tower and foundation design
- FEED geophysical geotechnical studies
- …

BVGassociates

Thank you

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

The Boathouse
Silversands
Aberdour, Fife
KY3 0TZ Scotland, UK
tel +44 1383 870 014

4444 Second Avenue
Detroit, MI
48201 USA
tel +1 206 459 8506

Charlie Nordstrom
US
cjn@bvgassociates.com

Bruce Valpy
UK
bav@bvgassociates.co.uk

info@bvgassociates.co.uk
@bvgassociates
www.bvgassociates.co.uk

BVGassociates