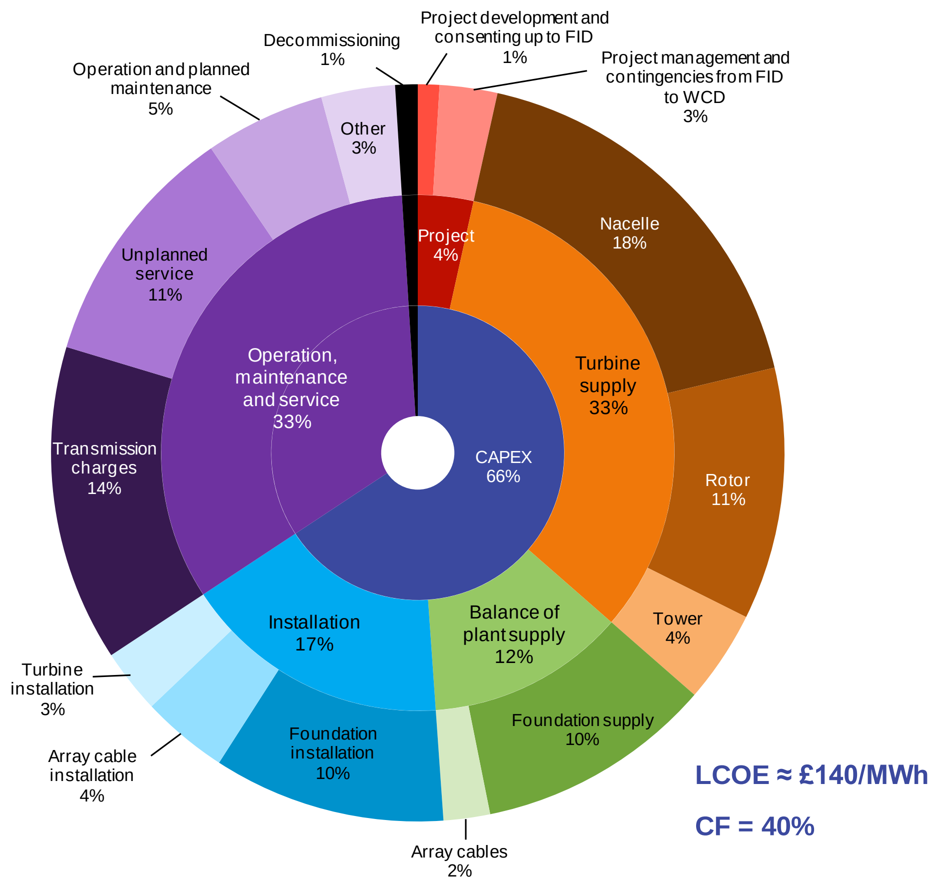
BVGassociates

Offshore wind: Industry's journey to £100/MWh

Cost breakdown and technology transition from 2013 to 2020

May 2013

Offshore wind: Industry's journey to £100/MWh



CAPEX = capital expenditure

CF = capacity factor

FID = final investment decision

LCOE = levelised cost of energy

WCD = works completion date

Full definitions of terms and scope of cost categories can be found in "Offshore wind cost reduction pathways: Technology work stream", BVG Associates, June 2012, which can be downloaded from our website at www.bvgassociates.co.uk.

Assumptions:
A typical wind farm constructed in 2013 has an installed capacity of 500MW, an average water depth of 35m, is 40km from shore and an average wind speed of 9.0m/s at 100m above mean sea level. A typical wind farm reaching FID in 2020 has a capacity of 500MW, an average water depth of 35m, is 80km from shore and an average wind speed of 9.7m/s at 100m above mean sea level.

Transmission charges include those paid to the offshore transmission operator and use of system charges. This cost therefore incorporates the transmission system supply and installation CAPEX, including export cables, offshore and onshore substations.

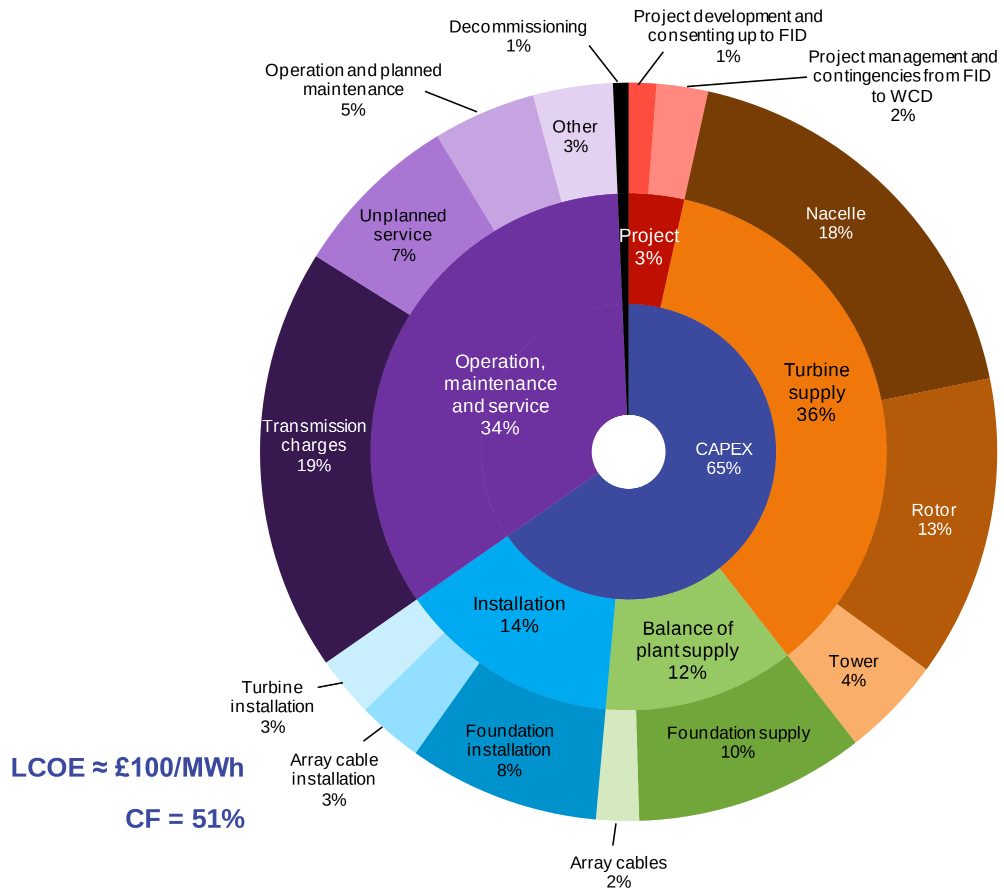


Figure 1 Proportion of LCOE for a typical wind farm constructed in 2013

Figure 2 Proportion of LCOE for a typical wind farm reaching FID in 2020

	Typical wind farm constructed in 2013	Example technology innovations	Signs of progress	Current progress	Typical wind farm reaching FID in 2020	
Project	• Scope of geotechnical and geophysical surveys defined by developer with limited supplier dialogue. • Wind farm layout designed through an iterative process involving multiple engineering disciplines. • Most design work is undertaken solely by the developer or its contractors. • A fixed meteorological mast is installed on the site to gather wind data.	• Floating LiDAR. • Multivariable array optimisation tools. • Additional investment in surveys and design data. • Innovations through early dialogue with supply chain.	• Demonstration of floating LiDAR. • Earlier involvement of suppliers in the design process of some projects.	Slow	• Supplier designs optimised based on increased level of geotechnical and geophysical surveys. • Computer design tools are used that assist with the optimisation of the wind farm layout, simultaneously considering multiple variables. • Developers consulted with component designers and installers from early in project development. • One or more floating LiDAR units supplementing or offsetting a reduced use of meteorological masts.	Project
Turbine	• 4MW class turbine using high speed doubly fed induction generators and rotor typical of onshore high-wind sites.	• Increased rated power. • Optimised rotor diameter. • Improved component manufacturing processes. • Improved aerodynamic and control design. • Increased focus on reliability and maintainability.	• Continued development, testing and demonstration of new technologies, including longer blades and new drive trains. • Increased focus on reliability (variable).	On track	• Typical urbine power rating is increased to 6-8MW. • Turbine design incoporates an increased rotor diameter relative to the capacity (increasing energy capture), medium speed or direct-drive drive trains (primarily aimed at improved reliability), as well as other aerodynamic, reliability and structural improvements.	Turbine
Foundation	• Steel monopile foundations with grouted transition pieces.	• Improved jacket design standards and manufacturing processes. • Monopiles with a diameter of more than 7m. • Self-installing concrete gravity base foundations. • Suction bucket seabed connections.	• Establishment of a joint industry project to develop the foundation design guidelines and standards. • Testing and demonstration projects including novel foundation solutions. • Foundation design for efficient cable installation.	Slow	• Steel space frame foundations, predominantly jackets. Some stretch of monopiles for deeper water and larger turbines, facilitated by new tooling. • Increasing use of concrete gravity base foundations, with start of whole turbine float-out-and-sink installation methods.	Foundation
Array cable	• 33kV 3-core AC copper cable. • Turbines are connected to a single substation that is centrally located in the wind farm. • Turbines are connected in strings of approximately 30-40MW.	• Increased cable voltage. • Improved burial standards and cable requirement specifications.	• Establishment of industry events that are focussed specifically on cables. • A number of joint industry projects starting.	On track	• An increase in cable voltage, likely to 66kV. • Possibly some used of DC array cable.	Array cable
Installation	• The foundation, array cables, tower and turbine are installed sequentially. The foundations are piled into the seabed. The processes are highly sensitive to weather. • A jackup or heavy lift vessel is used to collect foundation and turbine components from the construction port and install these at the wind farm. • A specialist cable lay vessel is used for the array cable surface lay with simultaneous burial using a plough or separate burial using an ROV. • Cables pulled through internal or external J-tubes.	• Increased range of operating conditions for foundation, turbine and cable installation. • Optimisation of installation vessels and sea fastenings. • Improved installation processes.	• Development of new installation vessels specifically for jacket foundation installation. • Trials of technologies for increasing range of lifting conditions for blades. • Market acceptance of new monopile and cable installation techniques.	Slow	• Use of bespoke installation vessels each optimised for its task. • Vessels incorpoate technologies allowing installation in increased wind and wave conditions, reducing weather downtime.	Installation
Operation, maintenance and service	• Time-based maintenance and reactive service strategies are predominantly used, where repairs are undertaken in order to rectify a fault. • Transfer of personnel to turbine takes place from a crew transfer vessel onto access ladders attached to foundation.	• Development of prognostic condition based monitoring systems and risk-based maintenance strategies. • Improved personnel access to turbines. • Improved inventory and service management.	• Technology transfer of condition based monitoring prognostic techniques from other industries. • Demonstration projects using new access solutions. • Uptake of specialist crew transfer vessels and systems.	Slow	• Integration of condition based monitoring systems to the turbine rotor and drive train allow use of more proactive maintenance to avoid expensive retrofits. • Access solutions, fitted to crew transfer vessels, allow transfer to the turbine in increased wind and wave conditions. • Use of offshore crew accomodation to reduce travelling time.	Operation, maintenance and service

BVG Associates

BVG Associates is a technical consultancy with expertise in wind and marine energy technologies. The team probably has the best independent knowledge of the supply chain and market for wind turbines in the UK. BVG Associates has over 130 career years experience in the wind and marine energy industries, many of these being "hands on" with wind turbine or marine device manufacturers in leading engineering, purchasing and production departments. BVG Associates has consistently delivered to customers in many areas of the onshore and offshore wind energy sectors, including:

- Market leaders and new entrants in wind turbine supply and UK and EU wind farm development
- Market leaders and new entrants in wind farm component design and supply
- New and established players within the wind industry of all sizes, in the UK and on most continents
- Department of Energy and Climate Change (DECC), RenewableUK, The Crown Estate, the Energy Technologies Institute, the Carbon Trust, Scottish Enterprise, Highlands and Islands Enterprise, Fife Council and other similar enabling bodies
- Developers, corporate and private landowners, wind farm owners, and
- Investors and technology innovators.

BVG Associates has produced a number of influential public reports for public and private sector clients. Many of these are available for download from our website (www.bvgassociates.co.uk).

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