

McKinsey&Company

Developing offshore wind power in Poland

Outlook and assessment of local economic impact

2016



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Acknowledgments

In this report we present the possible development of offshore wind power in Poland and assess the impact it may have on the economy.

Many companies operating in Poland are already active players in the industry, or have the potential to become such. The development of offshore wind power therefore has significant potential in terms of localizing the supply chain within Poland.

In this report we describe the current situation and outlook for offshore wind power in Europe and investigate how the development of this sector could impact the Polish economy. We have discussed our assumptions and conclusions in detail with experts, and the methodology that we used to calculate the potential economic impact – an input-output model – is that generally used around the world in studies of this type. We believe that an independent and fact-based analysis of this type is essential to ensuring constructive public debate about offshore wind power in Poland.

This report is a project of the McKinsey & Company office in Poland. A number of McKinsey experts from around Europe also contributed, in particular Florian Kuhn, Partner at McKinsey & Company in Oslo and leader of the McKinsey European Renewable Energy practice. The sizeable team behind the report was led by Marcin Purta, leader of the Electric Power and Natural Gas Practice in Central and Eastern Europe, in cooperation with Tomasz Marciniak and Kacper Rozenbaum. Agnieszka Chmielecka and Adam Chrzanowski and his team also made significant contributions to the report.

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Introduction – Transformation of the energy system in Europe

The energy system in Europe is undergoing a fundamental transformation. A clear shift toward low-carbon energy sources is evident – a reaction to several different factors including the European Union’s ambitious plans to cut greenhouse gas emissions, the nuclear power plant disaster in Fukushima, and rapid advances in technology.

Offshore wind power is one of the fastest-growing technologies for electricity production in Europe. Installed capacity is currently expanding by more than 30 percent a year.¹ Existing capacity across the continent already exceeds 11.5 GW² – the equivalent of over 28 percent of the total installed capacity of the Polish national power system.³

Offshore wind power has a complex supply chain. The average cost of building 1 MW of power is approximately EUR 4 million.⁴ This translates into millions of dollars in potential investments – indeed, more than EUR 40 billion⁵ has already been spent in Europe – and the creation of large numbers of new jobs. The European Wind Energy Association (EWEA) estimates that around 75,000 people currently work in jobs directly related to offshore wind power in Europe.⁶

The expansion of the sector has created opportunities for less developed cities in northern Germany and attracted investors to declining ports. Wind power is now one of the key sectors of the local economy for the German ports of Cuxhaven and Bremerhaven, and Mostyn and Grimsby in the United Kingdom,⁷ and new turbine factories create employment for thousands of people.⁸

The number of projects already planned for the coming years indicates the potential further development of this sector. Wind farms with a capacity of 1.4 GW⁹ are due to be built over the next twelve months (H2 2016 to H1 2017). In the longer term, construction permits have been issued for another 10.4 GW in the UK alone, and a further 3.1 GW is waiting for authorization.¹⁰

Poland has an opportunity to become part of this European trend. According to McKinsey analysis using an input-output model, offshore wind power could add as much as PLN 60 billion to Poland’s GDP¹¹ and contribute to the creation of 77,000 new jobs, particularly in coastal regions, as well funding state and local-authority budgets to the tune of PLN 15 billion in the period to 2030. And it doesn’t stop there: Offshore wind power could also stimulate the development of the steel and shipbuilding industries and act as an engine of economic growth post-2020, which is when the European Union’s current financial perspective ends.

The development of offshore wind power is also an opportunity for Poland to modernize its port infrastructure, with the creation of ports supporting the construction and maintenance of offshore wind farms. To realize the full potential of this opportunity, Poland will need to develop an appropriate system of subsidies and draw up a strategy for developing the supply chain within the country’s borders.

The European offshore wind-farm market – Current situation and outlook to 2020

A powerful European trend

Currently more than 90 percent of installed offshore wind-farm capacity is located in Europe.¹² Offshore wind power makes up just 1 percent of the EU's energy mix,¹³ but it is on a rapid growth trajectory, with a more than 30 percent annual increase in installed capacity over recent years.

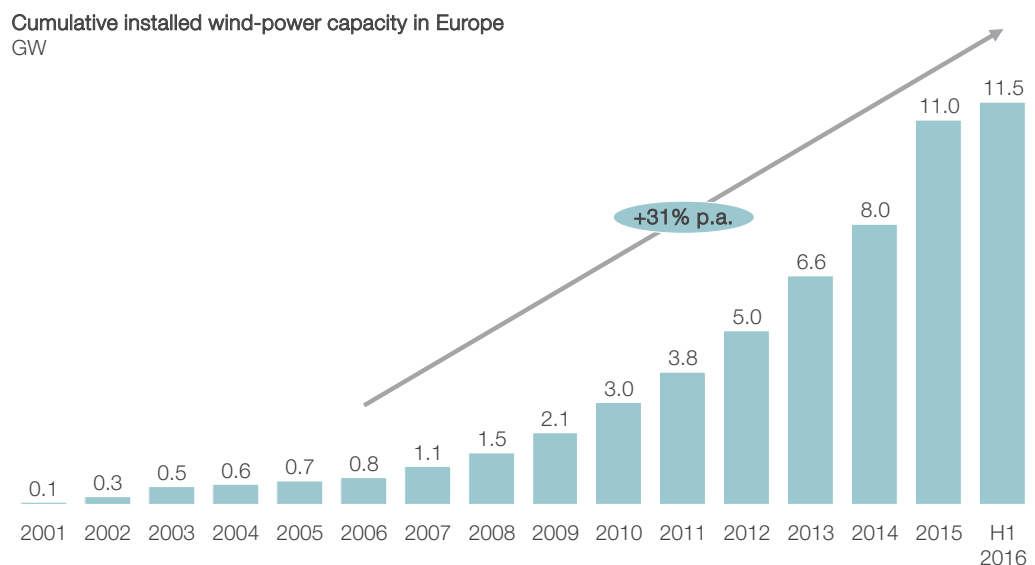
As per August 2016, more than 11 GW of capacity was fully operational and an additional 4 GW was under construction in Europe.¹⁴ By 2030 installed capacity could be somewhere between 26 and 84 GW – or even more,¹⁵ depending on the support for low-carbon technologies and technological advances, cutting the average cost per unit of energy production.

Localization of offshore wind farms

Today most offshore wind farms are located in the North Sea, as are the majority of planned farms for which construction permits have been issued or which are currently waiting for such permits. Another favorable location for wind power is the Baltic Sea, where the Germans and Danes already have wind farms and the Swedes are currently in the process of developing them.

Exhibit 1

Installed offshore wind power capacity in Europe has grown an average of 30% a year over the last ten years



SOURCE: McKinsey analysis based on data from 4C Offshore, *The European offshore wind industry – key trends and statistics 1st half 2016*, WindEurope

The reason most offshore wind farms are located in northern Europe is the good wind conditions found there. Within Europe, the average wind power density (the available wind power per 1 m²) is most favorable in the North Sea and the Baltic.¹⁶

United Kingdom, Germany and Denmark – the market leaders¹⁷

The United Kingdom currently has the most installed offshore wind capacity – approximately 5 GW, or 5 percent of the UK’s total energy mix.¹⁸ A further 1.6 GW is partially operational and will soon be fully commissioned. The UK has 25 offshore wind farms in total and more are in planning. Construction permits have been applied for (or have already been issued) for an additional 13 GW.

Exhibit 2

Offshore wind farms in Europe

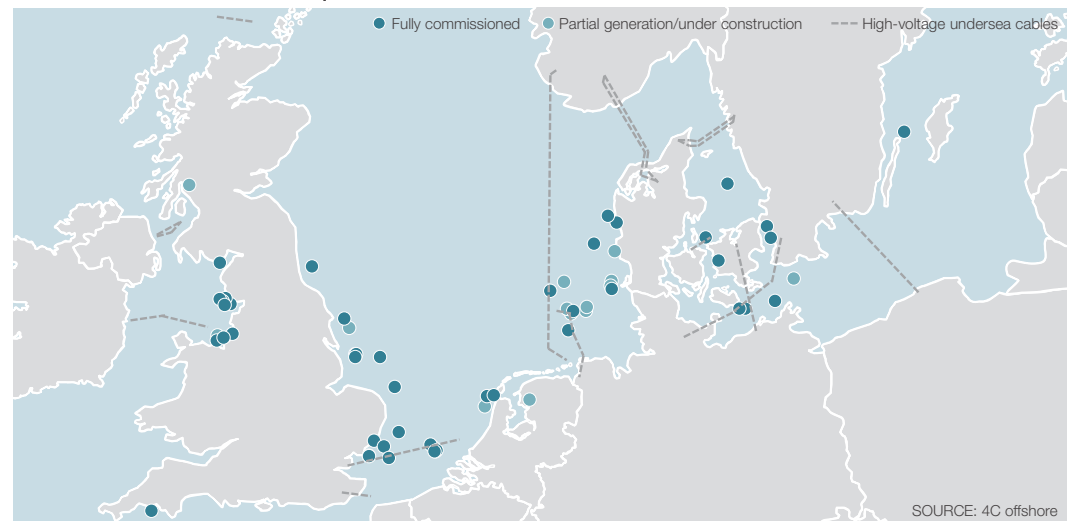
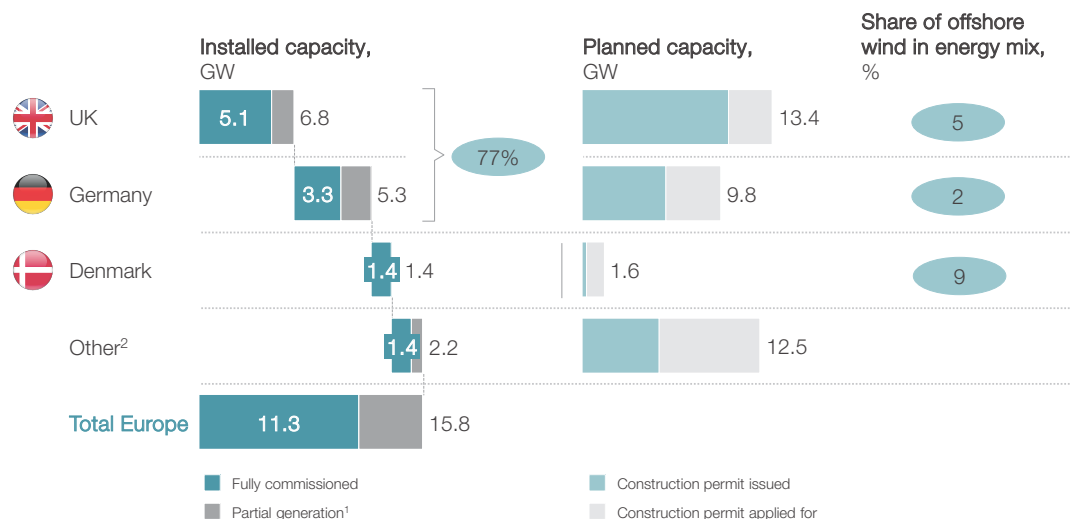


Exhibit 3

16 GW of capacity is already fully or partially operational – Almost 80% of this is in the UK or Germany

Status as per August 2016



¹ At least one turbine connected to the grid; part of the farm still under construction
² Belgium, Netherlands, Sweden
 SOURCE: 4C Offshore; McKinsey

Germany has more than 3 GW of installed power and a further 2.1 GW will soon become fully operational. Although offshore wind power represents less than 2 percent of the total installed capacity of the German power system,¹⁹ this figure could soon rise significantly, with plans for an additional 10 GW to be built, including 6 GW with permits already issued and nearly 4 GW for which permits have been applied.

Denmark is the birthplace of offshore wind power technology. It was here in 1991 that the first offshore wind farm was built. Denmark currently has 1.4 GW of installed capacity, representing fully 9 percent of the country's total power capacity.²⁰

Ownership structure of offshore wind farms

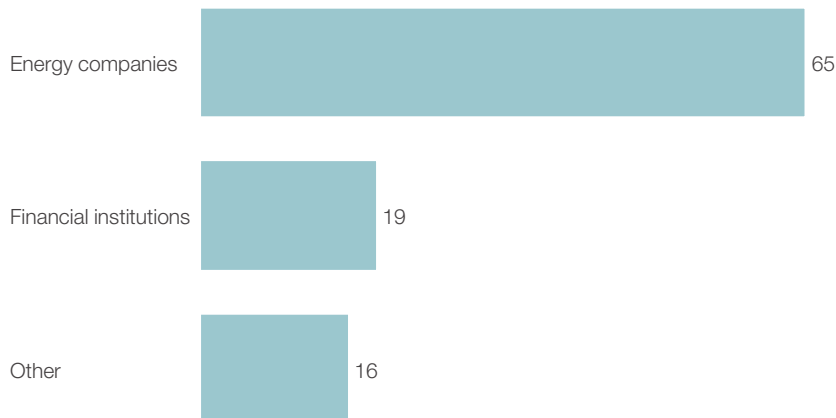
The offshore wind farms that exist today are mainly owned by northern European energy companies. These players currently account for 65 percent of the market.²¹

We can observe a clear trend for financial institutions, such as pension funds and private equity funds, to invest in wind farms. Together, these two types of investors currently own almost 20 percent of total installed capacity. Clearly this type of investment is becoming increasingly attractive. Other owners include oil and gas companies, turbine manufacturers and the companies that install them.

Exhibit 4

Over 65% of offshore wind capacity in Europe belongs to energy companies, and nearly 20% to financial institutions

Ownership of installed offshore wind capacity in Europe by sector, 2016
%, 100% = 11 GW¹



¹ Fully commissioned wind farms
SOURCE: EWEA; 4C Offshore; Powervision; press search; McKinsey

Growth scenarios through 2020

The European Wind Energy Association (EWEA) predicts that by 2020 the European market for offshore wind power will have grown to around 20-30 GW. It proposes three growth scenarios: a low scenario (20 GW installed capacity), a central scenario (23 GW), and a high scenario (28 GW).²²

Growth scenarios through 2030

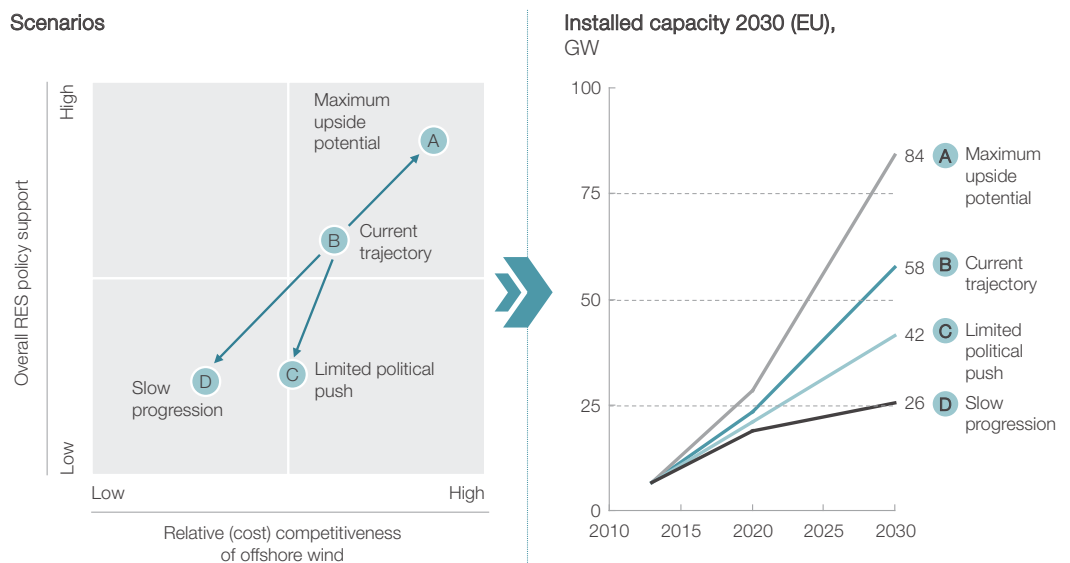
Our analysis indicates that the future growth of offshore wind power, and the speed of growth, will be driven by two factors above all else: the cost competitiveness of energy production by the offshore wind power industry and the level of policy support for the development of renewable energy in Europe.

These two factors are interlinked. If there is no improvement in the cost competitiveness of offshore wind, the currently favorable support schemes may change. A reduction in the level of support could create barriers to new investment. One of the main factors in reducing costs is achieving economies of scale, so if investment slows, the rate at which the cost competitiveness of offshore wind improves will also slow. Thus on the basis of our analysis, which takes these factors into account, we believe that the installed capacity of offshore wind power in Europe will be somewhere between 26 and 84 GW in 2030, depending on the scenario.

Exhibit 5

The size of the offshore wind farm market will be between 26 and 84 GW in 2030, depending on two key factors

ESTIMATES



SOURCE: McKinsey analysis

Characteristics of offshore wind power

Compared with other sources of renewable energy, offshore wind enjoys a favorable base load characteristics (see Exhibit 6).

Negative external factors only have a limited impact on offshore wind power. Because wind farms are located far away from where people live, they do not pollute the landscape and the noise associated with their operation does not cause a nuisance for local residents.

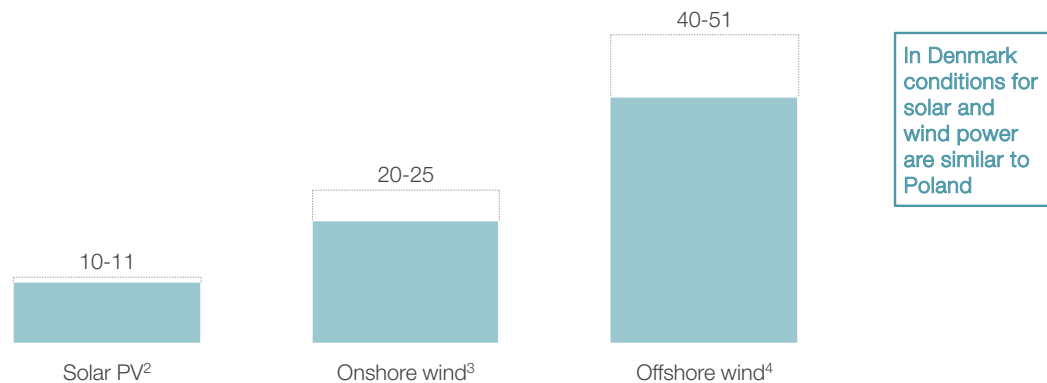
The main challenge for offshore wind is the current level of costs compared with other power-generating technology. In 2015²³ the average production cost of energy (LCOE)²⁴ for offshore wind was 153 EUR/MWh, compared with EUR 117/MWh for solar energy (photovoltaic power) and 64 EUR/MWh for onshore wind.

However, although offshore wind is still in its infancy, a decline in the average cost of energy produced by wind farms is already observable (see Exhibit 7). The chief players in the market are aiming for an LCOE of 100 EUR/MWh.²⁵ The main factors driving cost reductions are technological advance (above all larger, more efficient turbines), increasing market scale, specialization and standardization, and better cooperation between contractors and suppliers. EUR 100/MWh would make offshore wind competitive compared with other low-carbon energy sources – especially in the north of Europe, where it is windier and less sunny than in the south, especially in winter months.

Exhibit 6

Offshore wind generates power more steadily and more predictably than any other renewable technologies

Capacity factor¹ comparison
%



¹ Ratio of actual output over a period of time to its potential output. Example for Denmark 2013-14

² Based on summarized installed capacity and summarized production data

³ Range for average and 3rd quartile, based on individual data for 4423-4586 turbines

⁴ Range for average and 3rd quartile, based on individual data for 419-516 turbines

SOURCE: Data for installed capacity and solar PV production from Energinet.dk. Data for wind power based on analysis of all functioning wind turbines from "Master data register for wind turbines", ENS

Another key challenge for offshore wind is the length of projects. On average it takes about two years from the final financing decision to the commissioning of the wind farm. Prior to that, five to seven years are needed to prepare the investment and secure the necessary permits.²⁶

A significant reduction in the cost of wind power is already observable today. In Denmark and the United Kingdom, the guaranteed price that potential clients competed for in tenders in 2015 was down 25 percent on previous years. Thanks to lower costs, investors will continue to realize a return on their investments despite much lower energy prices. One major source of cost savings compared with previous years is the planned wider use of turbines with a nominal power of 6 MW and the expected corresponding reduction in installation costs (due to fewer foundations and turbines having to be installed for the same nominal power) and operating costs (fewer turbines to be maintained, cutting time and transportation costs), plus increased production.²⁷

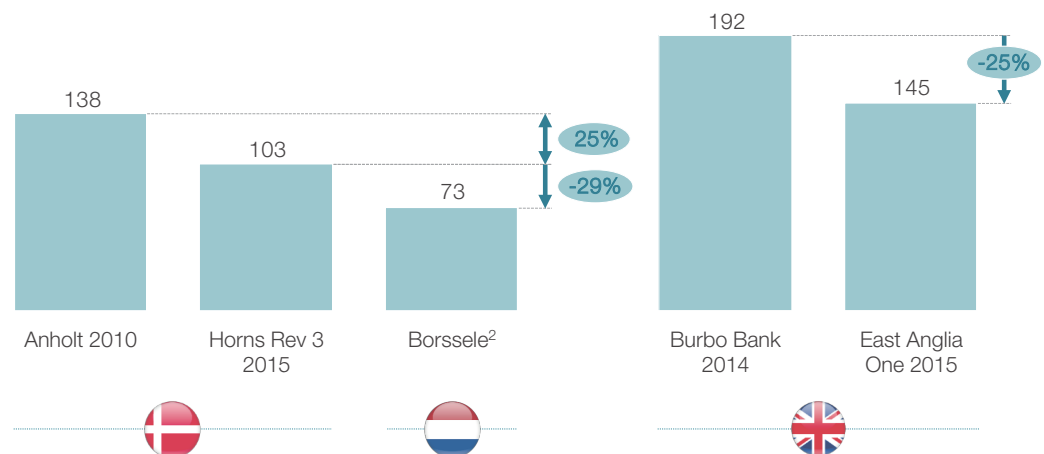
The difference between the strike price in Denmark and the UK is due to the different scope of investments. In Denmark the state-owned company managing the power grid is responsible for connecting new offshore wind farms to the grid, while in the UK this is the responsibility of the developer or a special entity (the Offshore Transmission Owner, or OFTO), which takes on the responsibility for constructing and in some cases also managing the transmission assets. In addition, the strike price in Denmark is not indexed to inflation.

We consider a further decline in prices to be realistic. In July 2016 the construction of an offshore wind farm with a capacity of 700 MW and a price of 72.7 EUR/MWh was announced in the Netherlands.²⁸ This price does not include connection to the grid.

Exhibit 7

In Denmark and the UK, the strike price for 1 MWh of energy has fallen by 25% on average – Further decline in prices is possible

Strike price,¹ EUR/MWh



¹ Average GBP/EUR exchange rate in 2014 was 1.24. <http://www.ens.dk/en/supply/renewable-energy/wind-power/offshore-wind-power/new-offshore-wind-tenders/questions-answers#Horns Rev 3>. The cost difference between Denmark and the UK is largely due to project scope. In Denmark the cost excludes the cost of connection to the onshore power grid

² Taking into account the element connecting the offshore wind farm to the onshore power grid, the cost is 87 EUR/MWh, <http://www.ft.com/cms/s/0/18b0f2b6-42db-11e6-b22f-79eb4891c97d.html?siteedition=intl#axzz4HXQpEPn3>

SOURCE: The Crown Estate; Danish Energy Agency

The value chain for offshore wind farms

Main components of an offshore wind farm

An offshore wind farm is a group of wind turbines located at sea, connected the power grid via undersea cables. Its main components are as follows.

- Offshore turbines
- Inter-array cables
- Offshore substation (one or more)
- Export cables
- Onshore substation

The wind farms built today have a maximum of 175 turbines, each generating up to 6 MW.

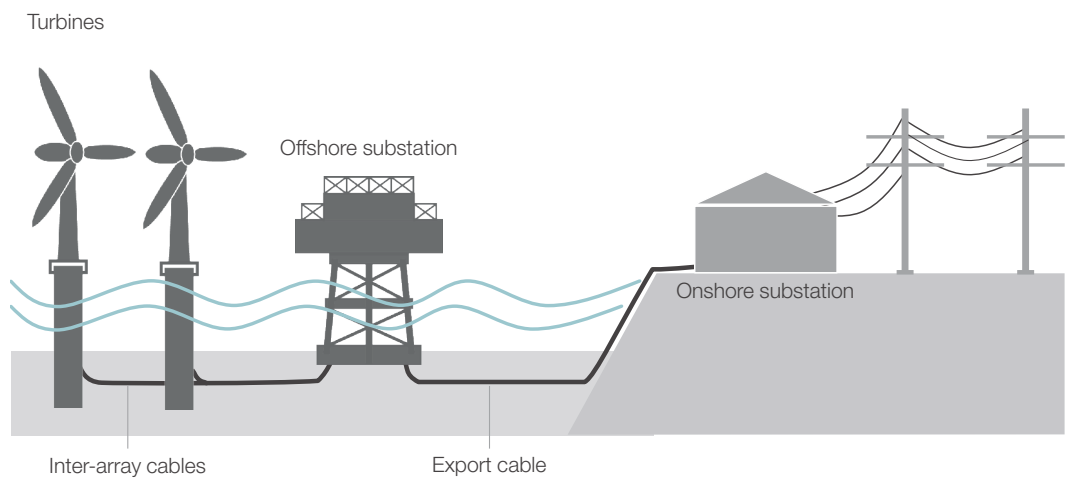
The value chain for offshore wind farms

The value chain for offshore wind farms comprises five stages:

1. Development and project management
2. Turbine production

Exhibit 8

An offshore wind farm is a group of wind turbines located at sea, connected to the grid via underwater cables



SOURCE: The Crown Estate; E.ON; DONG Energy; 4C offshore; press search; McKinsey

3. Production of the connection infrastructure and foundation
4. Installation
5. Operations & maintenance (O&M)

The main part of the investment is the cost of manufacturing the turbines, foundation and connection infrastructure; together they make up 70 percent of CAPEX (capital expenditure). The installation process accounts for around 25 percent of total expenditure, and development and project management roughly 5 percent.

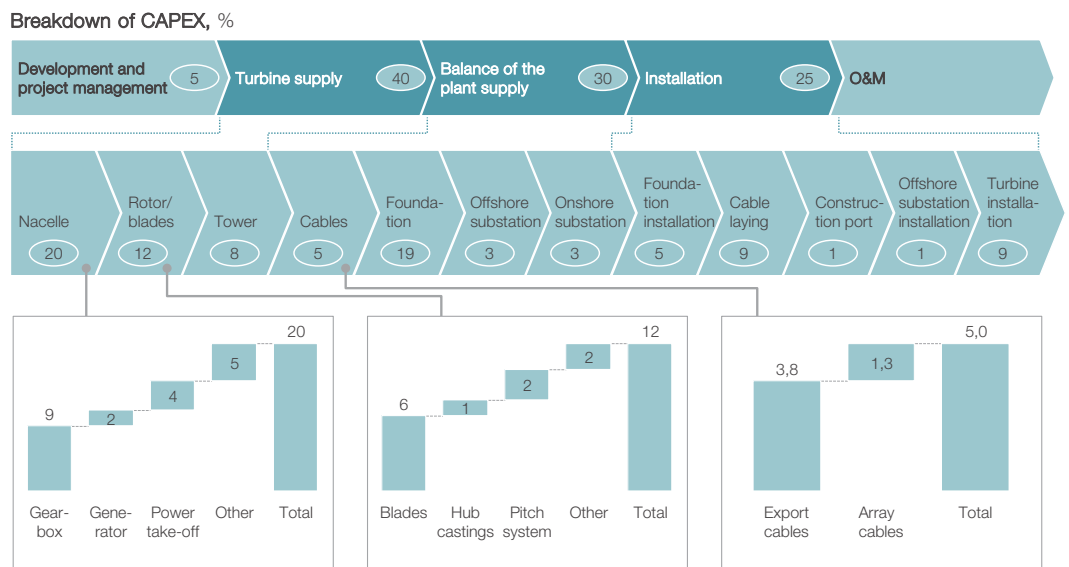
Development and project management

Although development and project management only account for 5 percent of CAPEX,²⁹ this phase is critical to the success of the project. It covers all the processes from the decision by the investor to build the wind farm to placing the orders for the various components. The investor exercises control over the entire phase, instructing relevant firms to carry out the various activities related to the development and project management process.

In this phase the investor bears costs mainly relating to project management, the purchase of a license, analyses to select a location for the wind farm, and planning the supply chain (in total approximately 35 percent of the total costs of this phase).³⁰ Activities relating to environmental studies and seabed surveys also generate significant costs, which together can make up over 40 percent of total expenditure in the development and project management stage.³¹

Exhibit 9

Turbine supply and balance of the plant supply are the major CAPEX contributors



● Average percent of total CAPEX for a 500 MW wind farm (in UK)

SOURCE: EWEA; BVG; The Crown Estate; McKinsey

Turbines

The turbines are the main component of an offshore wind farm. On average they account for a total of 40 percent of CAPEX during the construction of a new wind farm.³² The turbines convert the kinetic energy extracted from the wind into three-phase electric power. They consist of three main components: the nacelle, the rotor (of which the blades form the main element), and the tower.

Nacelle

The nacelle, which houses the electricity generator, is located at the top of the turbine. Nacelles weigh roughly 150 to 300 tonnes.

Rotor blades

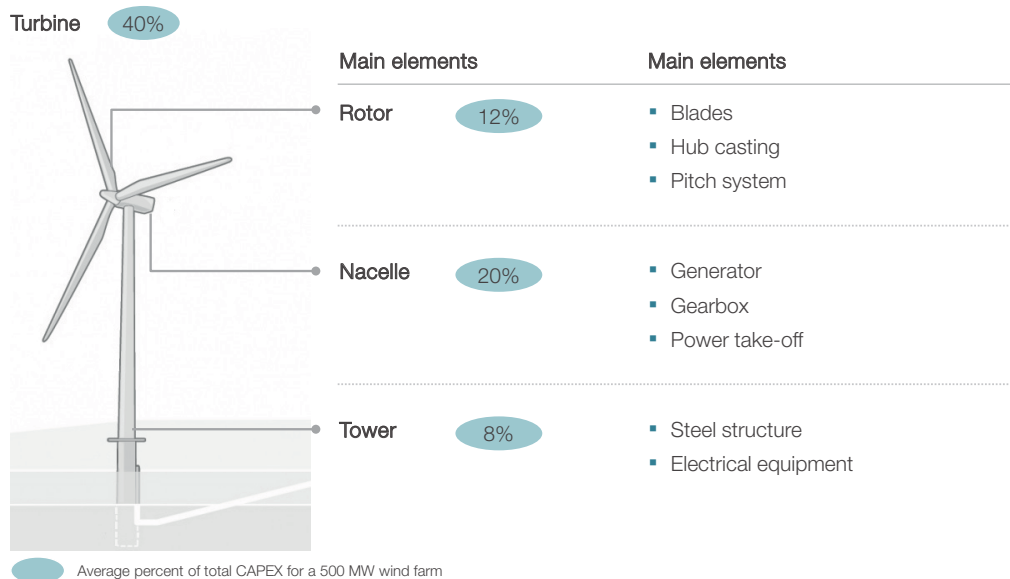
Rotors typically consists of three blades made of composites containing glass fiber, polyester, epoxy resin and sometimes carbon fiber.

The blades are usually produced by the wind-turbine manufacturers. About 30 percent of the market for blades is accounted for by independent suppliers.³³

The cost of the blades represents about 50 percent of the total cost of the rotor and around 15 percent of the total cost of the turbine. The cost of a single blade for a 5 MW turbine can be as much as EUR 300,000-500,000.³⁴

Exhibit 10

A turbine consists of a nacelle that houses the drive train, a rotor with blades, and a tower that attaches the turbine to the foundation



SOURCE: A Guide to an Offshore Wind Farm, The Crown Estate; McKinsey

Tower

The main material used in the production of the tower is steel sheet. The weight of the tower depends primarily on the power of the turbine, which affects the height and hence the mass of the tower. A 100-meter high tower generally weighs 300 to 400 tonnes. The cost of building the tower represents about 8 percent of total CAPEX.

The market for offshore wind turbines

The power of turbines has increased in recent years, as has their size and height. In 2002 the average installed power of a turbine was in the region of 2 MW, compared with up to 4.8 MW today.³⁵ By 2020 turbines with a capacity in excess of 8 MW are expected.³⁶ As the power increases, so does the diameter of the rotor and the height of the turbine.

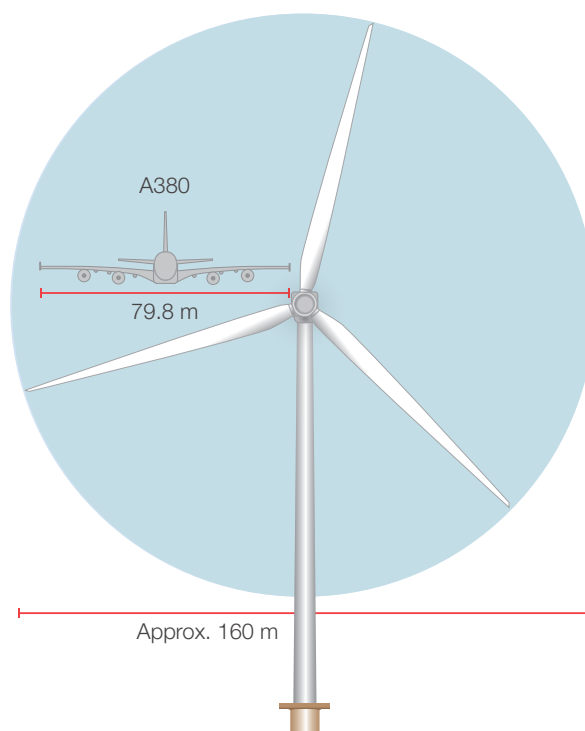
Production of connection infrastructure and foundation

Foundation

The foundation is the structure connecting the tower to the bottom of the sea. It provides stability and keeps the turbine upright.

Foundations for offshore wind turbines fall into two main types: fixed and floating. Fixed foundations are attached to the seabed. Several kinds of fixed foundations exist, the choice depending mainly on the characteristics of the seabed, the depth of the water, and the power of the turbine (see Exhibit 12).

Exhibit 11



The 8 MW turbines currently in use have a blade span of approximately 80 meters – comparable to the wingspan of the largest passenger airplane in world, the Airbus A380

Of the 78 offshore wind farms fully operational today, almost all have fixed foundations.³⁷ So far, floating foundations are only used for test turbines. The most common type of fixed foundation is monopiles, found for as many as 77 percent of offshore wind turbines. With increasing turbine power and advances in technology allowing wind farms to be built at greater depths, we expect to see an increase the proportion of another type of fixed foundation, namely jacket foundations.

Offshore substation

The offshore substation transforms the energy from the generators in the turbines to a higher voltage, allowing it to be fed into the onshore power grid. The offshore substation is built on a separate foundation, usually about 25 meters above sea level.

Cables





The main job of the cables is to transmit the electricity produced by the wind turbines to the power grid. The cables used in offshore wind farms are of two main types: inter-array cables and export cables.

Inter-array cables

Inter-array cables connect the turbines to the offshore substation. They are usually medium-voltage cables (about 33 kV) suitable for transmitting alternating current (AC). There are currently over 2,000 km of inter-array cables installed in offshore wind farms built in Europe since 2010.³⁸

Exhibit 12

Many different types of foundation exist, depending on the depth of the water and the size of the turbine

Foundation type	Structure	Max. water depth meters	Market share ¹ %	Materials used
Monopiles		25	77	<ul style="list-style-type: none"> Steel structure
Gravity-base		30	9	<ul style="list-style-type: none"> Reinforced concrete Up to 6,000 tonnes 45% steel, 45% concrete, 10% sand
Tripod		35	4	<ul style="list-style-type: none"> Heavy steel structure
Jacket		45	4	<ul style="list-style-type: none"> Steel structure

¹ Based on 78 wind farms completed and partially generating power
 SOURCE: <http://www.windpoweroffshore.com>; "U.S. Offshore Wind Manufacturing and Supply Chain Development" Navigant; "Wind Turbine Technology and Operations Factbook" E.ON; McKinsey

Export cables

Export cables are used to transmit power from the offshore substation to the onshore power grid. They are high-voltage (mainly 150 kV) AC and DC cables. Around 1,400 km of export cables have been laid in Europe since 2010. A limited number of suppliers exist for this type of cable.³⁹ We expect to see an increase in the voltage of both export and inter-array cables, which may help reduce power losses and hence costs.

Installation

The installation process includes installing the connection infrastructure and foundation, as well as the turbine components. Specialized ships and a well-developed port infrastructure play a key role in this phase. The process involves laying undersea cables, installing the foundation, installing the offshore wind turbines, and installing the offshore substation.

Port infrastructure

The preliminary assembly of the turbine components takes place in the port used during the installation process. This port must be located near the offshore wind farm in order to reduce the risks and costs of transportation. The main requirements for ports are a wharf length of around 200-300 meters with a high-load zone, sufficient depth for installation vessels (8-10 meters), availability of cranes, and a place to store the components of the future wind farm.

Specialized ships

Specialized ships are required for installing the various components of offshore wind farms. They fall into four different groups according to their function: vessels for installing turbines, for foundation installation, for laying inter-array cables, and for laying export cables.

Shipyards

The value chain in the installation phase begins with the shipyard that builds the vessel designed to support the offshore wind farms. The shipyards producing installation vessels are mainly in Asia, for example China and South Korea. However, the Polish shipyard CRIST has built two installation vessels, the Innovation and the Vidar, and Remontowa Shipbuilding S.A. in Gdańsk and Poltramp Yard S.A. in Świnoujście have been involved in the building of vessels for laying cables.

Installation companies

Installation companies are businesses with a fleet of specialized ships. Due to the high cost of building and maintaining such vessels and their highly specialized nature, no companies exist at present that cover all the services related to the installation of offshore wind farms.

There are two common ways of contracting companies during the installation phase. The first is with a single EPC⁴⁰ contract between the investor and the contractor, under which

the contractor takes on responsibility for selecting suitable installation companies. The second is with multiple contracts between the developer and the individual companies.

Operations and maintenance

Operations and maintenance (O&M) refers to all the activities following the commissioning of the wind farm, namely:

1. Operations and preventive maintenance
2. Unscheduled maintenance work (corrective maintenance).

Present value of expenditure during the operating phase accounts for 25 to 27 percent of the total costs of installing and running the offshore wind farm.

Main costs in the O&M phase

The main expenditure during the O&M phase is renting vessels and purchasing spare parts. Renting vessels accounts for around 36 percent of the total discounted costs, and spare parts for around 18 percent.⁴¹ Other expenses relate to technicians' salaries, insurance, and environmental studies.

Responsibility for O&M

Usually the first few years after the commissioning of the turbine are covered by the manufacturer's warranty. After this warranty expires, the owners of wind farms have three options:

1. Renew the O&M contract with the OEM (original equipment manufacturer)
2. Contract an external company specializing in O&M for offshore wind farms
3. Take on responsibility for O&M themselves

Employment during the O&M phase

The number of people employed during the O&M phase ranges between 70 and 100 per wind farm.⁴²

Operating an offshore wind farm requires continuous employment of technicians working both onshore and offshore, plus managers and administrative staff. The largest group of workers are the offshore technicians. For a 500 MW wind farm, around 60 technicians are needed for regular offshore work, and at least a few based onshore.⁴³

Length of offshore wind farm projects

From the project timetables for offshore wind farms completed in 2014-2015 it is clear that projects vary widely in terms of their length.

An analysis of eight recently completed projects⁴⁴ reveals that, on average, it took around five years from receipt of planning permission to final financing decision. After the final financing decision was made, around 12 months were needed before the start of construction work. This 12-month period was used to design the wind farm and carry out negotiations with suppliers. The average construction period for the offshore wind farms was two years.

Financing offshore wind power

Projects relating to offshore wind require major investment, often running into billions of euros. Investors therefore make use of a variety of funding models, a tendency supported by growing interest from investors outside the energy sector.

Capital recycling – A current trend in offshore wind power

The key market players in offshore wind power, namely northern European power companies, use what is known as a “capital recycling” model. This involves them selling shares in offshore wind farms to raise funds for building new farms. This model is increasingly common due to the interest it attracts from pension funds and financial institutions.

The moment the wind farm is commissioned it is no longer subject to regulatory or construction-phase risk. New investors then buy the shares from the initial investor, that is to say the power company. In recent years we have seen this capital recycling model being used in the earlier stages of projects.⁴⁵

Capital recycling allows power companies to focus on their core competencies – planning and constructing offshore wind farms.

Interest from institutional investors

Offshore wind farm projects are attractive for institutional investors because of their scale, the length of the projects and the stable returns. The low cost of capital for institutional investors makes buying shares in offshore wind farms during the operating phase an attractive option. However, to encourage institutional investors to participate in projects during the construction stage, developers must minimize the risks associated with possible failure of the project.

Offshore wind farms in Poland

Poland has a chance to become a leader in the development of offshore wind power. The Baltic Sea offers favorable conditions for wind farms, and a number of Polish investors have already obtained permits to build artificial islands. Two investors have signed agreements for connecting 2.2 GW wind farms to the power grid.⁴⁶ Assessments of the target potential of offshore wind power in Poland vary, ranging from 7.5 GW⁴⁷ to 14 GW,⁴⁸ in some cases looking as far ahead as 2050.⁴⁹

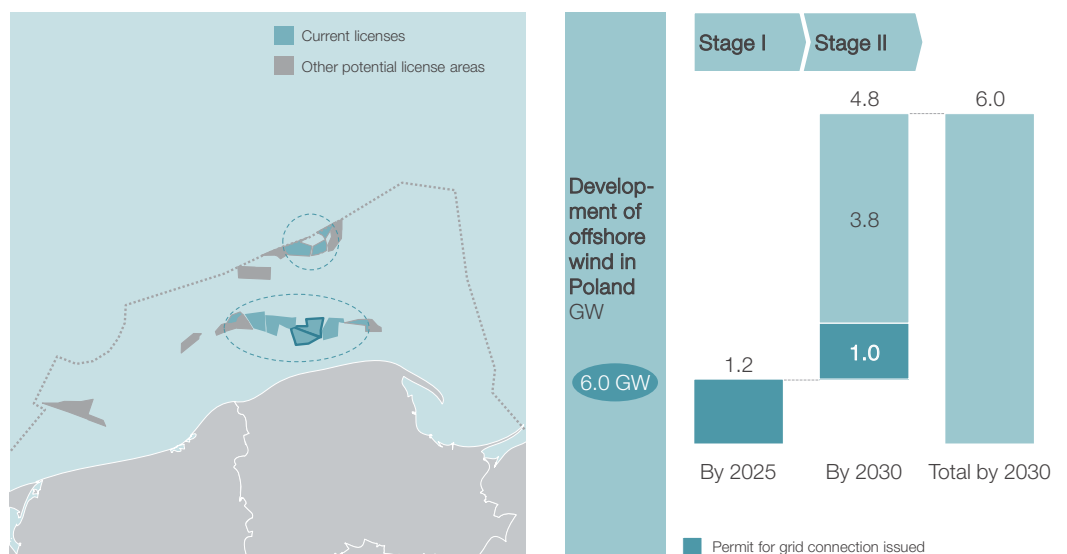
Our own analysis and interviews with potential investors lead us to believe that building 6 GW of capacity by 2030 is feasible. We use this target level of installed capacity as the basis for our analysis of the potential impact on the economy. Target offshore wind power on this scale in Poland will make it possible to locate a significant part of the supply chain within the country's borders, which translates into a significant impact on the economy. Beyond 2030, further development of offshore wind is possible in Poland, tapping into the full potential of the technology in the country. However, due to the distant time horizon we prefer not to include this perspective in our analysis.

The impact of offshore wind power on the Polish economy – Introduction

We calculate the potential impact on the Polish economy using an input-output model (also known as a “Leontief model”). The aim of the model is to show interdependencies in the economy.⁵⁰ Input-output tables contain a statistical description of the production activities of individual branches of industry, based on data from the Polish Central Statistical Office (GUS). We then use these tables to calculate the effect on the economy.

Exhibit 13

A potential 6 GW of capacity could be installed in Poland by 2030 – Permits for grid connection for 2.2 GW have already been issued



SOURCE: PGE; Polenergia

Methodology

To calculate the impact on the economy, we use the latest input-output tables for Poland published by the Polish Central Statistical Office (GUS).⁵¹

We calculate the impact on GDP and employment using multipliers based on the input-output tables. Each link in the supply chain for offshore wind power is divided into areas that can be associated with one of the industries for which it is possible to calculate a multiplier using the data from GUS. We then convert the value of the investments in each link in the supply chain, using the multipliers, into their impact on GDP. For each area of the value chain we also analyze the percentage share of labor costs. Using this analysis and the multipliers for employment, we then calculate the number of new jobs.

We calculate the impact on tax revenues by looking at the size of investments, the projected revenues of Polish enterprises, historical effective tax rates and employee salaries in offshore wind.

We calculate the impact on the economies of two Polish voivodeships, Pomorskie (Pomerania) and Zachodniopomorskie (West Pomerania), on the basis of the share of these two provinces and assumptions regarding localization of the supply chain.

To analyze the economic impact, we have also conducted interviews with experts and representatives of firms active in the supply chain.

Three types of impact are found

- Direct impact – effects created directly by the offshore wind power sector
- Indirect impact – employment and income created in the supply chain for offshore wind power
- Induced impact – effects resulting from consumer spending by workers employed in the economy as a result of the direct and indirect impact

Required investment for 6 GW of wind-farm capacity

Building offshore wind farms requires huge investments. At present the cost of building 1 MW of capacity is in the region of EUR 4 million.⁵² As mentioned earlier, the strike prices for tenders in Denmark, the UK and the Netherlands indicate a trend toward falling costs. In our analysis, the total CAPEX required to install 6 GW of capacity in Poland is PLN 70 billion.⁵³ This takes into account the cost of expanding the onshore transmission infrastructure. The Polish state-owned transmission system operator Polskie Sieci Elektroenergetyczne estimates that for the energy produced by 6 GW of offshore wind farms to be fed into the onshore power grid safely, the grid would have to be modernized and expanded at a cost of around PLN 3 billion.⁵⁴

GDP and employment in Poland

Investing in offshore wind farms with a capacity of 6 GW would create sufficient scale for a large part of the supply chain to be localized in Poland. As a result a significant part of the investment would return to Poland and be fed into the Polish economy.

By developing offshore wind power, the Polish economy could generate a total of PLN 60 billion in additional GDP by 2030 (almost half a percent of ten-year GDP at its 2015 level). This PLN 60 billion breaks down as follows: PLN 21 billion in direct impact from investments; PLN 22 billion in indirect impact from new ventures by companies in the offshore wind value chain, made possible by the initial investment; and PLN 17 billion in induced impact in other sectors of the economy, generated from the income of people working in the offshore wind value chain.

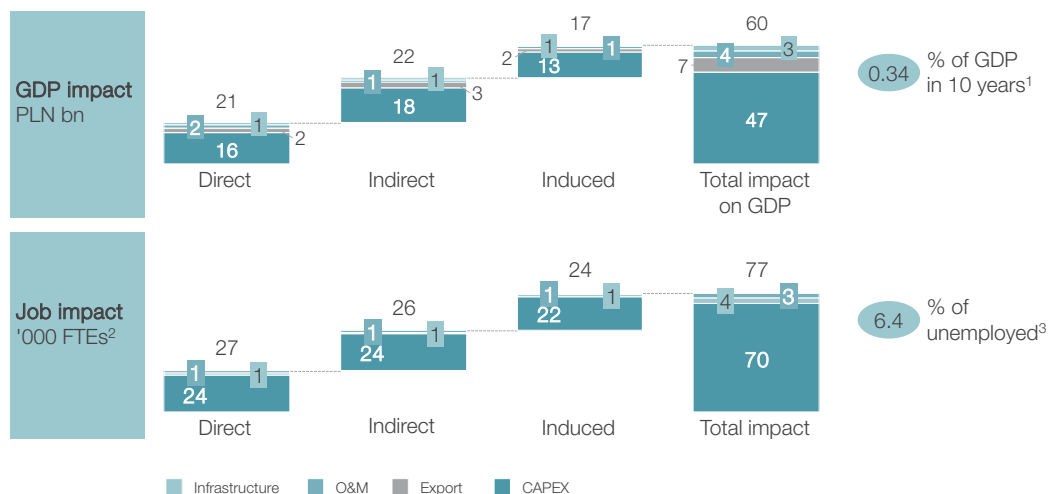
Breaking down the PLN 60 billion figure a different way, almost PLN 47 billion would be generated by the entire range of activities related to preparing and implementing investments. The remaining PLN 13 billion would result from additional exports by companies based in Poland operating in the offshore wind value chain, from O&M for offshore wind farms, and from investments in onshore electricity assets.

Developing offshore wind power in Poland could create 77,000 jobs in the construction period on a yearly average basis in the period to 2030.⁵⁵ Some 27,000 jobs could be created directly in the development and operation of offshore wind farms (direct impact). Up to 70,000 jobs in total (direct, indirect and induced impacts) could be created in the planning and construction of 6 GW of offshore wind farms. The remaining jobs would be created in O&M for offshore wind farms.

Exhibit 14

Offshore wind development in Poland could have a significant impact on the economy – More than PLN 60 billion in additional GDP and 77,000 jobs through 2030

Impact on the economy of 6 GW from wind farms through 2030



1 Compared to GDP in 2015
 2 Average
 3 1.2 million unemployed in Q1 2016
 SOURCE: GUS; McKinsey

Most of the additional GDP could be generated in three areas of the value chain: constructing the rotor components (mainly blades), building the foundation, and installing the structure. In terms of employment, other key areas are building towers, and offshore substations.

The real cost of technology

The profitability of offshore wind power – like other sources of renewable energy – depends on the level of subsidies the sector receives. To understand the true return on investment for society, we need to compare the level of subsidies with the resulting impact on GDP. Subsidies through 2050⁵⁶ amount to in present value⁵⁷ amount to PLN 42 billion.⁵⁸

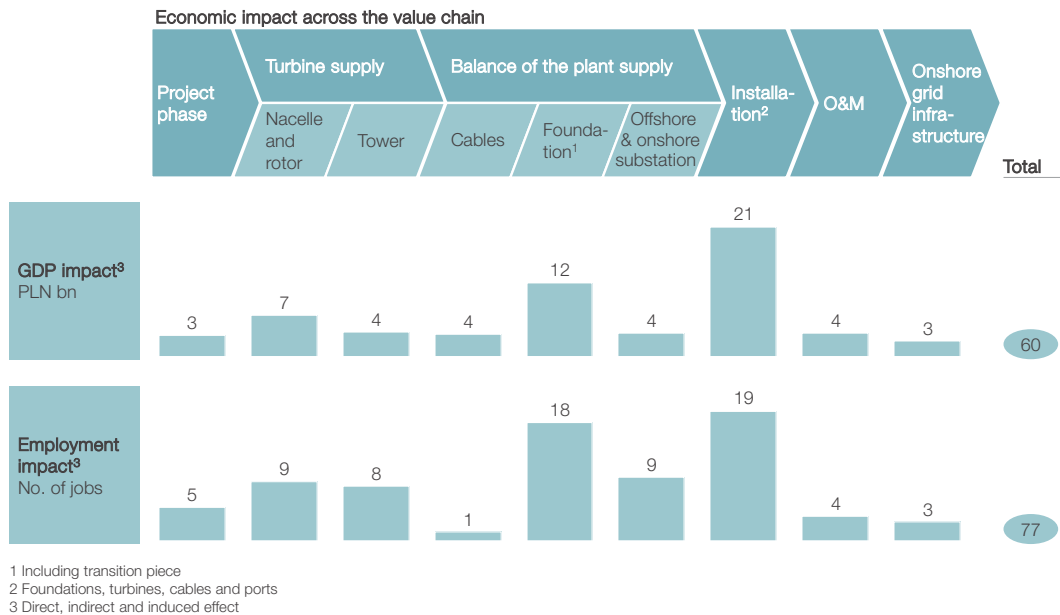
The discounted value of the impact on GDP in the same period is PLN 52 billion – 23 percent greater than the value of the subsidies.

We have also analyzed the hypothetical net cost of offshore wind power for each 1 MWh of energy produced. According to our forecasts, the average cost of generating electricity from offshore wind farms in Poland will be 96 EUR/MWh (on average, for power plants constructed before 2030, assuming a gradual decrease in costs as a result of technological advance, increased sales, enhanced competitiveness and improved operations). This figure is slightly below the target cost of 100 EUR/MWh that UK investors are already aiming for in projects with an investment decision in 2020.

For the investment in a wind farm to be profitable for an investor, and to convince the investor to actually make the investment, the subsidies need to cover the difference between the market price of electricity and the cost of producing it. We can therefore assume that 96 EUR/MWh is the average price of energy (including the cost of subsidies) and hence ultimately the cost for Polish citizens. However, if we use the same approach to calculate the impact on GDP per MWh,⁵⁹ it turns out that the actual cost is just 39 EUR/MWh (see Exhibit 17).

Exhibit 15

Wind farm installation and foundation manufacturing are two key value chain elements driving the economic impact of offshore wind



Tax impact

Building offshore wind farms could generate as much as PLN 15 billion in tax revenues by 2030. This would mainly come from VAT and CIT arising from transactions and activity by enterprises with value chains located in Poland. In addition, almost PLN 2 billion could flow into state coffers from personal income tax and license fees. Total revenues could make up just under 1 percent of the total ten-year budget revenues.⁶⁰

Local benefits

Besides the benefits associated with reindustrialization, increased tax revenues and employment along the entire supply chain, Poland's coastal provinces have the opportunity to attract industries and investments related to offshore wind power, which would help reduce unemployment. The total direct impact on the GDP of the Pomorskie and Zachodniopomorskie

Exhibit 16

Cumulative GDP impact of offshore wind in Poland is 23% higher than cumulative subsidies

PLN bn (present value¹) through 2050

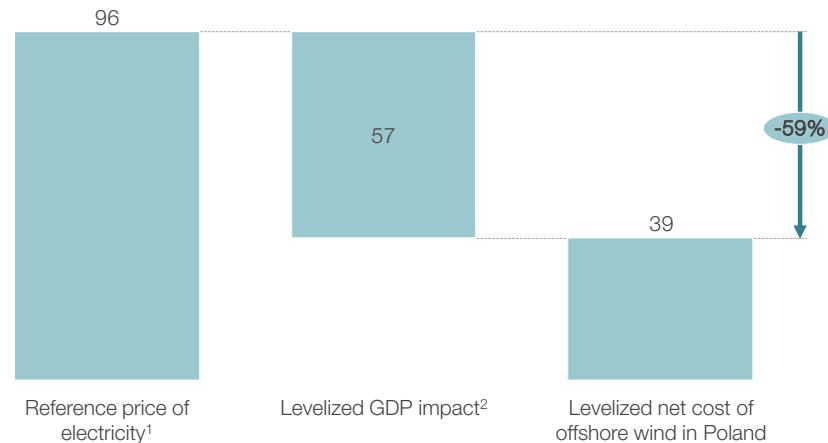


¹ Impact 2017-2050 (end of life of installed 6 GW) discounted with 4% discount rate (based on average 2012-2015 ten-year Polish PLN-denominated T-Bonds)
² In Contract for Difference set-up, with electricity price varying between 31 and 45 EUR/MWh post 2020
 SOURCE: McKinsey Power Model

Exhibit 17

The net cost of offshore wind for Poland is 60% lower than the average LCOE, due to the levelized GDP impact on the Polish economy

EUR/MWh



¹ Average LCOE for 6 GW in Poland, weighted by assumed lifetime energy produced (2019-2050)
² GDP impact of 6 GW of offshore wind in Poland during wind farms' lifetime, discounted with 4% discount rate (based on average 2012-2015 ten-year Polish PLN-denominated T-Bonds), divided by discounted assumed lifetime energy produced in MWh (similarly to average weighted LCOE calculation)
 SOURCE: Global Insight; McKinsey

voivodeships could be in excess of PLN 7 billion by 2030 – roughly 0.5 percent of the cumulative ten-year GDP for these provinces.⁶¹ Moreover, in excess of 10,000 new jobs could be created in these two provinces, the equivalent of nearly 7 percent of the total number of unemployed people there (or 9.6% if also indirect and induced jobs are included).⁶²

Value chain benefits

Developing offshore wind could usher in a renaissance in the shipbuilding sector. The sector could potentially build the ships required for installing and operating wind farms, as well as key elements of the wind farms, including the towers, turbines and foundations.

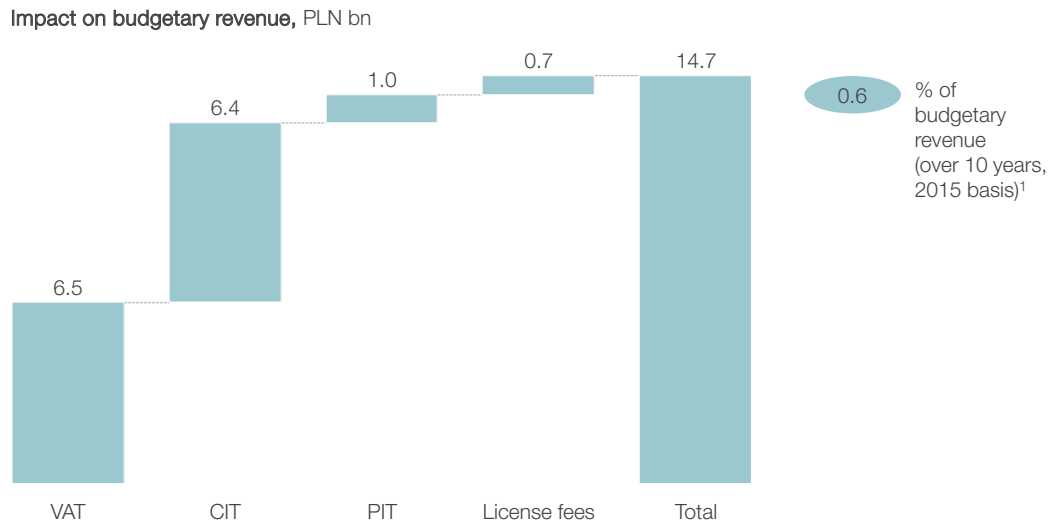
Another, less obvious benefit arising from the development of offshore wind power in Poland would be the impact on heavy industry and mining. The two main raw materials used for the construction of offshore wind farms are steel (primarily for towers and foundations) and copper (for inter-array and export cables).

O&M for offshore wind farms and its impact on unemployment

Offshore wind farms generally have a working life of around 20 years. During this period, according to our analysis, the servicing, monitoring and repairing of offshore wind farms in Poland with a total capacity of 6 GW could create work for more than 1,200 people.⁶³ A further 1,000 jobs could be created in the industries supporting offshore wind farms, such as port services, transportation, and servicing ships. This would create an opportunity for significantly reducing unemployment in the potential operating ports for Polish offshore wind farms – namely Władysławowo, Ustka, Darłowo, Łeba and Kołobrzeg.

Exhibit 18

Offshore wind development in Poland could have a PLN 15 billion impact on budgetary revenue in the form of taxes and fees



¹ Compared to 2015 tax collection of PLN 260 billion
SOURCE: GUS; McKinsey

The development of offshore wind farms in Poland through 2030 could become the biggest steel-consumption project of recent years. It could boost demand for products from many Polish steelworks, especially Huta Czesochowa, which in the past produced steel sheet (for ships) with roughly the same specifications as required for the production of towers for offshore wind turbines. This increase in demand could revive the steel industry in Czesochowa, where it previously formed the basis of the local economy.

Almost 30,000 tonnes of copper coils, worth PLN 0.5-1 billion, would be needed through 2030 for cables for building offshore wind farms with a total capacity of 6 GW.⁶⁴

Innovation

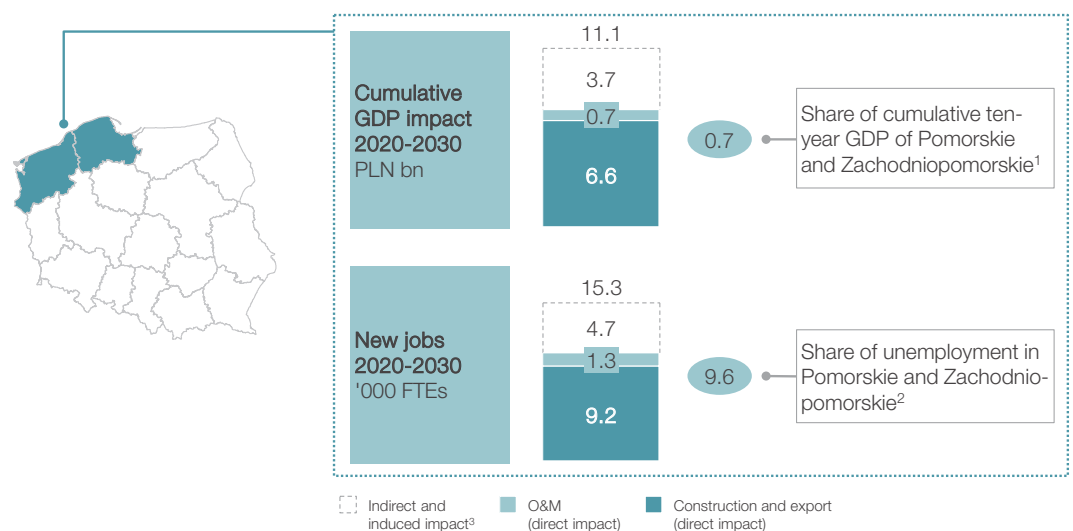
Offshore wind power is a relatively new technology, and one that is still gaining momentum.⁶⁵ The key to its long-term success is reducing costs. Accordingly, we can see an increasing focus on innovation. Poland, with its research centers in coastal regions, can benefit from this development to become one of the leaders in R&D in the industry. This would not only raise the level of innovation but also potentially strengthen the position of Polish companies in the value chain.

Exploiting opportunities – Development of the supply chain

For offshore wind to have a significant impact on the Polish economy, businesses in Poland must play a leading role in the supply chain. The key is for Polish companies to gain experience in this field, enabling them to build a strong position in the market for offshore wind and expand into the European market. Given the number of wind farms currently planned by Germany and the UK,⁶⁶ there is great potential for Polish companies hoping to enter this sector.

Exhibit 19

The economic impact of offshore wind on Pomorskie and Zachodniopomorskie in 2020-2030 is more than PLN 11 billion in GDP and over 15,000 jobs



1 Based on latest available GDP by voivodeship GUS data (2014)
 2 Based on GUS Q1 2016
 3 Estimated share of indirect and induced impact, based on share in Polish GDP of Pomorskie (5.7%) and Zachodniopomorskie (3.7%)
 SOURCE: GUS; McKinsey

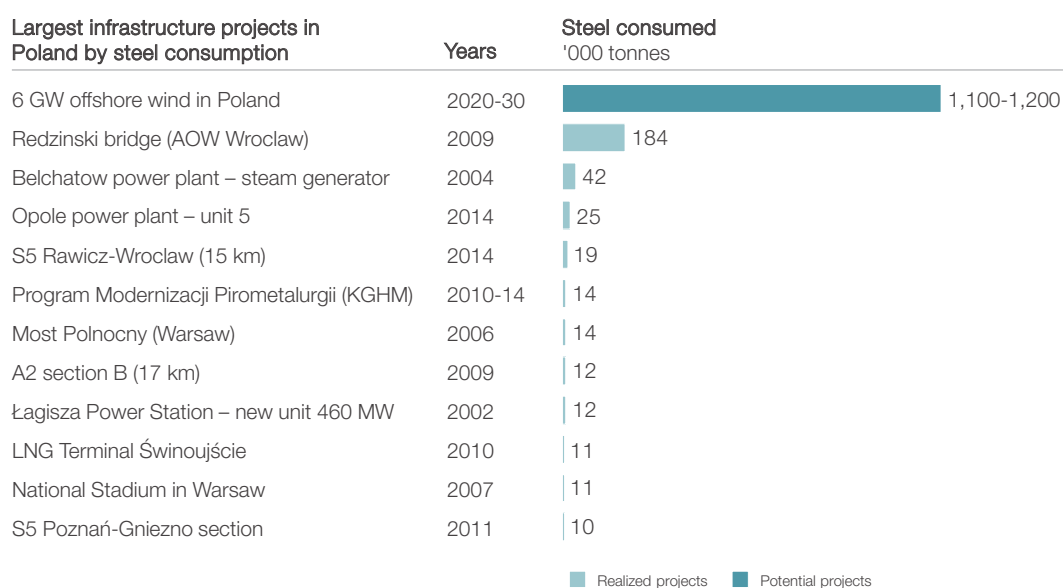
Moreover, participating in the market for offshore wind will mean that Polish players can create a cost-reduction trend. This will enable them to compete with foreign suppliers when companies are deciding which suppliers to use for Polish wind farms.

Example – Denmark’s Export Credit Agency

Denmark’s Export Credit Agency (EKF) supports the development of offshore wind farms. One-third of its portfolio in 2014 comprised projects related to offshore wind power. Moreover, it was involved in developing wind farms not just in Denmark but in Germany and Belgium, too.

Exhibit 20

Offshore wind development in Poland could become the biggest steel-consumption project of the last 25 years



SOURCE: Mostostal; Rafako; GDKKIA; ISD Huta Częstochowa; Ministry of Infrastructure; Blifinger Mars Offshore; press search; expert interviews; McKinsey

Conclusions

Offshore wind power is a fast-developing technology for energy production, and one that is creating tens of thousands of new jobs in Europe. The technology enjoys a more stable energy production profile than other low-carbon sources. Forecasts indicate that installed capacity in Europe will increase several times over by 2030.

Developing 6 GW of wind power capacity in Poland would require an investment of PLN 70 billion. Investment on this scale would enable Poland to build a supply chain within its borders, developing Polish businesses and localizing the plants of international companies in the sector inside Poland.

The development of offshore wind power through 2030 could generate PLN 60 billion of additional GDP for Poland, as well as creating 77,000 jobs and securing an extra PLN 15 billion in tax revenues for the state budget. This would benefit not only coastal areas but also companies throughout the country thanks to the development of a supply chain within Poland. Offshore wind could help develop and revive the shipbuilding and steel industries in Poland, becoming an engine of economic growth post-2020, when the European Union's current financial perspective ends.

Taking into account the potential economic benefits, the cost of offshore wind power will in reality be much lower for Polish society than traditional indicators imply. Moreover, developing the sector could act as a stimulus for developing local innovation potential, as offshore wind power is a technology where innovation is key.

Realizing this potential will involve many challenges. But a comprehensive strategy for developing offshore wind power, backed up by close cooperation between key stakeholders, could mean that Poland becomes one of the leaders in offshore wind power in Europe.

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Endnotes

1. *The European offshore wind industry – key trends and statistics 1st half 2016*, WindEurope
2. *The European offshore wind industry – key trends and statistics 1st half 2016*, WindEurope
3. *Informacje statystyczne o energii elektrycznej*, ARE, June 2016
4. *The European offshore wind industry – key trends and statistics 1st half 2016*, WindEurope
5. McKinsey analysis based on data from 4C Offshore
6. EWEA, <http://www.ewea.org/policy-issues/offshore/>
7. *Offshore Wind Industrial Strategy. Business and Government Action*, HM Government, 2013; “Port of Cuxhaven Forging Ahead with Offshore Wind”, <http://www.offshorewind.biz/2014/12/19/port-of-cuxhaven-forging-ahead-with-offshore-wind/> (accessed: August 30, 2015); Offshore Wind Report Bremerhaven, BIS, 2012; “Boomtown Bremerhaven: The Offshore Wind Industry Success Story”, <http://www.renewableenergyworld.com/articles/print/volume-12/issue-1/wind-power/boomtown-bremerhaven-the-offshore-wind-industry-success-story.html>
8. See, for example: “MHI Vestas Offshore Wind to serial produce blades on the Isle of Wight, UK”, <http://www.mhivestasoffshore.com/mhi-vestas-offshore-wind-to-serial-produce-blades-on-the-isle-of-wight-uk/>, (accessed: September 30, 2015); “Siemens to build wind power plant in Cuxhaven, Germany” [http://www.siemens.com/press/en/pressrelease/?press=/en/pressrelease/2015/windpower-renewables/pr2015080298wpen.htm&content\[\]=WP](http://www.siemens.com/press/en/pressrelease/?press=/en/pressrelease/2015/windpower-renewables/pr2015080298wpen.htm&content[]=WP), (accessed: September 30, 2015); “Siemens to build major offshore wind manufacturing site in the UK”, https://www.siemens.co.uk/en/news_press/index/news_archive/2014/major-uk-offshore-wind-manufacturing-site-to-be-built-by-siemens.htm
9. *The European offshore wind industry – key trends and statistics 1st half 2016*, WindEurope
10. McKinsey analysis based on data from 4C Offshore
11. In 2014 prices
12. McKinsey analysis based on data from Enerdata
13. McKinsey analysis based on data from Enerdata
14. McKinsey analysis based on data from 4C Offshore
15. McKinsey forecast
16. *Europe’s onshore and offshore wind energy potential. An assessment of environmental and economic constraints*, European Environment Agency, 2009
17. McKinsey analysis based on data from 4C Offshore
18. McKinsey analysis based on data from Enerdata
19. McKinsey analysis based on data from Enerdata
20. McKinsey analysis based on data from Enerdata
21. McKinsey analysis based on data from 4C Offshore; Powervision
22. *Wind energy scenarios for 2020*, EWEA, 2014
23. *The Power to Change: Solar and Wind Cost Reduction Potential to 2025*, International Renewable Energy Agency, June 2016; average exchange rate for 2015 from the Economist Intelligence Unit 2016
24. LCOE, or “levelized cost of energy”, is the total discounted cost of production (CAPEX, operating costs, cost of decommissioning) divided by the total discounted electricity generated in MWh. LCOE takes into account return on invested capital at the level of the discount rate

25. In the UK model, in which the investor is responsible for connecting the offshore wind farm to the power grid
26. Based on an analysis of the building of eight wind farms completed in 2014-2015
27. *Cost Reduction Monitoring Framework. Summary Report to the Offshore Wind Programme Board*, The Offshore Renewable Energy Catapult, 2015
28. "Dong Energy in offshore wind cost breakthrough", Financial Times, July 5, 2016
29. For wind farms built under the UK model, in which the investor is responsible for connecting the offshore wind farm to the power grid. Based on: *A Guide to an Offshore Wind Farm*, The Crown Estate
30. *A Guide to an Offshore Wind Farm*, The Crown Estate
31. *A Guide to an Offshore Wind Farm*, The Crown Estate
32. *A Guide to an Offshore Wind Farm*, The Crown Estate
33. *A Guide to an Offshore Wind Farm*, The Crown Estate
34. *A Guide to an Offshore Wind Farm*, The Crown Estate
35. *The European offshore wind industry – key trends and statistics 1st half 2016*, WindEurope
36. McKinsey analysis, based on data from 4C Offshore
37. McKinsey analysis, based on data from 4C Offshore
38. McKinsey analysis, based on data from 4C Offshore
39. McKinsey analysis, based on data from 4C Offshore
40. Engineering, procurement, and construction – a contracting arrangement covering all activities from design, procurement and construction to commissioning and handover
41. *Offshore Wind: Operations and Maintenance opportunities in Scotland*, Scottish Enterprise and The Crown Estate
42. Based on an analysis of ten wind farms of between 300 and 600 MW
43. Ibid.
44. Based on an analysis of the building of eight wind farms completed in 2014-2015
45. Based on McKinsey analysis of all European sale and purchase transactions for shares in offshore wind farms in 2010-2015, based on data from Dealogic
46. *Raport Roczny 2014*, Polskie Sieci Elektroenergetyczne S.A.
47. *Plan rozwoju w zakresie zaspokojenia obecnego i przyszłego zapotrzebowania na energię elektryczną na lata 2016-2025*, Polskie Sieci Elektroenergetyczne S.A.
48. *Model optymalnego miks energetycznego dla Polski do roku 2060*, Kancelaria Prezesa Rady Ministrów (Chancellery of the Prime Minister of Poland)
49. Ibid.
50. Czyżewski A., Grzelak A., "Możliwości wykorzystania statystyki bilansów przepływów międzygałęziowych dla makroekonomicznych ocen w gospodarce", *Przegląd Statystyczny* 1/2012
51. Input-output tables published in 2010: <http://stat.gov.pl/obszary-tematyczne/rachunki-narodowe/roczne-rachunki-narodowe/bilans-przeplywow-miedzygalezioowych-w-biezacych-cenach-bazowych-w-2010-r-,7,2.html>
52. *The European offshore wind industry – key trends and statistics 1st half 2016*, WindEurope
53. This takes into account both the pace of cost reduction and the strengthening of the zloty (based on the long-term forecast by IHS Global Insight)
54. Internal analysis by Polskie Sieci Elektroenergetyczne S.A.
55. Calculated as FTEs (full-time equivalents)

56. The assumed subsidy mechanism for offshore wind power is “contracts for difference”, providing support over a set period of 15 years. Under this mechanism, the energy producer sells the energy at the normal market price. If the price is lower than the price agreed in the contract (the “strike price”), the payer pays the difference. If, however, the market price is higher than the strike price, the producer reimburses the difference to the payer
57. Using a discount rate of 4 percent (based on the average interest rate for ten-year Polish PLN-denominated T-bonds in 2012-2015)
58. Assuming a “contracts for difference” subsidy mechanism
59. The impact of 6 GW of offshore wind power on Polish GDP over the lifetime of the wind farms, discounted by a rate of 4 percent (based on the average interest rate on ten-year PLN-denominated Polish T-bonds in 2012-2015) divided by the discounted assumed volume of energy in MWh generated over the lifetime (similar to the LCOE calculation)
60. Based on 2015 budget revenues
61. Preliminary estimates of GDP by province in 2014, Polish Central Statistical Office (GUS), January 2016
62. Based on data for Q1 2016 from the Polish Central Statistical Office (GUS)
63. Analysis by McKinsey, based on employment in O&M for 13 offshore wind farms in the UK and Denmark and publications by The Crown Estate and the Norwegian University of Life Sciences (UMB), indicates that on average 0.2 jobs in O&M are required per 1 MW of installed capacity
64. McKinsey analysis, based on interviews with suppliers. The value depends on the price of copper. The range indicated is based on the minimum and maximum copper price from 2010 to 2015 (LME)
65. In 2015 more offshore wind capacity was commissioned in Europe than in any year previously. Wind farms commissioned in 2014 and 2015 account for nearly 40 percent of total installed capacity in Europe
66. *UK offshore wind. Energy and infrastructure key facts 2015-16*, The Crown Estate; McKinsey analysis based on data from 4C Offshore

