THINK ACT

BEYOND MAINSTREAM

October 2016

Offshore wind power

Takeaways from the Borssele wind farm

Roland Berger

THE BIG 3

EUR 87/MWh

Strike price for Borssele I and II wind farms, including grid connection.

Page 4

54%

Levelized cost of energy drop between 2010 and 2016.

Page 4

150 GW

Potential offshore wind capacity in Europe in 2030.

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Cost reductions have led to a breakthrough in offshore wind.

The surprisingly low outcome of the tender for the Borssele I and II wind farms is excellent news for the entire offshore wind sector. It was not so long ago that the sector was trapped in a vicious circle: governments hesitant to support this expensive form of renewable energy, and industry reluctant to invest without reliable government support. The Borssele tender demonstrated that the sector is achieving significant, structural cost reductions. Offshore wind power is becoming competitive and has secured its place in the future fuel mix. Players in all offshore energy sectors can benefit from the takeaways of the Borssele experience.

VICIOUS CIRCLE

The development of offshore wind started with the first wind farm constructed 2.5 km off the coast of Vindeby in Denmark in 1991. The original rationale behind the development of wind energy offshore was sound: On land, space is limited, while at sea space is abundant. Turbines, moreover, are invisible when they are placed far enough from the coast. Winds are stronger and more constant at sea, meaning higher output rates.

However, installing and running turbines at sea was expensive. The first offshore wind farms were developed at a levelized cost of electricity (LCOE) of ~EUR 150/MWh, including grid connection – almost twice the cost of onshore wind. Serious mishaps in offshore construction and operation, together with higher financing costs (banks saw the risks as high) drove LCOE further up to ~EUR 190/MWh by 2010. Industry undertook several joint cost-reduction initiatives, like the Offshore Wind Accelerator in the UK, and the Far- and Large Offshore Wind program in the Netherlands. The industry also agreed on a 40% cost reduction target to bring costs down to EUR 115/MWh by 2020.

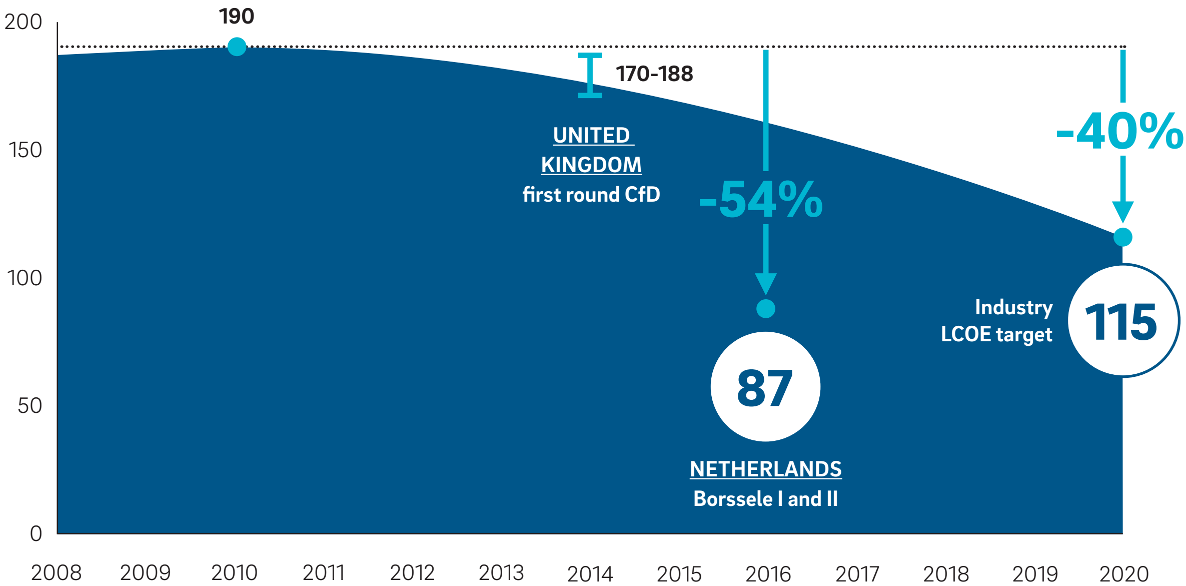
Nevertheless, governments remained hesitant to continue their support of this expensive form of renewable energy, which had no guarantees that it would ever reach competitiveness. In most countries, this caution led to insufficient and unstable support regimes. Without reliable support, industry was reluctant to invest. The offshore wind sector found itself trapped in a vicious circle.

BREAKTHROUGH

In September 2013, something happened in the Netherlands that drastically improved the fate of offshore wind. More than 40 Dutch organizations across government, industry, trade unions, NGOs and financial institutions signed the Energy Agreement. At the time, with a mere 4% of renewable energy in its energy mix, the Netherlands dangled at the bottom of the list of EU countries in terms of transition to renewable energy. Together, the 40 Dutch organizations agreed to change this by pledging to achieve 16% renewable energy by 2023. To do this, one of the firm objectives of the Energy Agreement was to expand the Dutch offshore wind capacity from 1.0 to 4.5 GW by 2023 via a reliable rollout that brought 700 MW online per year in the 2019-2023 period.

A

LCOE DEVELOPMENT AND STRIKE PRICES, INCLUDING GRID CONNECTION [EUR/MWh] [1]



1 The industry LCOE target was set by the Crown Estate in 2011: GBP 100/MWh for final investment decision (FID) in 2020. As FID typically happens 1 year after the subsidy tender, for an equal timing comparison with the strike prices, the target should be achieved in 2019. The Borssele strike price includes EUR 14/MWh for the grid connection

Source: Crown Estate; RVO; Roland Berger analysis

The Dutch Ministry of Economic Affairs decided to use the competitive tender methodology that had already been successfully pioneered in Denmark: the government executed spatial planning, arranged permits and collected environmental data for the wind farm plot. Consequently, the subsidies for the wind farm were granted to the lowest bidder in a fully competitive tender. TSO TenneT was assigned to develop the grid connection for the entire capacity roll-out until 2023.

The first tender under the new Dutch support regime for the Borssele I and II wind farms attracted overwhelming interest from investors and project developers. Tender information sessions were attended by hundreds from around the world. In the end, seven consortia placed bids. The winner was announced in July 2016 to be DONG Energy, at an average strike price of EUR 73/MWh – which surprised almost everyone in the industry. The grid connection costs were published at EUR 14/MWh, leading to a total cost of **EUR 87/MWh**.
→ A

This strike price was **54%** below the cost level of 2010, and was much lower than the industry target for 2020. It was also much lower than the first round of contracts for difference (CfD) in 2014 in the UK. Certainly, there had been signs that things were changing. In February 2015, Vattenfall won the subsidy tender for the Horns Rev III wind farm for EUR 103/MWh, excluding grid connection. In August 2016, Vattenfall also won the tender for the Vesterhav North and South wind farms for EUR 64/MWh (also excluding grid connection) – these two farms are only 6 km from the coast compared to the 23 km of Borssele, which makes their strike prices comparable. The Borssele strike price represents a major victory for cost reduction in the sector.

What lies behind the surprisingly low strike price for Borssele? What can players in the offshore energy sectors learn from the Borssele experience? And what does it mean for the future development of the industry?

The causes of the cost reduction are mostly structural.

To understand what lies behind the very low strike price in Borssele, we need to analyze the main cost drivers and how they have changed in recent years. → B The best way to illustrate the impact of the recent changes is to compare Borssele with the circumstances at the time of the non-competitive first round of contracts for difference in the UK in 2014, which awarded subsidies to five different wind farms. This comparison reveals that most of the changes in the main cost drivers were structural:

LONGER TRACK RECORD

At the beginning of 2014, offshore wind turbines in Europe had churned out 104 TWh. At the beginning of 2016, this amount had almost doubled to 180 TWh, leading to more mature industrialization of turbine and foundation construction and installation. This in turn lowered the perception of risk of financiers, leading to considerably lower financing costs.

TECHNICAL/OPERATIONAL INNOVATION

For a long time, innovation was focused on adapting onshore wind turbines to offshore conditions, and on adapting the offshore oil & gas foundation, transport and installation experience. Between 2014 and 2016, important advances were introduced, for instance in turbine reliability and through the successful use of the bolted, instead of the less reliable grouted connection between turbine mast and foundation.

MORE COMPETITION IN TURBINES

Project developers need an uptime guarantee of at least five years from a turbine supplier to be able to finance a wind farm. Turbine suppliers must have a large balance sheet to offer such a guarantee given the size of offshore wind projects. By early 2014, only Siemens and Areva were able to offer fully bankable turbines. Since then, three turbine suppliers (re)entered the market. Thanks to its joint venture with Mitsubishi in 2014, MHI Vestas was once again able to offer turbines that were bankable as of 2015. This also applied to Senvion, which was sold by Suzlon to Centerbridge Partners in 2015. And Alstom, after having been acquired by GE, entered the market with a bankable turbine in 2015. As a result, the competition between turbine suppliers became much fiercer.

LARGER TURBINES

Over the course of 2015, Siemens, MHI Vestas and GE/Alstom started to offer turbines commercially in the 6-8 MW class, leading to significant scale economies compared to the previous 3-5 MW class turbines. Instead of two foundations, only one (larger) now needs to be installed to deliver 8 MW. Maintenance costs are also comparatively lower per MW.

COMPETITIVE BIDDING FOR SUBSIDY

The first round of CfDs in the UK in 2014 was non-competitive. For the Borssele I and II wind farms in the Netherlands, the competitive tender methodology was used.

MORE PIPELINE AND SUPPORT CERTAINTY

While the 2010 Renewable Obligations legislation in the UK provided stability, the move to the CfD system in 2014 created uncertainty among investors. The Dutch Energy Agreement facilitated the development of legislation necessary to provide full regulatory certainty for wind farms that will go online in the 2019-2023 period.

MORE GRID CONNECTION CERTAINTY

In the UK, the responsibility for developing the grid connection lies with the wind farm developer. In the Netherlands, the responsibility for developing the grid connection has been granted to a third party, TSO TenneT, which gained a lot of experience through its German operations. Moreover, TenneT has standardized the grid connections of each wind farm of the 3,500 MW roll-out in the Netherlands, leading to even more certainty.

LARGER WIND FARMS

With 700 MW, the combination of Borssele I and II was the largest wind farm that was ever put out in a tender. Larger wind farms enable cost reductions from scale economies and the mobilization and demobilization of expensive offshore transport and installation equipment.

Between 2014 and 2016, cyclical effects from lower interest rates and steel and oil prices also led to cost reductions:

LOWER INTEREST RATES

Interest base rates continued to drop in the 2014-2016 period, leading to lower capital costs for offshore wind farms.

LOWER STEEL PRICES

Lower steel prices helped lower costs for turbines and foundations, therefore lowering LCOE.

LOWER OIL PRICES

Due to a significant drop in oil prices, many offshore oil & gas activities were discontinued because they were no longer profitable. The resulting overcapacity in offshore installation equipment led to lower prices for installation of offshore wind farms.

The cyclical cost drivers – interest rates, steel and oil prices – may rise again, causing a temporary increase in LCOE. But because of the strong structural reductions – proven at Borssele – offshore wind costs will continue to fall overall. Turbines will continue to increase in size: Siemens has hinted at a turbine larger than 10 MW; LM Windpower launched a wind turbine blade of 88.4 meters in length. Manufacturers will increasingly be able to industrialize the production of turbines and foundations in larger series due to increased standardization. The maintenance services industry will further develop through additional players and more advanced technical experience. The track record of successfully installed and operated wind farms will continue to improve the risk perception among financiers, further reducing financing costs. And R&D breakthroughs, for instance for new turbine and foundation concepts, will provide additional LCOE reductions.

B

CHANGES IN MAIN COST DRIVERS AND THEIR IMPACT ON LCOE

Between 2014 and 2016

	UK - 2014 First round CfD	NL - 2016 Borssele I and II	Indicative impact on LCOE
STRUCTURAL			
Strike prices [EUR/MWh, incl. grid conn.]	**170-188**	**87**	
Track record [TWh]	104	180	↘↘
Technical/operational innovation	ongoing	ongoing	↘↘
Bankable turbine suppliers [#]	2	5	↘↘
Turbine capacity [MW]	3-4	7-8	↘↘
Competitive bidding for subsidy	no	yes	↘↘
Pipeline and support certainty	no	yes	↘↘
Grid connection certainty	no	yes	↘
Wind farm capacity	90-400	700	↘
CYCLICAL			
Interest base rate [German bond 10 years]	~2%	~0%	↘↘↘
Steel price [EUR/t]	410-450	320-340	↘
Oil price [Brent, USD/bbl]	57-107	36-50	↘

Seven takeaways for the offshore energy sector.

The Borssele experience is excellent news for the entire offshore wind sector. Governments have their proof that offshore wind can deliver a low-cost renewable energy supply; they can now legitimately include offshore wind in their energy policy plans. Incumbent companies will benefit from strong and more stable growth, and should start preparing for global expansion if they have not yet done so. Many opportunities for new entrants will also arise as the market grows.

However, the sector should carefully consider what Borssele revealed about how the game is changing. We have extracted the major takeaways from Borssele's success for each of the main players in the offshore wind sector. And Borssele also has important lessons for the offshore oil & gas sector.

1. GOVERNMENTS

Governments should adapt their support regimes to the system so successfully pioneered by Denmark and further refined by the Netherlands. Germany has already moved towards competitive tendering, and the UK is considering the same. This will put new cost pressure on the entire supply chain. Governments have to monitor whether the supply chain is not pushed too far, leading to no or delayed financial closes on projects. Governments should also offer long-term certainty for the capacity pipeline and the grid connection. Furthermore, they should grant subsidies – while still necessary – and provide locations through a transparent, competitive bidding system. Finally, they should tender larger wind farms as well.

2. ENERGY COMPANIES

As competition becomes fiercer, energy companies will need a certain minimum market share to reap scale economies in financing and sourcing. Larger projects require sufficient scale to be able to manage a portfolio of projects to reduce risks and ensure optimal utilization of resources. Consolidation should therefore be expected.

Fiercer competition in auctions, where the winner takes all, requires intelligent strategies. DONG has effectively integrated the engineering, procurement, construction and installation (EPCI) contractor role into its multi-contracting strategy. This provides DONG with a thorough understanding of cost structures throughout the supply chain. Furthermore, it allows the company to wield its sourcing power for the negotiation of preferential prices for the main components. Integrating the EPCI role requires excellent project management skills to be able to manage the interfaces. Other energy companies should carefully consider embracing the multi-contracting strategy.

3. FINANCIERS

Financiers of the construction of wind farms should further develop their in-depth understanding of the risks involved in each part of the supply chain. With more competition between financiers, such understanding will become critical to be able to strike the optimal balance between risk and return. Financing of operational wind farms will become a commodity with relatively low profitability, as the track record of fully operational wind farms will become even more robust. Infrastructure funds are well-placed to finance these assets.

4. EPCI CONTRACTORS

Pressure on prices requires even more effective management of wind farm EPCI projects and close cooperation across the supply chain. Scale effects in project management and purchasing will lead to further consolidation among EPCI contractors. More energy companies may follow DONG's example and also assume an integrated EPCI role. The same holds for EPCI contractors. Currently, EPCI contractors are often not in charge of an entire project. Typically, three to five EPCI parties manage the work of various elements of the offshore wind project. A single EPCI contractor, therefore, would attract offshore wind farm developers and their financiers.

Long-term frame contracts with component suppliers can lead to significantly lower costs, however they are only possible if the EPCI contractor has a reliable pipeline of projects. Such contracts tend to be too inflexible for short-term market pressures. It will require good business judgment to determine when and how to choose flexibility versus long-term cost reduction.

EPCI contractors should find the optimal balance between the "carrot" and "stick" approaches: subcontractors should be given an incentive to outperform the contract and be held accountable to pay liquidated damages in case of mishaps or time overruns. However, complex negotiations of liquidated damages should not get in the way of effective project management and raise transaction costs.

5. COMPONENT MANUFACTURERS

In manufacturing turbines, foundations and other components, long-term framework contracts will become indispensable to efficiency and scale economies and to avoid the fluctuation of market demand due to large project size. A strong push for standardization is expected in the name of further cost reductions. Companies need scale to be able to negotiate framework contracts and influence the standards. The move to larger 10+ MW turbines will require the entire supply chain to enlarge and optimize the design of components and equipment, offering opportunities to new entrants. Groundbreaking innovations may lead to a shake-up of the industry, such as new turbine concepts (e.g. 2-bladed, vertical axis, hydraulic) and new foundation concepts (e.g. floating, hybrid).

6. TRANSPORT & INSTALLATION CONTRACTORS

Further innovation and specialization of transport and installation equipment are expected. While skills and equipment from the offshore oil & gas industry can be used in offshore wind, there are important differences: offshore wind puts much more focus on building in series at the lowest cost, instead of realizing a one-off installation to achieve "first oil" as soon as possible. Standardization and speed will become critical determinants of the competitive position. Pressure on cost and speed should never compromise safety procedures and training, both of which are indispensable in the harsh offshore conditions.

7. OFFSHORE OIL & GAS SECTOR

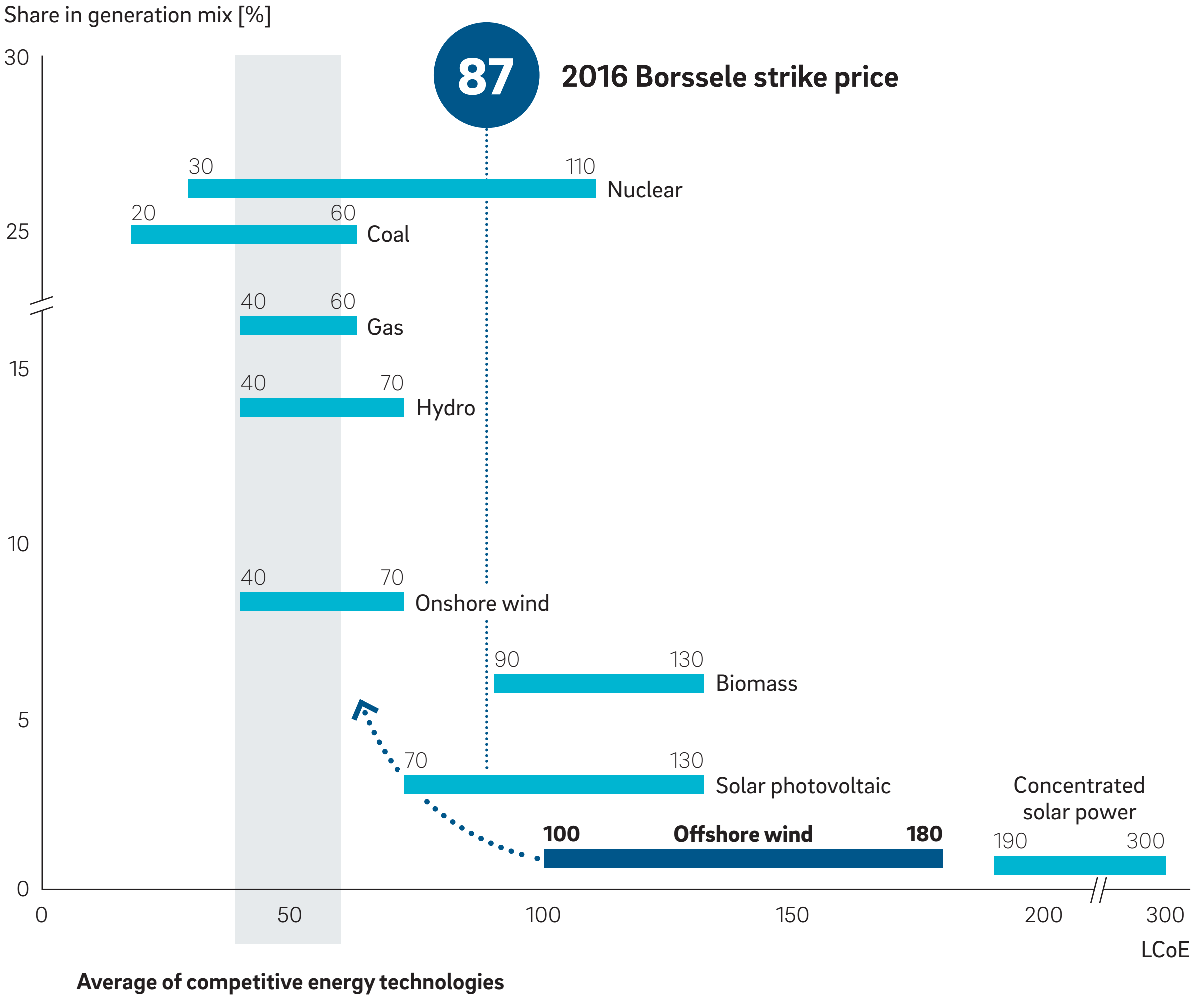
The offshore wind sector is now leading the way on how to achieve cost reductions for designing, constructing and installing offshore installations. The offshore oil & gas sector should therefore carefully examine the lessons of Borssele, to be able to survive in a world with low oil prices.

C

LCOE AND SHARE IN GENERATION MIX IN EUROPE

The strike price of the Borssele wind farm is the tipping point to accelerated worldwide expansion and growth of offshore wind.

Europe, 2015, EUR/MWh, including grid connection



Source: IEA; Roland Berger

Tipping point towards strong growth and worldwide expansion.

GROWTH AND EXPANSION

Borssele represents the tipping point for offshore wind. The average long-term cost of fossil fuels lies in the EUR 40-60/MWh range[2]. → C As it becomes fully competitive with other forms of energy, offshore wind will account for a significant share of the power generation mix in Europe. In their forecasts of wind capacity in the European Union, ENTSO-E and WindEurope predict that around a third of new capacity will be installed offshore between now and 2025/2030. Because of the rapid decline in the costs of offshore wind, we suggest that this share could grow to more than 45% in this period. While assuming no change in the forecast for total capacity of onshore installations, total offshore wind capacity would then reach **150 GW** by 2030. The share of offshore wind in the fuel mix will increase at the expense of conventional energy generation technologies, also thanks to higher load factors offshore.

Due to strong winds and large open areas at sea, offshore wind resources are abundant, and will soon expand beyond the North Sea to other parts of the world. Approximately 50% of the world's population lives within 200 kilometers of the coastline, and according to UNESCO, by 2025 this share will increase to 75%. Many of these coastlines are shallow and therefore ideal for the development of seabed-based offshore wind farms. China, the US East Coast and Brazil have such favorable conditions for offshore wind development. → D

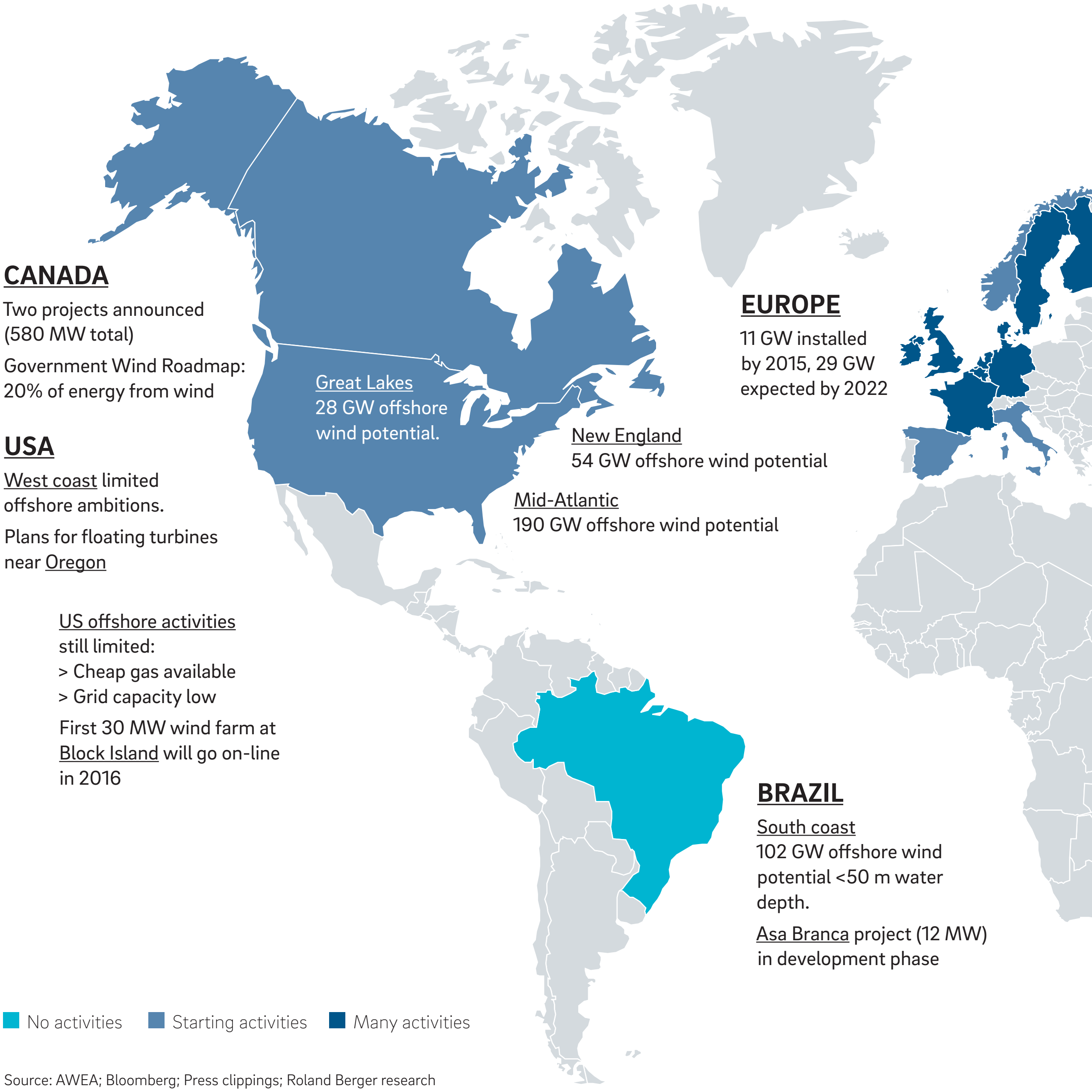
The development of floating foundations will make offshore wind in deeper waters also possible. In the past few years, many large-scale floating offshore wind prototypes have been planned, financed and installed in Japan, Scotland, France, Portugal and the US. Industrialization of floating turbines is imminent. Therefore, industry experts have predicted that floating turbines will reach similar cost levels as their seabed-based counterparts by 2025.

Symbiosis between the offshore wind and oil & gas sectors will accelerate the development of offshore wind. The first step will be wind turbines powering offshore oil & gas platforms to avoid emissions from fossil fuel generators. A next step may well be using offshore platforms of depleted gas fields to collect power from hundreds of wind turbines around them. The power will be transformed to gas on the platforms, and the gas brought onto the shore through the existing submarine pipelines. In the longer term it is even imaginable that floating wind farms will be installed in the middle of the ocean. They will deliver their power to a floating production, storage and offloading (FPSO) vessel, where it will be transformed to gas. Supertankers will collect the gas and bring it to land. And further in the future, those floating wind farms may use kite technology to harvest stronger and more constant winds at altitudes of several kilometers, as in the middle of the ocean the space on the water and in the sky is abundant.

2 In this comparison one should take into account that commercial prices for some conventional energy technologies are relatively low today as overcapacity leads to pricing at marginal cost instead of full cost. Furthermore, an increase of the EU Emissions Trading System (ETS) price for CO2 emissions may lead to higher prices for fossil fuels. The comparison should also take into account the intermittent character of renewable energy sources.

D

WORLDWIDE OFFSHORE WIND DEVELOPMENTS, AMBITIONS AND POTENTIAL



Source: AWEA; Bloomberg; Press clippings; Roland Berger research

Offshore wind potential is large due to urbanization along coasts, with favorable conditions in Europe, China, US and Brazil.

E

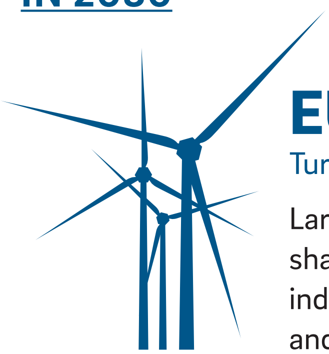
COMPARISON BETWEEN EUROPEAN OFFSHORE WIND AND RAIL INDUSTRIES

By 2030, the European offshore wind industry will strongly resemble the European rail industry.

SIMILAR CHARACTERISTICS

- → Highly capital intensive
- → Robust installations and equipment
- → Long lifetime
- → Continuous innovation to improve quality and cost

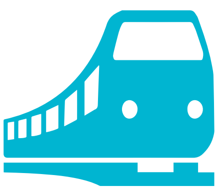
OFFSHORE WIND INDUSTRY IN 2030



EUR 40 bn
Turnover

Large potential market share of European industry at home and abroad

RAIL INDUSTRY IN 2014



EUR 47 bn
Turnover

84%
Market share in Europe

46%
Global market share

Source: UNIFE; Roland Berger analysis

COMPETITIVE INDUSTRY

The European offshore wind industry had a turnover of EUR 11 bn in 2015 and this will grow to EUR 40 bn by 2030, which will then be comparable to the European rail industry. And like the rail industry, the offshore wind industry relies on robust installations and equipment that perform under tough circumstances and continuous innovation to improve the quality and cost of the sector.

Europe has the technical expertise, operational experience and innovation capabilities in all areas of the offshore wind value chain, which gives the European offshore wind industry a sustainable competitive advantage in this growing market. The industry can conquer and hold a large market share both at home and abroad just like the European railway industry did. → E

Borssele will prove to be the tipping point towards strong growth and worldwide expansion of offshore wind, offering huge opportunities for governments and companies. Players in all offshore energy sectors can benefit from the takeaways of the Borssele experience. ◆

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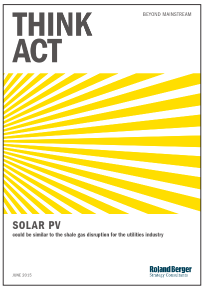
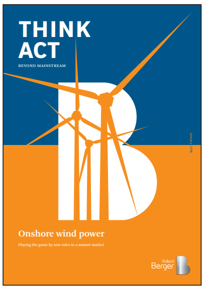


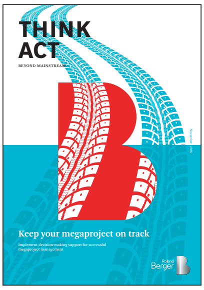
SOLAR PV
A game changer for the utilities industry

Solar PV has become a high growth market globally. The increase in 2014 in solar PV capacity of 39 GW is close to the nuclear power capacity of Japan and total global capacity now stands at 177 GW. Solar PV is installed on rooftops of houses and commercial building and at a utility-scale on landscapes. In Europe, traditional utilities are absent in this market segment.



ONSHORE WIND POWER
Today's European wind power players face the challenges of a maturing market

There are fewer suitable sites for new projects, citizen opposition to expansion is growing, and the reduction in subsidies coupled with significant regulatory restrictions are all creating fierce competitive pressure. Nonetheless, onshore wind power offers a substantial number of benefits that will allow it to remain Europe's most important source of renewable energy.



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