Federal Ministry
for Economic Affairs
and Energy

Energiewende
Switch to the Future

The energy transition – a great piece of work

Offshore wind energy

An overview of activities in Germany

Imprint

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Content

Dear Readers,

By the end of this year, more than 3,000 megawatts of offshore capacity will have been installed in the German North Sea and Baltic Sea. This marks the arrival of the industrialisation phase for offshore wind energy in Germany, which holds the potential to reduce energy costs further in future. In 2014, we introduced important legal parameters which permit the determination of funding levels within calls for tender, as we also seek to reduce energy costs by attracting increased competition. The learning curve of recent years has resulted in new technological developments, this particularly evident in wind turbines, which play an important role in the energy transition.

The experience gained in these depths of water and at these coastal distances is globally unparalleled. As a result, investors, manufacturers, contractors, suppliers and logistics specialists as well as policy-makers have learned important lessons, facilitating the resolute expansion of offshore wind energy. These lessons apply to both technical and economic issues and legal questions.

It is already apparent that we set the right course with last year's reform of the Renewable Energy Sources Act: since the act came into effect, further investment decisions for new offshore wind farms from 2015 onwards have been taken.

The industry is also sending out positive signals, both in terms of technical innovation in wind turbines and in regards to the logistical challenges associated with constructing and operating the plants. That is why I am confident that we will soon be able to achieve the industry's planned cost reductions.

One thing is certain: both the industry and investors will find very clear legal frameworks up to 2020. These frameworks are accompanied by stable economic prospects for the upcoming projects, which constitute both an opportunity and an obligation for the industry. The opportunity lies in the option of industrialising offshore wind energy now. Yet, at the same time, we have an obligation to reduce costs significantly in the interest of electricity consumers. The Federal Ministry for Economic Affairs is also a reliable partner in this respect, particularly as regards overseeing research and development work that leads to reduced costs and increased efficiency, or the removal of bureaucratic hurdles.

If the energy transition is to be a success, it is crucial that we synchronise all aspects of the energy supply system. This is why we continue to develop and dovetail the design of the electricity market, energy efficiency and the electricity grid itself nationally and at a European level. Only in this way can the chosen course for the energy transition be successful in the long run.

A change in the funding system for renewable energies is due from 2017 onwards. This year and next, we will be holding mutual discussions regarding the drafting of calls for tender for the funding of individual technologies, with the goal of operating offshore wind farms more efficiently and cost-effectively in future. Competition in allocation procedures and a greater variety of stakeholders will lead to the success of the energy transition and go hand in hand with technological progress.

All the elements are in place. It is now time to pick up the pace and meet this ambitious schedule. This brochure seeks to clarify the complex interrelationships, describe the major technical challenges and accentuate the remarkable performance of the German economy in this area.
I wish you a pleasant read.

Yours,

Sigmar Gabriel,
Federal Minister for Economic Affairs and Energy

Chapter 1 Status and milestones – an introduction

The energy transition is one of the most important ventures of our time. The restructuring of our energy system permits us to phase out nuclear energy, makes Germany less reliant on imported fossil fuels and reduces CO_2 emissions. By 2050, renewable energy is expected to provide up to 80 per cent of our power supply. In addition, the energy transition acts as a modernising force within our industrial society and creates sustainable jobs through innovation. For this generational task to become an ecological and economic success story, energy must remain affordable and secure. Only then can Germany remain competitive as an industrial centre.

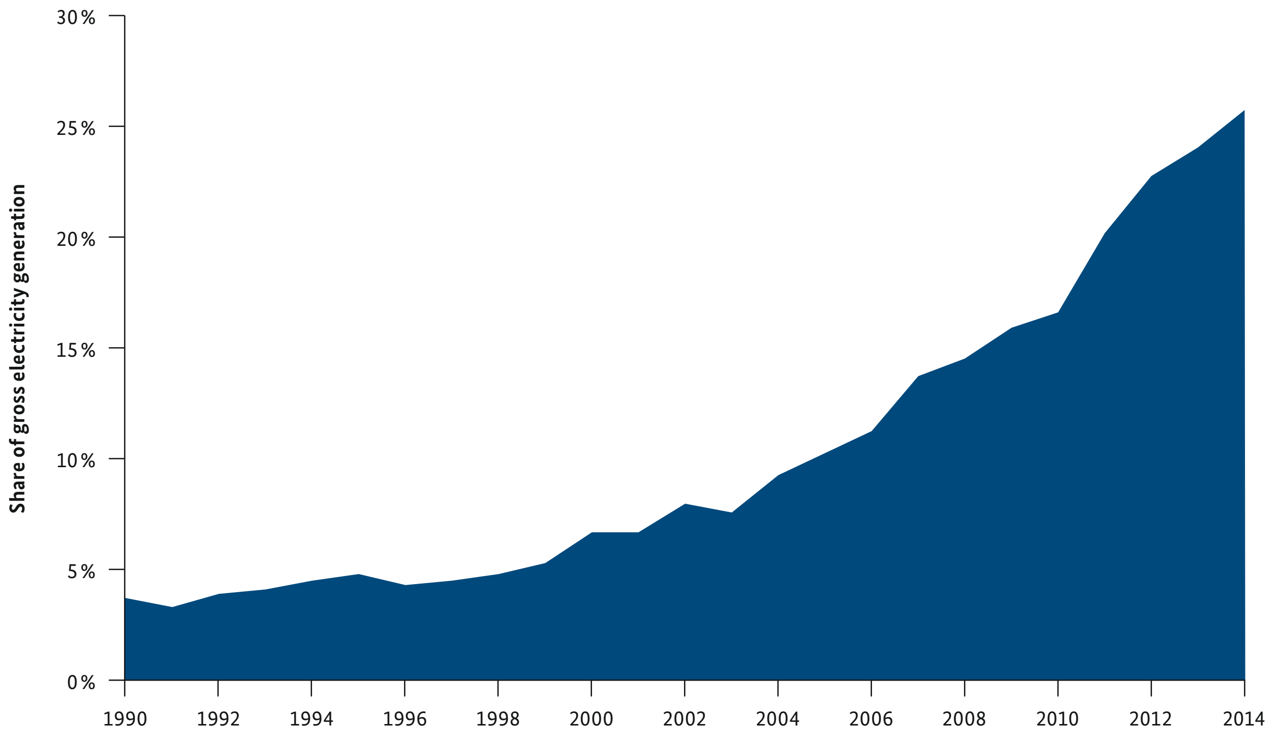
The energy transition for the future

The essential framework for the expansion of renewable energies was laid down in the German Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz, EEG), which came into force in 2000. The EEG acted as a door opener for the technology, then still in its infancy, through a system of targeted incentives. It guaranteed the acceptance and priority access of renewable energy and introduced fixed payments. As a result of this funding, renewable energies underwent a transformation from niche products to one of the mainstays of our energy supply. The cost of electricity production from renewable energy sources fell significantly. However, the rapid expansion also led to an increase in the EEG surcharge for electricity consumers. As a result, the German government fundamentally reformed the Renewable Energy Sources Act in 2014.

Under the special equalisation scheme, energy-intensive industrial companies that face international competition are charged a reduced EEG surcharge or none at all. In addition, the reform is driving the integration of renewable sources within the electricity market by committing the operators of major new plants to direct marketing of the electricity they produce.

It is vital to reduce the cost of further expansion. On the one hand, this is achieved through a strengthening of the competition. In the future, a tendering system should be used to determine the level of funding for electricity from renewable sources. On the other hand, the EEG is now focusing increasingly on the cheaper energy sources photovoltaic and wind energy. The latter in particular has developed into a key part of the energy transition. It already provides more than eight per cent of the power supply.

Share of renewable energies in gross electricity production in Germany between 1990 and 2014



Source: AGEB/Statista 2015

In order to fully plan and manage the expansion and to ensure the economic viability of wind farms, an expansion pathway has been put in place. The annual expansion amount should lie between 2.4 and 2.6 gigawatts (gross).

Paving the way for offshore wind energy

It goes without saying that regulations on the use of wind energy at sea also exist (see Chapter 2). Off the coast, i.e. offshore, there are much higher average wind speeds. At the measuring station FINO 1 in the North Sea, the average wind speed is around 10 metres per second and thus significantly higher than average wind farm sites on land. Consequently, offshore plants can produce much more electricity at a more consistent rate. This potential played a decisive role in the German government's decision to adopt a policy paper on the use of offshore wind energy in 2002. Knowledge of the effects of development on the marine environment was limited, and there were numerous technological, economic and legal uncertainties. The policy paper included measures that contributed to an increase in planning security for offshore wind farms.

Connection to the grid poses a challenge.

The industrial importance of energy

As a study by the Fraunhofer Institute for Wind Energy and Energy System Technology (IWES) demonstrates, offshore plants are of immense importance to the energy industry. According to the study, these power plants can provide electricity almost every hour of the year. In addition, the approximate electricity yields can be predicted. Above all, offshore wind energy offers greater economic efficiency. The study proposes three possible scenarios for 2050, in which 80 per cent of our energy needs are provided for by renewable sources. In the scenario featuring a high proportion of offshore plants, both the overall costs on the one hand and the flexibility costs on the other hand are reduced. The latter are generally accrued by renewable energies as a result of the backup and storage capacities required. When compared with the scenario featuring a high proportion of onshore or photovoltaic plants, the costs associated with the extensive use of large-scale offshore wind energy plants decrease by 2.9 billion euros and 5.6 billion euros respectively per year.

Moving expansion forward

As the expansion of offshore wind energy has progressed more slowly than anticipated in the 2002 policy paper, numerous measures have been adopted or adapted to the real needs of the industry over the years. They include coordinated grid connections through the transmission system operators, the construction of the offshore test area alpha ventus as well as the Offshore Wind Energy credit programme initiated by the Kreditanstalt für Wiederaufbau development bank (KfW), which allows operators to eliminate financing shortfalls in borrowed capital at market rates. The programme has 5 billion euros at its disposal and will support the first ten wind farm projects. As the offshore wind energy industry involves relatively new technology, the investment risks were difficult to calculate and banks were cautious in their lending. The German government also created the KfW programme to collate important technical know-how and to identify ways of reducing costs incurred by the construction of a wind energy plant (WEP).

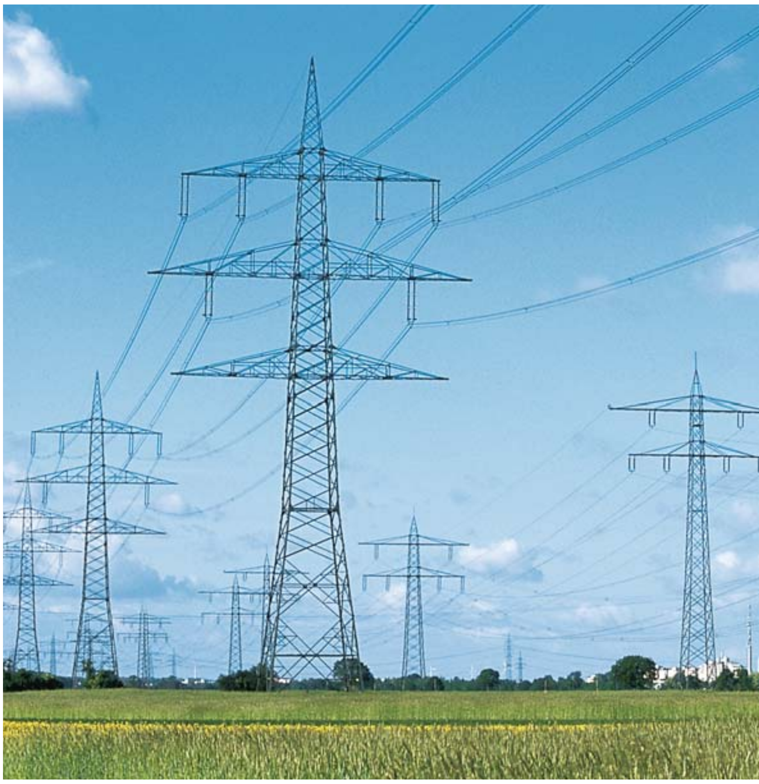
alpha ventus was the first German offshore wind farm. It has been supplying the German grid with electricity since 2009.

Full Load Hours

A full load hour is the measure to indicate how high the capacity of a power plant is. For example, a wind power plant with a maximum capacity of five megawatts, the equivalent of 5,000 kilowatts, would produce 22.25 million kilowatt hours of energy per year. Dividing the energy generated (22.25 million kilowatt hours) by the maximum power (5,000 kW), one obtains the capacity figure: 4,450 full load hours.

Conversion table:

1,000,000 kilowatt hours (kWh) is:
= 1,000 megawatt hours (MWh)
= 1.0 gigawatt hours (GWh)
= 0.1 terawatt hours (TWh)



The legislator seeks to accelerate expansion of the grid.

The EEG reform of 2014 adjusts the expansion targets in line with realistic development and, at the same time, creates planning security through the regulation of the expansion of offshore wind energy until 2030. By 2020, the installed capacity will amount to 6.5 gigawatts, a figure set to rise to 15 gigawatts by 2030. These binding targets make it possible to estimate the cost to the consumer and also provide both operators and investors with planning security. The latter also applies to the extension of funding via the so-called acceleration model (see Chapter 2) until 2019.

Challenge: connecting to the grid

Previously, each wind farm was, under certain conditions, entitled to be connected to a grid within a certain timeframe. This resulted in significant delays in grid connection. To rectify this, the legislator developed the Spatial Offshore Grid Plan (BFO). Since 2012, the BFO has determined which regions of the exclusive economic zone in the North and Baltic Seas are suitable for the construction of wind farms with joint grid access. In addition to these clusters, the plan also identifies pathways for the connection lines and the locations of the transformer platforms. It is updated annually. In order to synchronise the construction of wind farms and grid connections more effectively, the German Energy Act was amended in late 2012, which resulted in the introduction of the Offshore Grid Development Plan (O-GDP). This determined the number of offshore connection lines required for the next decade and established a fixed timetable for their creation.

Against the background of binding expansion targets, the Federal Network Agency assigns the available grid capacity via a transparent allocation procedure facilitated by an amendment to the Energy Act in 2014. This permits the quantitative monitoring of the expansion process and ensures that the network infrastructure is used efficiently. In August 2014, the Federal Network Agency (BNetzA) published its stipulations for the allocation of offshore connection capacities, assigning prospective operators capacities for connection lines accordingly. In terms of the expansion targets for offshore plants, the maximum connection capacity will amount to 6.5 gigawatts by 2020. However, the Federal Network Agency is entitled to increase this figure to 7.7 gigawatts until 1 January 2018. In addition, the Agency put in place regulations for an auction of connection capacities – in the event that demand exceeds supply. In January 2015, the Federal Network Agency allocated a total of 1.5 gigawatts of additional network connection capacities, meaning that a total of 7.5 gigawatts of mains power are assigned to wind farms.

Commencement of construction on the Trianel Wind Farm in 2011: before the jack-up-vessel Goliath drives piles into the seabed, another boat puts a bubble curtain around the construction site for purposes of noise reduction.

The first offshore wind farms

Numerous wind farms are currently either already in operation or under construction. By the end of 2015, the offshore production operations will be supplying the German grid with approximately three gigawatts of electricity.

The wind farms that are already in operation, under construction or have successfully undergone approval procedures have a total capacity of around ten gigawatts. This could supply approximately ten million German households – a quarter of the nation's private households.

The first ever German offshore wind farm, alpha ventus, began operations in April 2010 and was a pilot project for the energy providers EWE, E.ON and Vattenfall with the support of the German Offshore Wind Energy Foundation. Numerous research projects at alpha ventus were also provided with funding from the Federal Ministry for Economic Affairs and Energy. The wind farm is located around 45 kilometres off the island of Borkum and is situated in the German Exclusive Economic Zone (EEZ) in the North Sea. Experience gained through the offshore test area has proved advantageous for the further expansion of offshore wind energy.

Research projects implemented at alpha ventus have included the development of an extensive database since 2010, which is unique by international comparison. Among other things, this serves the technical optimisation of system components and the development of control systems. It also permits an exploration of the impact of the development of offshore wind energy on the marine environment from the earliest stages of offshore wind farm operations and allows operators to develop appropriate measures to mitigate this.

2011, the first full year of operations, saw alpha ventus produce around 268 gigawatt hours of electricity from its 12 wind turbines – there are six 5-megawatt turbines from AREVA Wind and another six from Senvion (formerly REpower Systems). In other words, the wind farm supplied electricity to almost 70,000 households – measured according to the average consumption of 3,500 kilowatt hours per year. This was a huge success, given that the estimated figures were much lower. The operators were expecting 3,900 full-load hours, whereas alpha ventus produced approximately 4,500 full-load hours.

The first ever commercial offshore wind farms also supply the German grid with electricity. Baltic 1, located 16 kilometres off the coast of Mecklenburg-Western Pomerania and thus falling within the 12 nautical mile German Baltic Sea zone, comprises 21 wind turbines from Siemens with an individual capacity of 2.3 megawatts. According to the operator EnBW, the offshore wind farm Baltic 1 has the capacity to generate 185 gigawatt hours of electricity annually, allowing it to supply 50,000 households. 35 kilometres off the coast of Heligoland, the Nordsee Ost wind farm, operated by RWE Innogy, was completed in late 2014. This offshore wind farm (owf) features 48 wind turbines with a capacity of 295 megawatts. On average, the farm can generate 4,000 full- load hours and supply 320,000 households with electricity.

The largest offshore wind farm currently in operation is BARD Offshore 1 with a capacity of 400 megawatts. Meerwind Süd/West and Riffgat have been on the grid since 2014 and supply 288 and 108 megawatts respectively. The smaller offshore wind farms such as ENOVA Offshore Ems-Emden, in the industrial port of Emden, and Hooksiel, north of Wilhelmshafen, provide 4.5 and 5 megawatts of power respectively. Many more offshore wind farms are being planned or are currently under construction, particularly in the North Sea. This means that, by the end of 2015, the installed capacity should provide approximately three gigawatts to the grid. An important milestone was achieved in December 2014 when the 285 offshore wind turbines produced over one gigawatt of electricity – 1,049.2 megawatts to be precise – for the first time.

The installation of a nacelle.

Chapter 2 Offshore wind farms in Germany

The Baltic Sea wind farm Baltic 1 has been in operation since 2011 and serves the electricity needs of around 50,000 households. When the 80 wind turbines of Baltic 2 are fed into the grid over the course of 2015, this figure will increase to just over 390,000 households. The 2014 EEG amendment defined a fixed target for installed capacity at sea by 2030. This reduces the former long-term goal of 25 gigawatts to 15 gigawatts – which is still an ambitious undertaking. However, the already completed farms are joined by many offshore wind farms still under construction, particularly in the North Sea where approximately 80 per cent of the currently installed capacity are located. Not only do they all entail significant financial expenditure, but also a comprehensive approval process.

The approval process

The sea off the coast is divided into the 12 nautical mile zone, which starts at the coast, and the adjoining Exclusive Economic Zone (EEZ). The Federal State grants approvals within the 12-mile zone off the coast. The Federal Maritime and Hydrographic Agency (BSH), a branch of the Federal Ministry for Transport and Digital Infrastructure, is responsible for the Exclusive Economic Zone.

Most of the projects are planned far from the coast, simply because the EEZ has more space. The projects' location ensures that the sensitive coastal ecosystems are effectively protected. For example, no offshore wind farms may be built in the vicinity of the Wadden Sea nature reserve. Project approvals within the EEZ have their legal basis in the United Nations Convention on the Law of the Sea and the German Federal Maritime Responsibilities Act. The Offshore Installations Ordinance, which regulates the approval process, is based on these two agreements.

The BSH, which acts as a planning authority, provides planning permission for all wind farm projects within the EEZ. Decisions are based on a comprehensive examination, which also weighs all public and private interests. Planning permission is only granted if:

- the wind farm does not impinge on the safety and efficiency of traffic and the security of national and allied defence;

- it jeopardises neither the marine environment nor bird migration;
- other requirements of the Offshore Installations Ordinance and public law requirements are met.

Several stages are necessary in order to ascertain whether the project complies with the requirements. Firstly, following submission of the application, checks are carried out to determine whether it is sufficiently detailed and precise. The opinion of various public interest bodies is also sought during this initial phase of planning permission (e.g. the Federal Waterways and Shipping Administration, the Federal Environment Agency or the Federal Agency for Nature Conservation). Their response may result in the developer revising its proposal. A second participatory round is geared towards public interest groups such as nature conservation, marine, fishing and wind energy associations. The federal states bordering on the 12-mile zone and the transmission system operators, who are responsible for connection to the power grid, are also involved. The public is also included in the second participatory round. The application documents are open to public inspection. This is followed by the application conference, which provides applicants with an opportunity to present their projects. Topics discussed within this context include studies required as regards the marine environment and which interests or types of usage may compete with the proposal. Following the application conference, the BSH sets out the framework for investigation in order to determine the project's impact on the marine environment and the waterways.

In the next phase, the applicant obtains the necessary assessments, such as a risk analysis for ship collisions, an FFH (Flora Fauna Habitat) impact assessment and – for projects with more than 20 turbines – an environmental impact assessment. Likewise, the building soil, the technical design and the wind farm configuration are all examined.

After this, first and second round participants are permitted to submit new statements – the discussion phase is under way. In a public hearing, the findings and observations are discussed by all stakeholders. The BSH then decides on planning permission on the basis of all submit-

"Standards developed with industry and science"

Interview with Dr Nico Nolte, Head of the Division for Sea Regulation at the Federal Maritime and Hydrographic Agency, who is responsible for the planning approval procedure regarding the construction of a wind farm.

How long do the approval procedures take?
As a rule, the approval procedure for an offshore wind farm takes between two-and-a-half and three years, with the marine environment assessment taking approximately one year alone. The broad public participation, within the context of which citizens, organisations and authorities are invited to contribute their opinions on the applications documents submitted, is also part of the procedure. As the potential impact on the shipping industry and the marine environment requires close scrutiny, three years is not very long for an infrastructure project of this size!

Wind farms are only licensed to operate for 25 years. Why is this?
We anticipate the technical life of wind energy plants to be 25 years, to be followed by dismantling, as no abandoned structures are allowed to remain at sea. However, if the foundations are still viable and stable and the interests of the marine environment and marine safety do not preclude this, an extension of the operation period or replacement of the wind turbines may be authorised.

Can new standards in the approval procedures lead to cost reductions?
The Federal Maritime and Hydrographic Agency has worked together with industry and science to develop three standards to support wind farm developers in the realisation of their projects: the standards on ecology, foundations (geotechnical studies) and construction (erection of the power plant). We now call on the industry to exchange its experience of the construction and operation of offshore wind farms, not only nationally but also internationally, in order to reduce the cost of new projects, via factors such as logistics and component manufacturing.

North Sea

Wind farms in operation

	Wind energy plant	Plant's performance in MW
ENOVA Offshore Ems-Emden	1	4.5
Hooksiel	1	5
alpha ventus	12	60
BARD Offshore 1	80	400
Meerwind Süd/Ost	80	288
Riffgat	30	108
Total	**204**	**865.5**

Wind farms installed or under construction

	Wind energy plant	Plant's performance in MW
DanTysk	80	288
Global Tech 1	80	400
Nordsee Ost	48	295.2
Borkum West II – Phase I	40	200
Butendiek	80	288
Amrumbank West	80	288
Sandbank	72	288
Godewind 1	55	332
Nordsee One	54	332
Total	**589**	**2,711.2**

Baltic Sea

Wind farms in operation

	Wind energy plant	Plant's performance in MW
Rostock	1	2.5
Baltic 1	21	48.3
Total	**22**	**50.8**

Wind farms installed or under construction

	Wind energy plant	Plant's performance in MW
Baltic 2	80	288
Wikinger	80	400
Total	**160**	**688**

Data extracted: February 2015, Source: BSH, www.offshore-windenergie.net, www.4coffshore.com, TenneT, BNetzA, Deutsche Windguard

ted documents and statements. The decision's ancillary provisions regulate, among other things, the period within which construction must commence, requirements such as sound limits when pile-driving, safe construction operations and the use of foundations that are as collision-friendly as possible. They also stipulate the approval's limitation period of 25 years.

Costs of building and operating a wind farm

The wind-giants at sea make high demands of both man and technology. These stringent requirements are reflected particularly in the costs of construction and operation of a wind turbine. The turbines, and the foundations which bear their weight, must be adapted to the conditions on the high seas, so that large amounts of energy can be generated long-term. The distances covered for maintenance and repair are also considerable. Nevertheless, the economic efficiency of offshore wind energy is apparent. According to the experts at Prognos AG and Fichtner Group, substantial savings could still be made. In the study entitled "Cost Reduction Potentials of Offshore Wind Power in Germany", commissioned by the German Offshore Wind Energy Foundation, the Offshore Forum Windenergie (OFW) and other partners, two expansion scenarios for the period from 2013 to 2023 were investigated. The study identified a significant cost reduction potential in the modest scenario 1, which corresponded fairly closely to the EEG's pathway to expansion (32 per cent of the site example quoted below). The scenario is based on a changing "plant and wind farm configuration", i.e. the plants with a capacity of six to eight megawatts per turbine and rotor diameter of more than 150 metres are significantly larger. As a result, fewer plants are built in total.

At the same time, site characteristics are changing. Increasingly, wind farms are being constructed further away from ports and are anchored deeper in the water. The study defines a wind farm B type, for example, where the plants are located at depths of 40 metres 80 kilometres away from the nearest port. This type of wind farm looks set to dominate the industry between 2017 and 2020.

At site B, the study envisages a 17 per cent reduction in specific investment costs. This is primarily due to increased turbine performance and improved logistical planning. Anticipated increased competition and learning curve effects as regards the approval process may also play a role.

The specific annual operating costs are reduced by 19 per cent according to the level of expertise in the field. It would be particularly helpful if operators could draw on the same "maintenance and logistics concepts". In addition, the increase in turbine output would "result in substantially lower specific costs".

Financing options

Due to the high investment costs, project developers and energy producers can hardly take on the full cost themselves. For offshore wind farms, mixed financing is common, consisting of equity capital and borrowed capital.

Ambitious: offshore wind farms challenge man and technology.

The study "Cost Reduction Potentials of Offshore Wind Power in Germany" verified that this mixed financing method also offers a reduction in costs – not least due to an increased understanding of these projects which develops as years pass. This diminishes the risks and boosts the confidence of external creditors, such as banks, in consequence. The resulting reduced equity capital ratio also reduces the cost of capital. Risk premiums also decrease.

As financial institutions usually only provide a limited sum for offshore wind farms, several banks are often involved in the financing. For some projects, loans have been provided by the Kreditanstalt für Wiederaufbau (KfW) or the European Investment Bank (EIB), bridging the financial shortfall and supporting the construction of the first wind farms at sea. Within the framework of the offshore credit programme, the KfW Bank is contributing with a loan of 265 million euros to the financing of offshore wind farm, Meerwind Süd/Ost, while the KfW IPEX-Bank is lending 195 million euros. For Global Tech I, the KfW's loan amounted to 330 million euros, while Butendiek received 239 million euros. The EIB financed the largest wind farm in the Baltic Sea, EnBW Baltic 2, with 500 million euros. Projects are frequently supported by a number of investors. The system of multiple investors proves advantageous for small shareholders like public utility companies, which can participate without having sole responsibility for the project management.

For more information: www.erneuerbare-energien.de

The EEG provides impetus

The German Electricity Feeding Act (Stromeinspeisungsgesetz) had required electricity providers to purchase some of their power from renewable energy sources from 1991 onwards. The German Renewable Energy Act (EEG) followed nine years after this first regulation, and has, since then, resulted in the creation of more incentives for the faster expansion of renewable energies. This systematic enhancement may justifiably be deemed a success. Not only has the share of renewable energies in electricity consumption increased, from 6.8 per cent (2000) to about 25 per cent (2012), but the law itself is also an export hit. To date, it has served as a template to advance the provision of renewable energies in the electricity sector in 65 countries.

The amendment of the EEG in 2014 allows operators to choose between two funding models. The basic model offers them a greater funding support of 15.4 cents per kilowatt hour for the first 12 years of operation. An extension of this period is possible for all wind farms situated outside the 12 nautical mile zone and anchored at a depth exceeding 20 metres. After the opening phase, funding support decreases to the basic amount of 3.9 cents per kilowatt hour.

The second option, the acceleration model, offers more attractive conditions and is aimed primarily at investors. It provides an initial funding support of 19.4 cents – if only for eight instead of twelve years. An extension of the higher funding support period is possible depending on distance from the coast and water depth. After this, the basic model rate of 15.4 cents per kilowatt hour is paid. Initially, the acceleration model applied to power plants due to commence operation before 1 January 2018. However, the 2014 EEG amendment extended the model until the end of 2019.

EEG in brief

Basic model:

- 15.4 cents/kWh for the first twelve years
- Remuneration is prolonged depending on water depth (1.7 months for each full metre beyond a depth of 20 metres) and distance from the coast (by 0.5 months for each full nautical mile from the 12-mile zone).

Acceleration model:

- 19.4 cents/kWh for the first eight years
- The increased initial compensation is extended according to the distance from the coast and the water depth.

Degressions act as an incentive for the rapid construction of wind farms. In the acceleration model, the funding support for power plants which still have not delivered electricity by 1 January 2018 decreases by one cent per kilowatt hour. This remains constant until the end of 2019. In the basic model, half a cent per kilowatt hour will be deducted at the start of 2018. From 1 January 2020 onwards, the remuneration is decreased by one cent per kilowatt hour, and from 2021, there is a further annual decrease of 0.5 cents per kilowatt hour. The remuneration is granted for a maximum of 20 years.

With the planned amendment of the Renewable Energy Sources Act (EEG) in 2016, the support scheme will gradually transition into invitations for tender. The change should be undertaken transparently and involve all the relevant stakeholders. The switch from support scheme to invitations for tender is currently being tested with photovoltaic facilities within the context of a pilot project.

Supporting development of the grid

Since August 2014, the Federal Network Agency has been responsible for assigning connection capacities to the operators. If the demand is greater than the supply, an auction for the available potential is held.

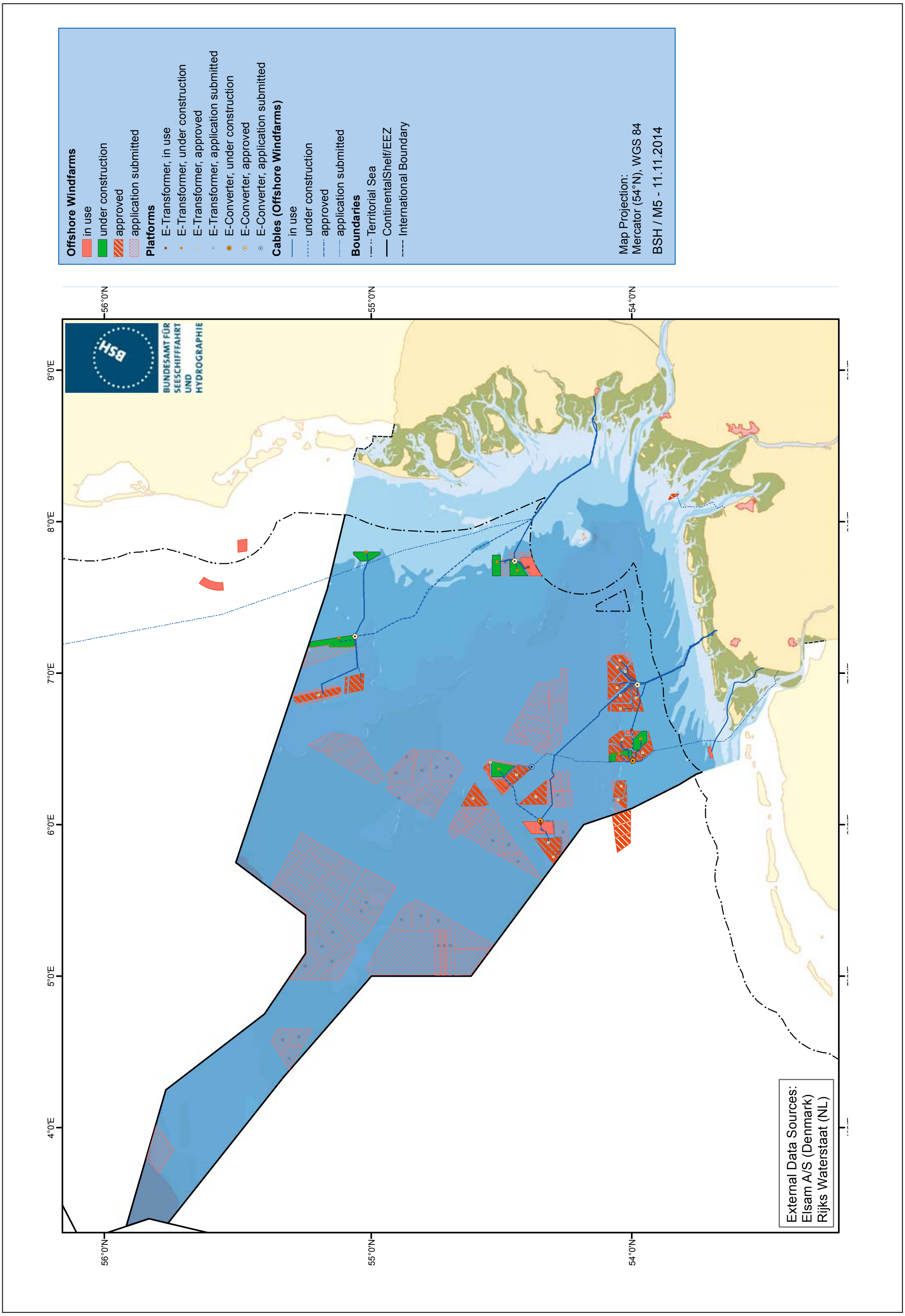
Connection to the grid is one of the most pressing challenges for the offshore sector. The transmission system operators – in other words, the companies that operate the national electricity grids – are legally obliged to install the lines to the substations of offshore wind farms in the most technologically and economically viable point on the grid. The costs incurred can be transferred to the network charges. A number of technical challenges have resulted in a reduction in the amount of connection lines to offshore wind farms being established in recent years. In addition, the liability issue was still unresolved: who pays the damages when a wind farm is able to produce energy, but due to lack of connection lines the power cannot be fed into the grid? The unresolved issue of liability had an impact on investment in networks on the high seas, which almost came to a standstill.

To reverse the trend, the German government introduced a liability regulation which came into force in late 2012. According to this, operators are liable for the losses as soon as a wind farm cannot supply electricity for at least eleven days as a result of connection problems. Electricity consumers may cover these expenses to a maximum of 0.25 cent

The offshore wind farms are connected to the transmission network on dry land via submarine cables.

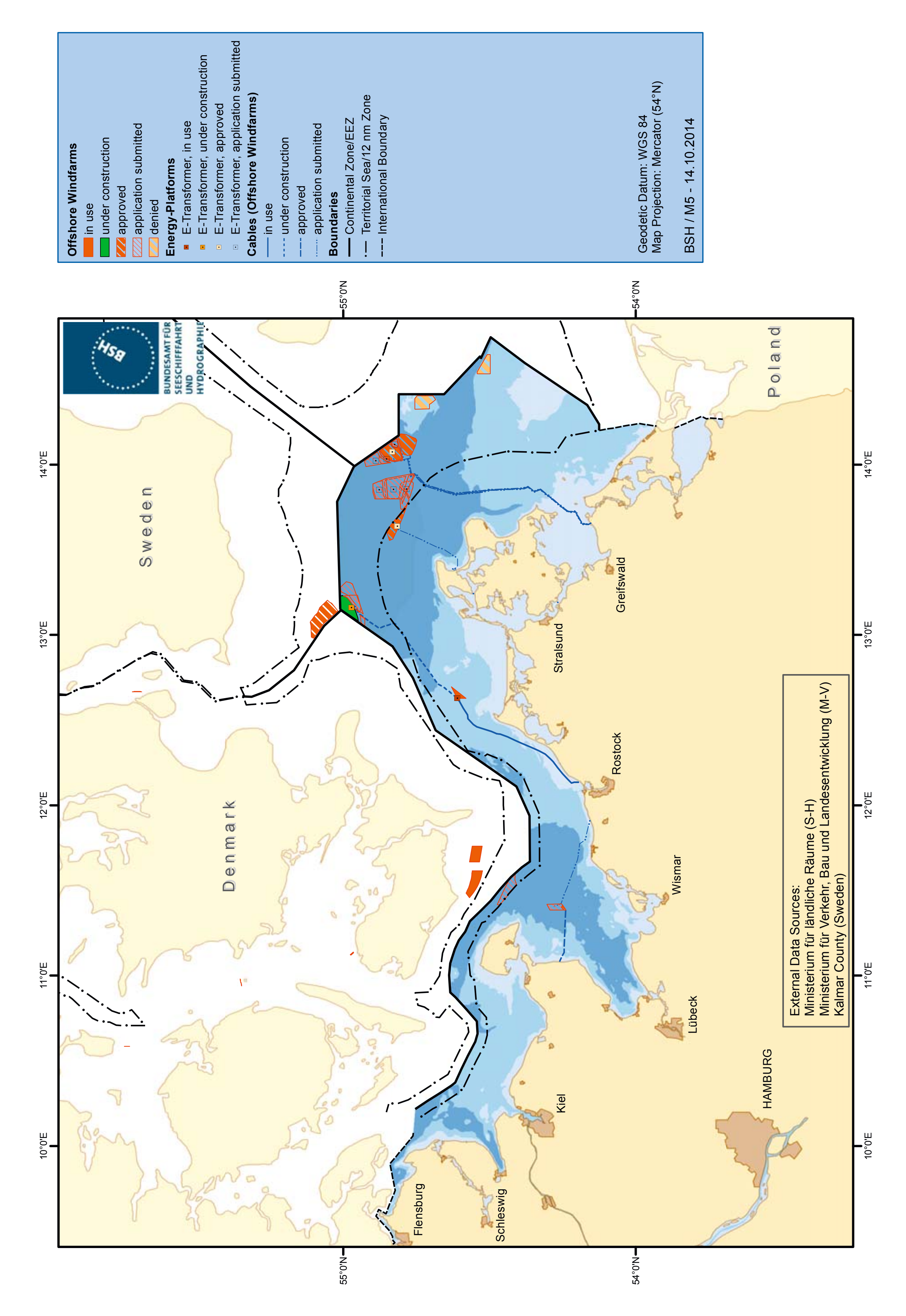
per kilowatt hour, but only if the transit grid operators are not responsible for the connectivity problems themselves and a damage mitigation strategy is being followed. For their part, the wind farm operators are entitled to claim compensation amounting to 90 per cent of the lost EEG remuneration. However, the regular EEG remuneration that is paid for an offshore wind farm decreases during this period. This is to prevent the consumers' electricity prices from skyrocketing. Also introduced with the amendment of the Energy Industry Act (EnWG) in late 2012 was a new instrument for development of the grid in the offshore sector, the Offshore Grid Development Plan (O-NEP). The transmission system operators submit the plan, which contains a timetable for implementation of concrete grid connection projects for the next ten years. The Offshore Grid Development Plan must be approved by the Federal Network Agency and is based on the so-called Federal Requirements Plan (Bundesbedarfsplan). The transmission system operators are obliged to adopt the measures in accordance with the prescribed schedule.

North Sea: offshore wind farms



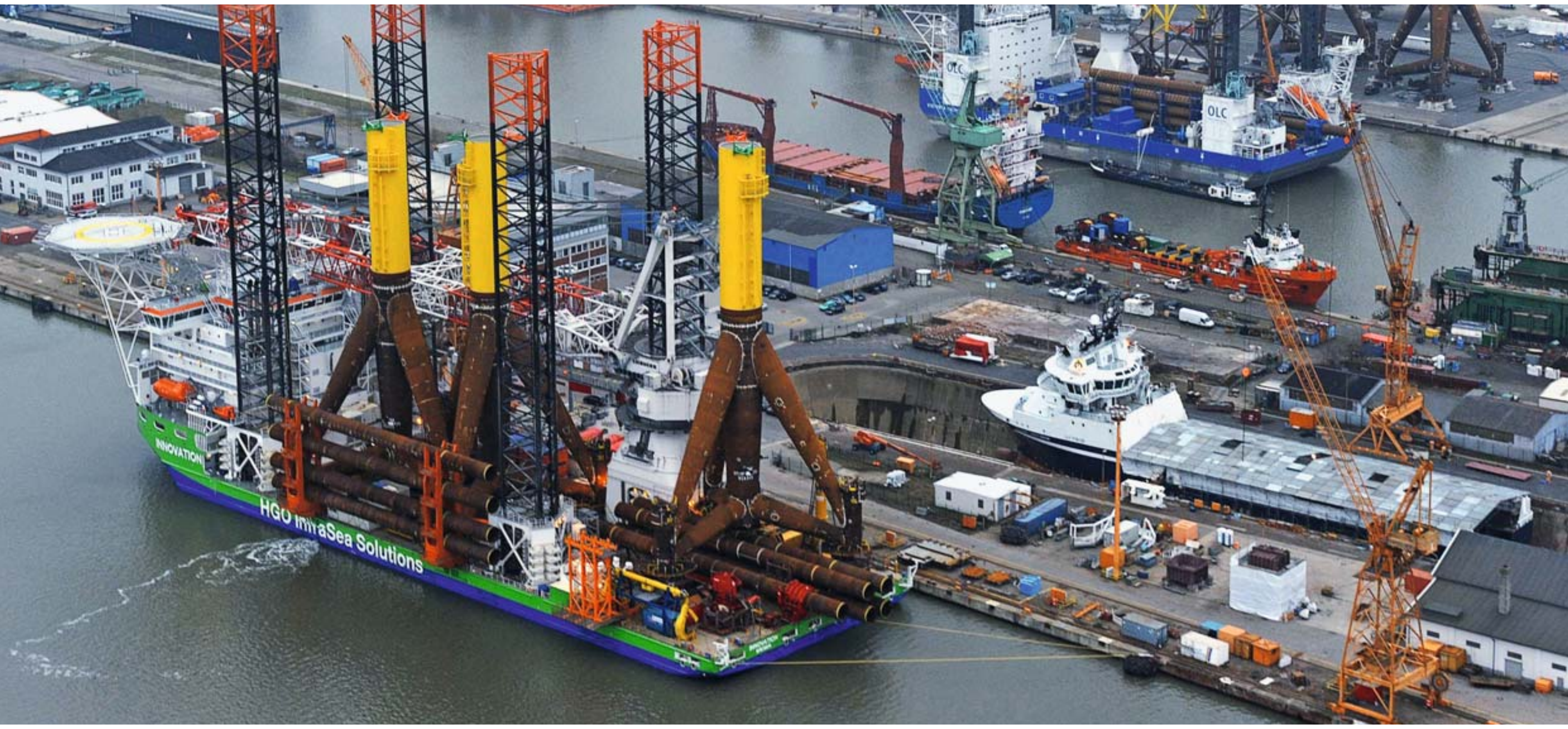
Source: Federal Office for Shipping and Hydrography

North Sea: offshore wind farms



Source: Federal Office for Shipping and Hydrography

Chapter 3 On the road to wind farms



Offshore wind farms are exposed to extreme conditions on the high seas. A wind power plant must be designed to withstand powerful wind forces, the waves and the strong currents for over 20 years. The extremely salty air and the salt water have a corrosive effect on the power plants. The plants' foundations must be particularly well-selected and soundly constructed.

The main components of a wind turbine

The main components of a wind turbine are the foundation of the tower, the nacelle and the rotor. Although the construction of the turbines is the same on land and at sea, some components differ depending on the varying conditions.

The tower is the longest part of a wind turbine. It supports the nacelle and the rotor. The nacelle houses the components required for the operation of a plant, such as the main bearings, gearboxes, generators, the drive shaft and the control and security systems. The hub and three rotor blades are part of the rotor. The former connects the rotor blades to the rest of the machine and transfers the energy that is generated. The weight of a wind power plant often exceeds 1,000 tonnes.

These days, many operators are planning plants with a capacity of five to seven megawatts. Due to the higher investment costs on the high seas, these systems are installed with a stronger capacity, to generate more energy from the wind. Several manufacturers are working to increase power capacity to further raise energy production between ten and fifteen megawatts per plant. As the capacity increases, the diameter of the rotor becomes larger as well. Rotors used in German projects currently span between 107 and 126 metres, while the latest plants boast rotor diameters of 150 metres.

Foundations for offshore wind turbines

The foundations, in particular, are subject to stringent requirements. A danger exists, for example, regarding sub-surface erosion ('scouring'). This occurs when the seabed at the foot of the foundations is washed out, causing wind turbines to lose their hold. Countermeasures include the very deep anchoring of the turbine in the seabed and depositing stones and stacking sandbags around the foundation. For wind farms at sea, there are various types of foundations that anchor a plant safely to the sea bed.

Monopile (single pile)

The monopile is the easiest to construct and involves the lowest material expenditure. The foundation is hollow and consists of a support. Many European wind farms located near the coast use the monopile. It was, until recently, only suitable for use up to depths of 20 metres. Meanwhile, so-called XL monopiles are being manufactured, which are secure up to a depth of 40 metres. This foundation has its advantages, particularly in terms of profitability: the potential savings are 30 per cent to 40 per cent greater than the jacket or tripod models.

Tripod

Manufacturers developed the tripod foundation specifically for offshore wind turbines. A steel tripod structure supports the main pillars under water. Tripods are suitable for depths of up to 50 metres and cannot be used in stony ground.

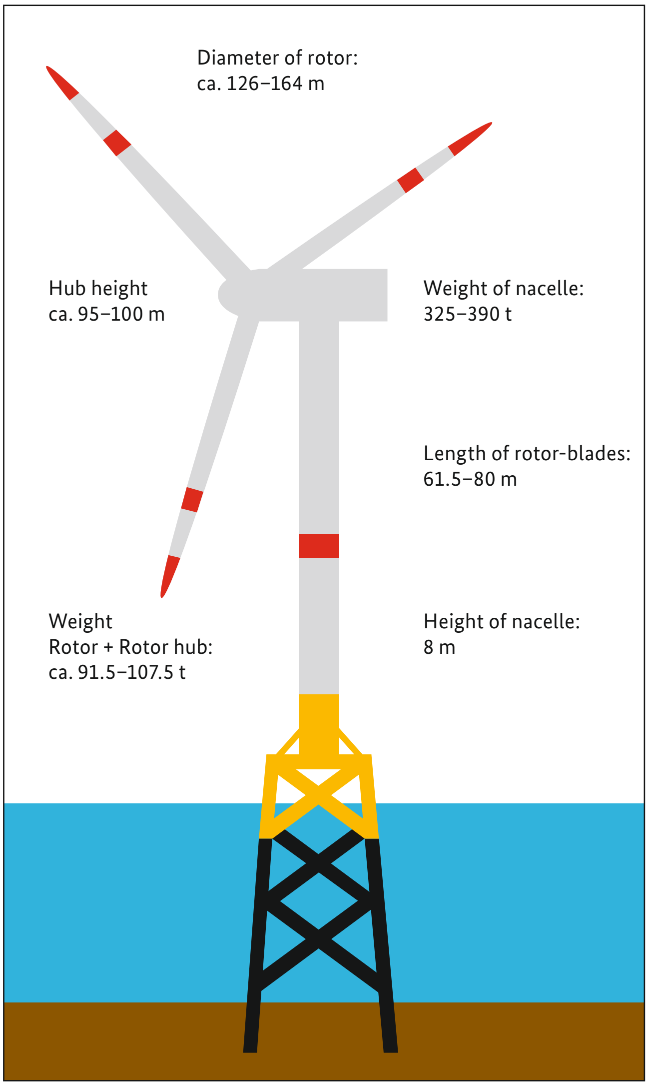
Tripile

The industry developed another type of foundation especially for wind turbines at sea. In the tripile, three steel pillars are anchored under water and another tripod structure is mounted on this above the water's surface. According to the manufacturer, the foundation is suitable for water depths of up to 50 metres.

Jacket (lattice tower structure)

The foundation is similar to the construction of an electricity pylon, thus saving 40 per cent to 50 per cent on materials. A jacket stands on four feet anchored with stakes in the seabed. The design has proven effective for oil rigs and is suitable for a water depth of 70 metres. Because its components are relatively small, a jacket can be produced fully automatically. Transport and installation are simple and cost-efficient. However, since the foundation is made of welded joints which require regular maintenance, this increases operating costs.

Big, bigger, offshore



Source: German Energy Agency (dena)

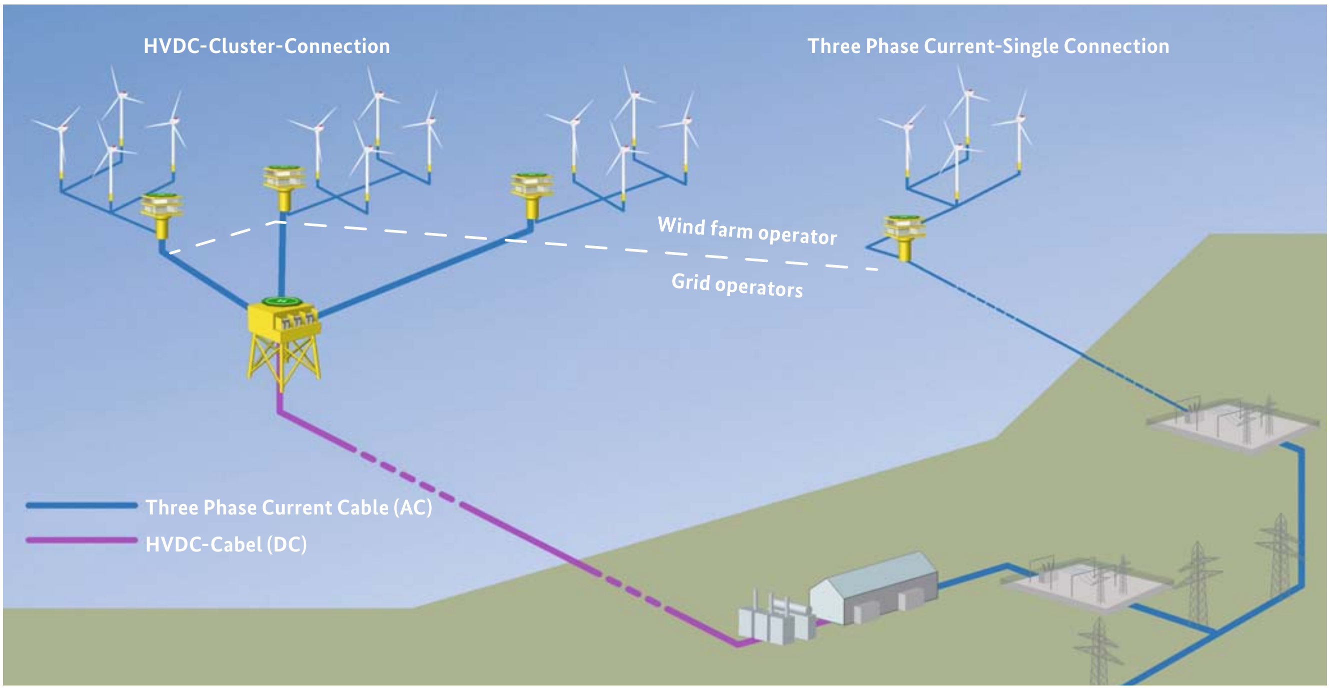
Gravity-based foundation

This foundation constitutes a large concrete block which supports the steel structure of a wind turbine. Because the foundation itself is not made of steel, the material price is lower than other types of foundation. The construction has so far only been tested for depths up to 30 metres, but is due to be adapted to deeper waters.

Floating foundations

With this construction, the wind power plant floats on the water and can be connected by a steel cable to the foundation. The advantage of a floating foundation is that it is easier to install. It can be completely prefabricated on land, and therefore does not require installation via jack-up vessels. Nevertheless, there are major challenges in terms of

Cluster connection of offshore wind farms



Source: German Offshore Wind Energy Foundation

cable connection and the management of wind and wave damage to the foundation and to the wind farms' powertrain. The company Gicon has developed a promising innovation. Four steel cables keep the floating foundation in place, which, according to the manufacturer, can even be used at depths of several hundred metres. The state of Mecklenburg-Western Pomerania is funding a prototype in the Baltic Sea, which will be installed at the site Baltic 1.

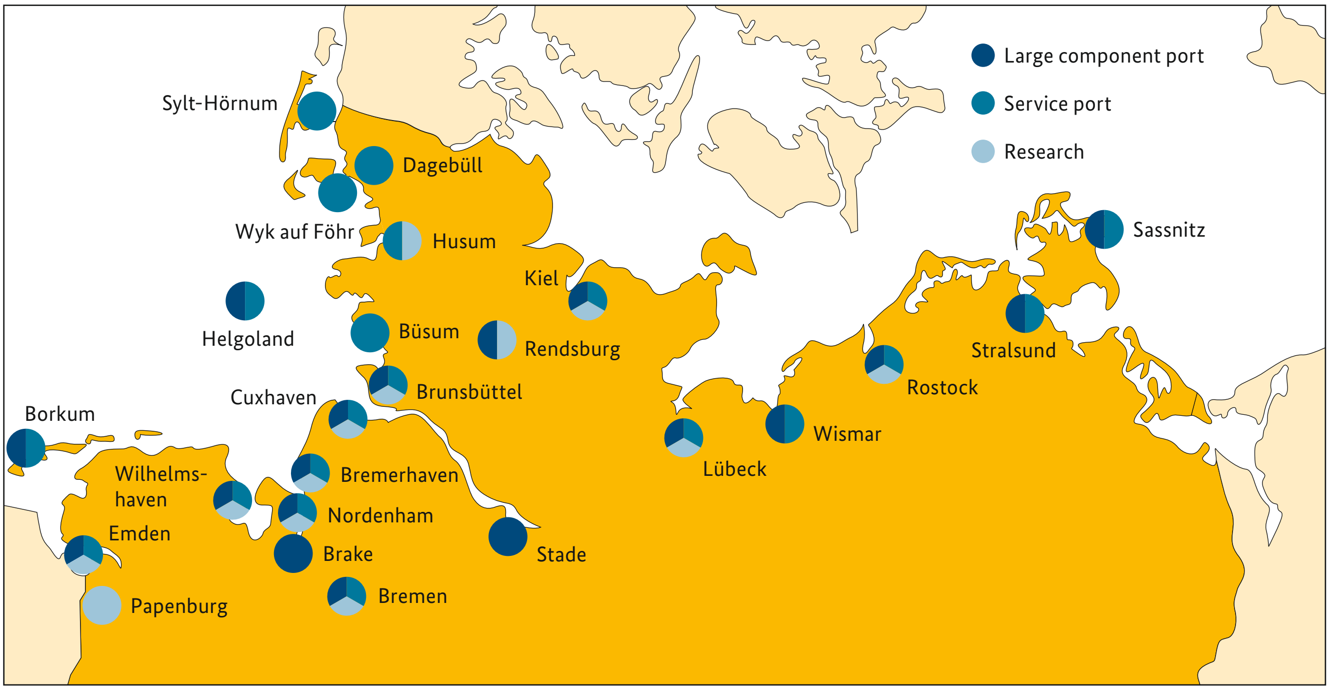
Suction bucket foundation

The suction bucket foundation is an inexpensive and relatively new way to anchor a wind turbine. Here, a vacuum is created between a steel flange, which looks similar to an inverted bucket, and the seabed. The foundation attaches itself firmly to the ground, ensuring that the wind power plant is secure and stands vertically. However, to achieve the required suction effect, the substrate must be homogeneous and not stony. One advantage of the bucket foundation is that it does not have to be driven into the seabed, making it particularly environmentally friendly. The method allows sound pressure that is dangerous to sea mammals to be reduced to insignificant levels. This, in turn, could speed up the approval procedures. The design is also suitable for deeper waters. For example, the operating range for the suction bucket foundations manufactured by Dong Energy lies between depths of 30 and 60 metres. Three steel cylinders, open from their underside, burrow into the seabed. The suction bucket solution promises lower foundation costs and a faster installation, which was demonstrated at the construction of the wind farm located at Borkum Riffgrund 1.

Turbines

The study "Cost Reduction Potentials of Offshore Wind Power in Germany" has shown that an increase in turbine output can also lead to a significant decrease in investment and operation costs (see page 13). Stronger rotors allow for a reduction in the number of turbines at a wind farm. The cost of building foundations and the expensive transport and maintenance would thus all be reduced. The current average output for turbines is four or five megawatts. However, a significant increase in output is predicted for the coming years. Vestas, for example, has developed an 8 megawatt rotor with a diameter of 164 metres, while, the new D6 Platform by Siemens, with a 154 metre rotor diameter, offers a nominal capacity of six megawatts. The turbine is gearless and functions instead with a direct drive. This reduces the number of necessary parts and thus, ultimately, decreases maintenance and installation costs. The longer rotor blades allow for a relatively high power output even at more moderate wind speeds.

Germany's offshore ports



Source: Central Association of German Seaport Companies (Zentralverband der deutschen Seehafenbetriebe e. V.)

Connecting a wind farm

To feed the energy from the sea into the German grid, the power generated at all the turbines in a wind farm is collected at a substation, processed for transmission and then increased in voltage. The method followed depends on the distance from the coast. If a wind farm is close to the coast, a submarine cable is used to carry the current to the nearest network node on land. But because most German offshore projects are further away from the coast, they are connected via a so-called cluster. Here, the power generated by several wind farms is collected on another transformer platform, the converter platform, and transported to land via a DC cable. In the Baltic Sea, connection takes place via AC.

Ports – hubs of offshore wind energy

In order to be able to ship the parts of a wind turbine out to sea, infrastructure needs to meet the special requirements of offshore wind energy. The seaports act as hubs for the offshore industry. For large components, ports with large storage areas and manoeuvring areas, as well as a high load capacity, are required. A rotor blade can be up to 75 metres long and a nacelle weighs around 300 tonnes – with rotor and hub, the weight can reach 400 tonnes, depending on the manufacturer.

How is electricity generated from wind energy?

The kinetic energy of the wind acting on the aerodynamic blades creates an uplift. When a certain wind velocity is reached, the rotors align with the wind direction. When the wind power is transmitted to the blades, the rotor starts turning. Via its drive shaft, the rotor is connected to the transmission, which adjusts the RPM of the rotor in line with the RPM of the generator. Once the critical speed is reached, an electric current is generated.

At the wind farms alpha ventus and Baltic 1, the wind must reach speeds of three to five metres per second – equivalent to wind force 3 – so that the rotors rotate. The systems are at full capacity when wind force 6 is reached, with wind speeds of twelve to fourteen metres per second. As soon as a very high wind speed is reached, a turbine turns off automatically for safety. For example, the average wind speed at alpha ventus (located in the North Sea) and Baltic 1 (Baltic Sea) is between nine and ten metres per second (wind force 5).

Many manufacturers have their premises directly by the port in order to produce or assemble plant components. The logistics for offshore components are always a great challenge. The motorway bridges with a standard height of 4.5 metres are insufficient for the transportation of six metre-wide rotor blades. Ports are both the departure point for maintenance work and of central importance for research purposes.

Depending on their function, the offshore ports are used either for the grouping of large components, or operate as service ports. Some are also sites of training, research and development.

Ports for large components

Installation port

Preassembly takes place in the installation port. The port must have sufficient storage and assembly areas, heavy-duty hinterland connections and the necessary quay surface and loading capacities. The port also requires water depths of at least eight metres.

Production port

Manufacturers produce parts for wind turbines directly next to the harbour or even in the harbour area itself. Examples of possible components manufactured here are nacelles, rotor blades or even foundations.

Import and export port

These ports are a transit point for wind turbine components. Sufficient storage space, quay surfaces with heavy-duty capacity and loading capacities are essential here.

Safety port

In bad weather, large, protected waterside areas provide places of refuge for ships used in wind farm construction.

Suction bucket foundation by Dong Energy.

"The market is thinking less and less regionally"

Interview with Andreas Wellbrock, CEO of BLG Logistics Group AG & Co. KG. The company has equipped its port terminal in Bremerhaven to provide logistics services to the offshore wind energy industry.

How have the port and logistic industries experienced the initial large wave of expansion? Can many processes be handled more efficiently?
In the past three years, BLG LOGISTICS has successfully executed several reference projects for wind farms in the German North Sea. As a logistics provider, we assumed the entrepreneurial risk, performed research and development and implemented innovative solutions in collaboration with our customers. This resulted in logistics concepts that offer a standardised, reproducible, industrial process chain for the offshore wind industry today.

How is the logistics sector preparing for the operation phase?
The consolidation process between the logistics sector and the wind power market continues. This is made manifest by takeovers, mergers and purchases of equipment. The market is thinking less and less regionally – it is becoming more European and global. Components now come from China; the USA is implementing projects with components from Europe.

What I like about the industry is that it is innovative and dynamic, and that those involved repeatedly seek exchange with each other. A so-called "lessons learned" workshop was held, for example, in which the participants involved in the first round of the project drew conclusions from the previous work.

Are the developments to date sufficient to meet the future needs of the offshore wind energy sector?
The expansion of offshore wind power is falling behind our – admittedly optimistic – expectations. The reasons for this are varied, but for us a central reason is the lack of planning capabilities and innovation security. The use of offshore wind turbines requires large financial investments in seaports, which, in turn, necessitates the correct framework conditions, which need to be secured in the long term. This is impossible without the support of the German government. The amendment of the EEG has helped to dispel a great deal of uncertainty within the sector. Now the industry, the federal and the state governments need to work together to dispel misgivings – also with a view to phasing out the existing funding support scheme by the end of 2019. BLG Wind Energy Logistics has already responded by broadening its position and offering its expertise in offshore logistics for all sorts of outsized goods on the terminal side.

Service port

Response port

The response ports are situated close to the wind farms and maintain operating materials, instruments and smaller components. This type of port is therefore a starting point for immediate, incidental repairs.

Supply port

The supply ports store operating equipment and tools, as well as small and large wind turbine components in order to provide offshore wind farms or response ports with the seas required.

Research, development testing and training

Be it manufacturers, universities or government research institutions – they all use the ports for research and development activities. Offshore wind turbines are installed and trialled at test sites in order to glean the most up-to-date findings. The sites are also used for training purposes for work on wind turbines at sea; including, for example, the necessary completion of safety training.

Chapter 4 Environmental benefits

Renewable energy is the key to climate-friendly power generation. CO_2 emissions generated by wind energy are negligible. The more electricity generated from renewable energies, the more environmentally-friendly the electricity mix becomes. In 2013, renewable energy sources accounted for savings of 105 million tonnes of greenhouse gases in Germany.

That said, what is the impact of offshore wind power on the marine environment? How do wind turbines affect animals such as birds and porpoises? In addition to the effects of wind and waves on offshore wind turbines, scientists have studied the effects of the construction and operation of offshore wind farms on the marine ecosystem during a variety of projects carried out at the offshore wind farm alpha ventus, and at the research platforms FINO 1, 2 and 3. These findings are important because, in the case of significant ecological damage, planning permission may not be granted. The results and findings of these studies also contribute to the development of environmentally-friendly solutions, thereby avoiding or reducing the negative effects on the marine environment. However, comparative studies from elsewhere, and particularly from larger wind farms, are still lacking. Generalisations concerning the possible cumulative impact of the proposed offshore expansion should be made with caution on the basis of the current state of knowledge.

The Federal Ministry for Economic Affairs and Energy funds projects for ecological research in the offshore sector and is thus instrumental in ensuring that knowledge gaps are closed and that the wind energy sector is developed in an environmentally-friendly manner.

RAVE research initiative

Since its commissioning, Germany's first offshore wind farm, alpha ventus, has also served scientific purposes. Funded by the Federal Ministry for Economic Affairs and Energy, the research initiative RAVE – Research at alpha ventus – unites 40 institutions which collaborate on over 30 individual projects. Here, the key question is how can electricity be produced reliably, economically and, above all, in an environmentally-friendly way? One focus is ecological research in order to gain an insight into the impact of construction and operation on the marine environment and compare this with prior forecasts. Assessments of environmental impact, which should be carried out according to the Standards for Environmental Impact Assessments (StUK) drawn up by the Federal Maritime and Hydrographic Agency (BSH), constitute part of the approval process for offshore wind farms. The StUK stipulates which assessments must be submitted for approval of a wind farm. It also sets out the analytical framework for ongoing monitoring during the construction and operation phases, which serves to detect possible impact on the marine environment and bird migration. At the wind farm alpha ventus, a broad-based research project (StUK-plus) additionally aims to expand the knowledge base regarding the ecological impact on the marine environment. The results influence the further development of StUK.

For more information: http://stukplus.com/en/

FINO 1, 2, 3

The idea to generate wind energy at sea, far off the German coast, was uncharted territory. In order to analyse wind conditions on the high seas, wave forces which structures must withstand and the height and frequency of bird flight and migration, three research platforms were built in the North and Baltic Seas. These research platforms are used for the extraction of meteorological, oceanographic and ecological data and form the basis of various research

FINO 1 collects data in the immediate vicinity of alpha ventus.

FINO: Research platforms in the North Sea and Baltic Sea

Source: Research and Development Centre FH Kiel GmbH

Bird migration is measured through methods such as scanning.

Sound minimisation techniques are used to protect porpoises.

projects. The first of the three FINO platforms – the acronym, in German, stands for "Forschungsplattformen in Nord- und Ostsee" (Research platforms in the North Sea and the Baltic Sea) – was put into operation in 2003 and is located 45 kilometres north of the island of Borkum, close to alpha ventus. The site of the first German offshore wind farm was deliberately chosen so that it could use the data from FINO 1 to test the wind turbines. In 2007, FINO 2 was erected around 40 kilometres north of the island of Rügen. The most recent research platform, FINO 3, which is situated about 75 kilometres west of the island of Sylt, has been providing data since 2009.

All research platforms are located in close proximity to areas where wind farms are due to be built. Essential results are obtained through the measured data, which serves to optimise the planned wind farms and provide input on various environmental issues. The data generated by FINO 1, 2 and 3 is publicly available on the website of the Federal Maritime and Hydrographic Agency (BSH).

For more information: www.fino-offshore.de/en

The marine environment

Birds

Several studies have investigated how seabirds react to wind farms and whether the wind turbines constitute an obstacle to their migration. According to previous findings, seabirds (depending on their species) have two basic response patterns to alpha ventus – either avoidance or attraction. Important indications were provided in the final report of the StUKplus' subproject entitled "Effects of the alpha ventus offshore test site on distribution patterns, behaviour and flight heights of seabirds". Avoidance was observed in lesser black-backed gulls, northern gannets, common guillemots, razorbills and loons. For the latter three, the density only increased significantly again at 2.5 kilometres' distance from the test area. However, the area between the offshore wind turbines does not form part of the loons' main resting sites. Little gulls, on the other hand, could benefit from alpha ventus. It is believed that the turbines change the current conditions, resulting in small food particles accumulating on the surface, which could prove advantageous to surface feeders.

For migratory birds, potential collisions and exhaustive evasive movements add to the problems posed by offshore wind farms. The collision risk is lessened when birds fly at such high altitudes that wind turbines pose virtually no obstacle. The StUKplus' final report for the subproject entitled "Bird migration" includes results of investigations at FINO 1 and alpha ventus. Migrating birds flying during the day usually encounter little danger from the plants because they recognise the rotating windmills and avoid them. However, a large proportion of migrating birds fly at night. Here, the collision risk varies depending on the weather conditions. In bad weather and unfavourable wind conditions, their flight altitude often falls below 200 metres, and the turbines' illumination attracts the birds, serving as a guide, resulting in an increased risk of collision. One solution would be to manage selected beacons, for example by reducing light spill upwards. In addition, further studies on the temporal distribution and density of bird migration are needed – this could facilitate a targeted shutdown of lighting. In principle, a shutdown is only possible if it is compatible with the safety of air and maritime transport. A main focus of future research activities is to investigate how a larger number of wind farms will impact on migratory behaviour.

Porpoises

Measuring an average of 1.80 metres in length, the harbour porpoise is one of the smallest species of whale. It weighs up to 90 kg, can live to be 12 years old and is very dependent on its sense of hearing. Wind farm operations pose no danger to porpoises. They have been spotted both individually and in groups around the alpha ventus wind farm, with sightings particularly common from April to June. Construction of offshore

"Substantial progress in the last few years"

Interview with biologist Anika Beiersdorf of the Federal Maritime and Hydrographic Agency (BSH), where she coordinates the research project StUKplus.

How do seals react to wind turbines and the construction process?
As yet, relatively little is known regarding the reactions of seals to wind farms. British researchers found that, for the first time, seals seem to be seeking out wind farms. Common seals and grey seals on the British and Dutch coasts were tagged with GPS devices and their movements were tracked. Some of the animals visited the offshore wind farms alpha ventus in Germany and Sheringham Shoal in the UK. They even swam from one plant to the next for foraging purposes. Presumably seals benefit from the additional food supply found amongst the foundations, since these are populated quickly.

Which soundproofing measures have proved successful?
In the past couple of years, considerable progress has been made in the development of sound insulation systems, such as bubble curtains, hydro silencers and sound insulation jackets. The use of combined noise protection systems has proven particularly effective. It is now fair to say that state-of-the-art construction of monopile foundations at depths of 25 metres has been achieved. The construction of the wind farm Butendiek, for instance, took place using a double soundproofing jacket in combination with a double bubble curtain, while consistently complying with the prescribed noise level of 160 decibels. In future, further solutions need to be developed to ensure the reliable protection of marine mammals during the construction of special structures (jacket-tripod foundations) and of foundations in up to 40 metres of water depth.

Is there evidence regarding the reaction of porpoises to pile driving?
Underwater noise can be carried widely during the pulse drilling of steel foundations into the seabed. Higher noise input can lead to a temporary or permanent shift in porpoises' hearing frequencies. To protect their hearing, before the beginning of each jacking process, marine mammals are scared away from the construction site through the use of acoustic devices (pingers and seal scarers). In addition, the Federal Maritime and Hydrographic Agency establishes an approved noise frequency at each wind farm, which must be observed during the building process. The banishment is only temporary; upon completion of the drilling process, the animals return to the area.

wind farms is much more dangerous to marine mammals because the principal method for anchoring the foundations to the seabed is through the use of hydraulic impact hammers. The resulting sudden noise can damage the hearing of porpoises temporarily or even permanently.

In order to protect the animals, the Federal Maritime and Hydrographic Agency (BSH) has stipulated a dual noise criterion developed by the Federal Environment Agency, which forms part of the approval process. When driving foundations into the seabed, the limit for the so-called Sound Exposure Level (SEL) is 160 decibels, which must be contained within 750 metres. It is presumed that, additionally, abnormal avoidance and escapist patterns may occur in the behaviour of porpoises. The lower the frequencies of the drilling sound, the smaller the interference radius for the sea mammals.

Safeguards

Vibratory pile driving

This method involves a vibrating action to lower the foundation into the seabed, creating a less hazardous continuous noise. Overall, the sound level is reduced by 15 to 20 decibels. However, the technique has only been used to anchor monopiles into the seabed so far. To date, vibrating pile driving has been limited to uppermost eight to twelve metres; anything deeper requires impact pile driving.

Bubble curtain

The Big Bubble Curtain is a tube ring system with nozzle openings, situated around the drilling area at a distance of approximately 70 metres. If a tube ring is filled with compressed air, a veil of bubbles rises to the surface. This bubble curtain deadens the sound. It works similarly to a Small Bubble Curtain. The tube rings with nozzles are installed directly onto the pile on the seabed and at various levels. The bubbles generated by compressed air envelop the driven pile.

Hydro Sound Damper

The Hydro Sound Damper is a new and promising concept that is still in its infancy. Gas-filled balloons attached to nets enclose the driven pile. Even though the project is still at the research and development stage, two major advantages of the method are already apparent. Due to the number, size and distribution of balloons, sound insulation can be more precise. In addition, there is no need for the air compressors that are required for a bubble curtain.

Pile sleeve

Pile sleeves enclose the driven pile to dampen the emission of sound. They can be constructed in various ways and consist of several layers. An example of this is the IHC Noise Mitigation Screen with a double-walled cladding tube, made of steel. In the inner tube, an air bubble curtain is produced which reduces the sound. Between the inner and the outer tube, there is a layer of air to further reduce noise. Another system, the so-called cofferdam, consists of a single-walled steel tube which is placed on the seabed. Water is then pumped outside the tube, so that the pile driving can take place in a dry space. Sound penetration of the body of water is effectively reduced as a result of this acoustic decoupling.

Suction bucket foundation

Suction bucket foundations are characterised by a particularly quiet anchoring procedure. In contrast to the gravity based foundations, which have already achieved a high level of marketability, suction bucket foundations only take up small spaces, making them some of the most promising alternatives to the monopiles, tripods and jackets. Using a vacuum, the buckets dig into the seabed. They can be used in depths of up to 60 metres. To date, these foundations have not played a significant role in the construction of offshore wind turbines, although they have already been put to use at substations and auxiliary platforms for oil and gas production. In 2014, the company DONG Energy installed a wind turbine on a suction bucket jacket at the Borkum Riffgrund 1 wind farm. The Federal Ministry for Economic Affairs and Energy funded a research project associated with this installation, which will measure and record data regarding the construction.

On 1 December 2013, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety published a sound insulation concept. This pays particular attention to the main area known for its concentration of porpoises, northwest of Sylt, during the period from May to August when the animals are raising calves. At this stage, no construction work may take place if more than one per cent of the main nesting area is in the interference radius.

No more than ten per cent of the German EEZ in the North Sea may lie within the radius of construction outside these periods, described in the sound insulation concept as “very sensitive times”. The sound insulation concept also stipulates the use of the best available technology. In principle, the porpoises are driven from the construction site by acoustic signals before the pile driving begins. There are also measures for soundproofing (see infobox). Probably the most effective protection is achieved when the foundations are constructed without impact driving. The use of vertical drills or insertion with vibrating pile drivers, which generate a less harmful, continuous sound, will ensure that foundations can be erected on the seabed with much less noise in future. Suction bucket, gravity based and floating foundations are all viable options for future-oriented solutions.

Benthos and fish

Researchers observe the effects of a wind farm’s construction and operation on benthos in the alpha ventus test area and at the research platforms. The term “benthos” comprises all organisms living on or in the seabed, such as crabs, fish, starfish and mytilidae. The underwater foundations of the wind turbines constitute artificial reefs, which are populated by various animals and provide a new habitat for plant life. Research carried out at alpha ventus has shown that the sandy areas between the wind energy plants remain unaffected. Divers have also observed a far greater density of brown crabs, up to a hundred times more than is typical for the area’s undeveloped soft substrate. After three years, growth on the underwater foundations of wind turbines is prominent: mytilidae, amphipods, brown crabs, sea anemones and velvet crabs – all animals that love the hard substrate habitat – have colonised the wind farm. The vegetation on the structures also attracts larger animals, which find new sources of food on the turbine’s underwater foundations. The artificial reef community includes fish such as mackerel, common dragonets, and pouting.

The wind turbines offer a new habitat for animals such as sea anemones.

The predatory longspined bullhead, a rare inhabitant of purely sandy areas, has discovered a new habitat in the shape of the foundations. In 2014, researchers settled 3,000 specimens of the rare Heligoland lobster at the turbines of the Riffgat coastal wind farm. Many experts consider this reef effect a positive development because it increases biodiversity. However, some fear that the habitat, which previously featured predominantly sandy soil, will become petrified.

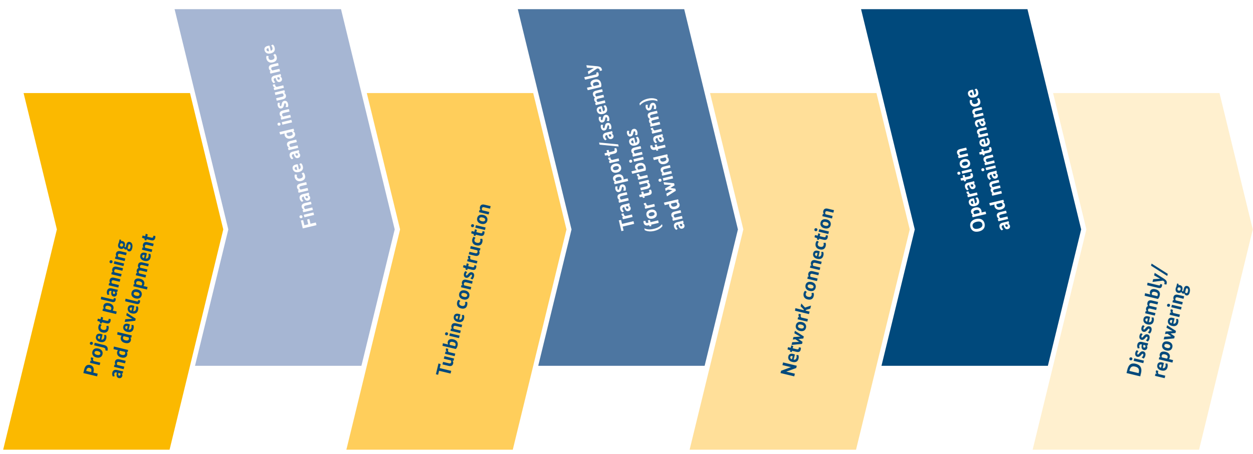
The actual impact on the fish population and marine benthos will only be able to be established after several years of operation. It is predicted that a positive outcome will be the recovery of fish stocks and benthic communities in the areas of wind farms, where ecologically harmful bottom trawling is forbidden. In the studies carried out at the alpha ventus wind farm, this can be expected, because there has already been an increase in the number and weight of fish. Catches in 2011 were more than twice as high a yield as 2010. Larger fish were caught as well.

Chapter 5 Rotor as motor

Offshore wind energy offers significant economic development potential. Whether during the construction of plant components, the assembly of a wind farm or its subsequent operation – generating energy from the sea requires products and expertise from numerous industries. The fledgling technology is also in need of specialised professionals.

Economic acceleration

Offshore wind energy is bringing new momentum to the economy. The industry already employs almost 19,000 people. This number is set to rise continuously as the industry heads towards the 6.5 gigawatts of installed capacity prescribed in the EEG amendment of 2014. In addition to the currently dominant sector of plant construction, the operation and maintenance sectors will gradually become established. After all, the wind farms already



Offshore wind energy value-creation chain

providing power will need to be regularly serviced, maintained and retrofitted.

Benefits for coastal regions

Wind energy on the high seas stimulates the economy in many regions across Germany. In particular, structurally weak coastal regions are benefiting from this new energy source. Unlike other federal states, Bremen, Hamburg, Mecklenburg-Western Pomerania, Lower Saxony and Schleswig-Holstein attract companies that cover the entire value-creation chain in the respective regions. Manufacturers of plant components such as rotor blades and nacelles often favour locations in close proximity to ports. Even producers of other major components settle in coastal areas, as transportation of component parts is usually costly and sometimes infeasible. Project developers, investors and service providers ensuring the operation and maintenance of a plant have established bases in the northern federal states.

Boost for inland areas

These days, traditional mechanical engineering locations situated far from the coast also do very well out of offshore wind energy. Plant construction suppliers are frequently found in Bavaria, Baden-Wuerttemberg and North Rhine-Westphalia. Some 50 per cent of revenue and 40 per cent of employees in the sector come from these three states. Take the example of North Rhine-Westphalia: companies in this region produce gearing mechanisms, generators, brakes, bearings and cast components.

In contrast to companies located in coastal regions, companies involved in generating energy from the high seas inland tend to cover only one area of the value chain. Companies offering services in plant production finance and insurance, for example, can be found in Saarland. Investors come from all over Germany, including public utilities and public utility networks from southern and central Germany.

Shipyards

Similar to ports, which assume many functions for the wind energy industry, new areas of business are also opening up for shipyards. Various studies have observed a sharp rise in demand for the shipyard industry. While these expert opinions are often based on rather optimistic development scenarios, the demand for ships – in particular for the maintenance and operation of the plants – is undeniable. Jack-up vessels and cable-laying ships are needed, as are repair and transportation ships for the wind farm employees. In addition, shipyards produce various platforms (converter platforms, transformer substations and residential platforms) and foundations. At the end of June 2014, shipyards had received seven contracts for platform construction. In spring 2014, the Aeolus became the first jack-up vessel built in Germany to leave its shipyard. German shipyards have the technical potential to benefit from offshore wind power expansion, but they also face intense international competition. However, it is not only construction but also the necessary maintenance and repair work that offers shipyards new turnover prospects.

Rotor blade assembly at the wind farm EnBW Baltic 1.

Export of expertise

Cutting-edge expertise opens up the industry to new sales opportunities abroad, as other European countries such as Great Britain, Belgium, Ireland, France and Sweden, as well as the USA, China and Korea are also planning high-performance offshore wind farms. As a result, the Renewable Energies Export Initiative helps German

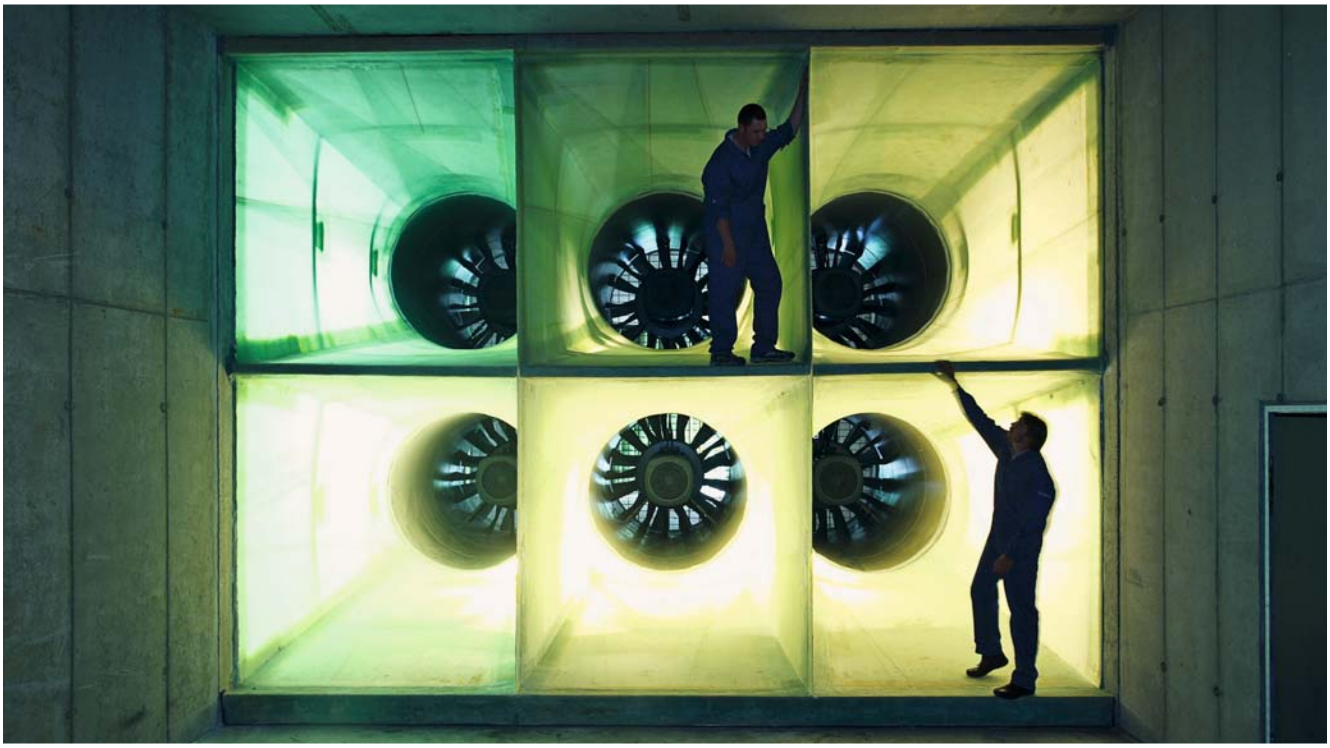
"Well-positioned within the international market"

Interview with Andreas Nauen, CEO of the German Engineering Federation (VDMA Power Systems). VDMA Power Systems deals with issues including energy policy, legislation and export promotion and is an important point of contact for wind turbine manufacturers.

German technology is found in practically every offshore wind turbine. International business is lucrative for the offshore wind industry. How important is the German market in all this?
At the end of 2014, Germany achieved the important gigawatt milestone at sea. Offshore wind turbines supplied a total of 1,049.2 megawatts of electrical output. In 2015, we expect a further 2 gigawatts from offshore wind turbines. This corresponds to a total investment of approximately six to seven billion euros. In this exceptional year, the German market may even account for about two-thirds of the European market. But, in the midterm, the domestic market will stabilise at between a third and a half. The value of exports from manufacturers of turbines, foundations and network technology is also now in billions of euros. However, the German market will remain very important for the export-oriented offshore wind industry.

How strong is international competition?
Within Europe, Germany faces competition from Denmark, France and Spain, and, outside Europe, from Japan and Korea, as well as increasingly substantial competition from China. Thanks to its leadership in technology, the German offshore wind industry is well-positioned within the international market. Nonetheless, much continues to rest on reliable legal parameters being implemented in Germany, which lay the foundations for a reduction in costs, leading to innovation and success in the global market.

How does the VDMA support the offshore wind energy industry?
All manufacturers of offshore wind turbines, foundation engineering and network technology active in Germany are represented on the VDMA Steering Committee for the Offshore Wind Industry. VDMA Power Systems networks and represents the manufacturing offshore wind industry in issues regarding the energy industry, industrial policy and technology. Its current focus is the tendering models for the domestic market, sustainable solutions to issues of grid connection and leveraging cost reduction potential.



Maintenance works on the turbines in a wind tunnel: engineers are consulted during the development and testing of the components.

companies in the renewable energy sector to successfully position themselves in international markets. This offers a comprehensive range of information on selected international markets and workshop events, among other issues, and is particularly effective for small and medium-sized businesses, helping launch their activities abroad.

Upswing in the labour market

In 2014, around 18,800 people in Germany worked in the field of offshore wind energy. This is a rising trend. The European Union anticipates 170,000 jobs in the industry by 2020 and around 300,000 just a decade later. The offshore wind energy sector places special demands on skilled workers, to which the various industries must adjust.

Numerous professional groups are involved in the development and operation of a wind farm. The fields of work are diverse and cover the entire supply chain: from the planning and development of a wind farm and the production of system components for construction to maintenance and repair services.

Engineers

Engineers are almost always required, irrespective of the wind energy plant's development stage. Their expertise in different fields such as mechanical, electrical and surface engineering, material science and aerodynamics is essential from the start of component development. During the planning phase, industrial engineers are often charged with analysing a project's efficiency. Offshore project managers manage and organise the various construction phases of an installation. They have specialist knowledge of foundations, cabling and grid connection. Engineers frequently act as project managers.

Skilled workers from the metal and electrical industries, surface engineering and mechatronics

Professionals from the metal and electrical industry provide support during all the important phases of the supply chain. They are involved in the development of plant components as well as the installation and commissioning of wind turbines. Personnel from the metal and electrical engineering industries also carry out service and maintenance work. The following technical professions are required: welders, metalworkers, mechanics, mechatronic engineers, electronic technicians, electricians, operating engineers, mechanical technicians and laminators.

Abseil training: work on offshore wind farms places high demands on technical service personnel.

Meteorologists, geologists and marine biologists

Before operators receive permission to construct a wind farm, they must provide certain verifications. For this purpose, geologists and marine biologists compile reports on the wind farm's environmental impact. Meteorologists collect and evaluate climate data to determine the wind conditions at a site.

Skippers and machine operators

Skippers and machine operators are required for the construction of a wind turbine. They operate special jack-up vessels and equipment needed for the construction.

Industrial climbers

Industrial climbers are mainly needed during a power plant's construction. They also carry out quality checks and maintenance.

Professional divers

Similar to industrial climbers, professional divers are needed for construction and maintenance work – this time below the water surface.

Other professions

Other professional groups collaborate directly or indirectly for the offshore wind energy industry. To plan a wind farm, a project developer requires commercial experts who can assess the economic viability of future wind farms. Personnel are also needed in the areas of finance and insurance. Shipbuilders manufacture the special ships required for transport and construction.

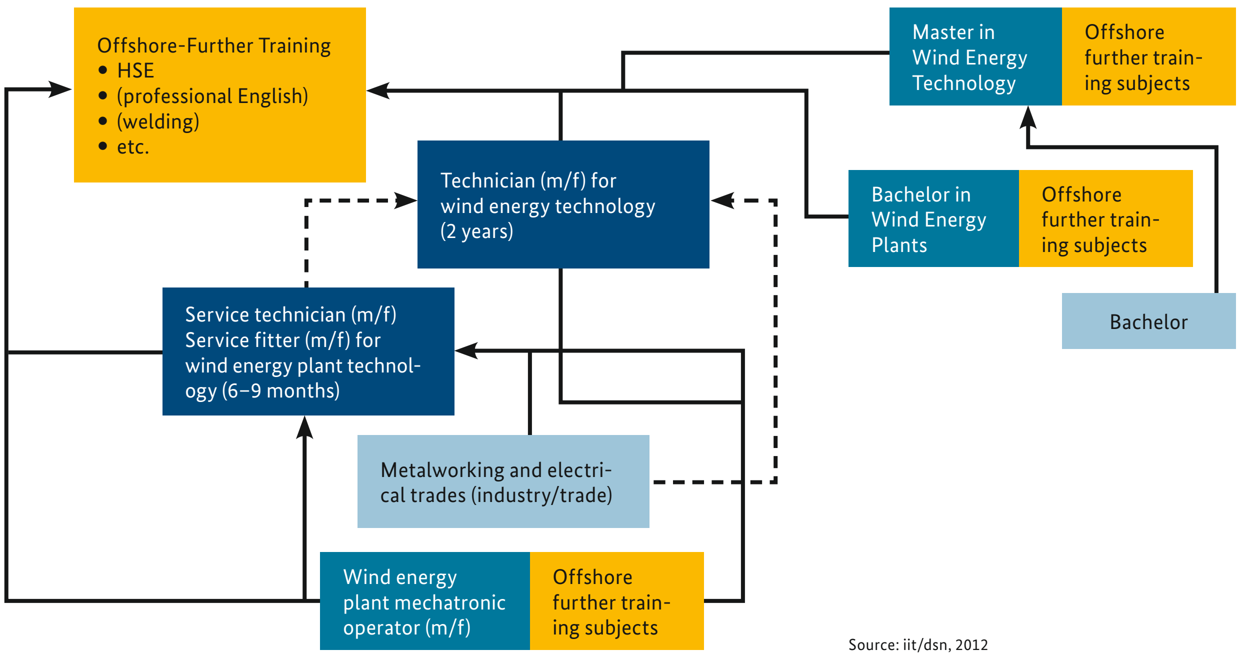
Education and further training

At the end of 2012, the study entitled "Offshore Wind Energy: A Platform for Jobs for the Future" was published, commissioned by the German Offshore Wind Energy Foundation and the Economics, Transport and Innovation Authority of the City of Hamburg. It focuses on training and describes the measures required to meet the growing demand for skilled workers.

A high demand in this area is anticipated, particularly for qualified and seaworthy technicians in the fields of installation and operation. There is an equally urgent demand for expert engineers in various disciplines ranging from construction and mechanical engineers to electrical engineers and technicians for electrical power systems. According to the study, a lack of well-trained personnel can pose a problem, not only for the installation and operation of offshore wind turbines – a lack of specialised skills also risks inefficient procedures in the areas of approval and certification. Overall, there is, additionally, a lack of technical experts in the fields of manufacturing and production of wind turbines. Here, the offshore wind energy industry is in direct competition with other industry sectors.

Wind power companies themselves have a rather low rate of in-company training programmes – just 22 per cent had any in 2012. An increase is essential to meet the demand for skilled labour. According to the report, obtaining additional professional qualifications is initially adequate for mechatronics engineers or electricians. However, in the medium term, entirely specialised and new occupations should emerge. There is also potential at universities. Although Masters courses specifically for

Potential structure of professions



Source: iit/dsn, 2012

offshore wind energy already exist, Bachelor qualifications are, as yet, virtually non-existent, with the University of Applied Sciences in Kiel, which offers a Bachelor degree programme in offshore installation engineering, an exception to the rule. For the time being, additional modules could remedy the issue, before longer-term Bachelor programmes establish themselves.

In addition to industry-specific jobs, the authors of the report also broach the issue of the professions which, while not requiring profile tailored specifically to offshore developments, would benefit from further training. These include naval engineers, who could "strategically position German shipyards" through their newly-acquired knowledge of jack-up and supply vessels. Further training for marine biologists or geologists could also streamline the approval process, while lawyers and economists with additional skills could create improved clarity in liability and financing issues.

Those working at offshore wind energy plants must first obtain certain certifications and be prepared for unusual working conditions. For example, skilled workers supervise not only German wind farms, but European ones as well. Staff members often live on the supply platforms for extended periods, as daily commuting is too time-consuming. A challenging job at sea can therefore result in long absences from home. As travelling to a wind farm can take up to four hours by ship, a position at offshore wind farms is unsuitable for people who suffer from seasickness.

Working at a wind energy plant involves greater security conditions than are usual on land as a result of the maritime location. Transport by ship or helicopter, often in poor weather conditions, pose particular risks. Prior to their first deployment, all professionals must complete offshore safety training. Course providers align their content to a range of internationally applicable guidelines. Such training is often offered at port locations, and includes:

- safety on board and fire protection;
- first aid;
- measures for preventing accidents on offshore plants.

Electrical and mechatronic engineers working as service personnel on wind farms must also prove that they have a head for heights and receive training in personal protective equipment.

More information

- Comprehensive information about advanced training courses and degree programmes can be found online:
- The Federal Employment Agency's KURSNET internet platform lists details of countless vocational education and training courses. http://kursnet-finden.arbeitsagentur.de/kurs/
- WAB – the Wind Energy Agency provides information ranging from introductory seminars to degree courses. www.wab.net
- The WindEnergy Network lists education and further training opportunities offered by its partners. www.wind-energy-network.de/en
- windcomm schleswig-holstein provides information about professional and academic training opportunities on offer in the state. www.windcomm.de/Seiten/en/
- A search database for training providers operating across Germany was launched on the website of the German Offshore Wind Energy Foundation in February 2015. www.offshore-stiftung.de/about-us
- All courses on the topics of renewable energy and wind power can be found via the search function of the German Rectors' Conference website. www.hochschulkompass.de/en

Chapter 6 International cooperation

German public institutions and companies are active participants in many international associations. These partnerships often focus on knowledge sharing and initiate joint research projects. Other organisations aim to pool resources in order to promote the development of wind farms. In terms of international cooperation, Germany is particularly involved in European initiatives.

EU funding

The European Union is an important pacesetter in the renewable energy sector. Via the Trans-European Networks Energy (TEN-E) programme, for example, it identifies and funds particularly important network expansion projects. Its Guidelines for Environmental Aid also provide support to Member States seeking to align the promotion of renewable resources to market conditions. The 2014 version of the EEG goes some way towards developing tendering procedures that support projects and is based on EU regulations.

At the same time, the EU also acts as a sponsor for wind farms in the North and Baltic Seas. The European Investment Bank (EIB) provided loans to finance projects such as Baltic 1 and 2. The Nordsee Ost wind farm is one of the flagship projects for the expansion of renewable energies. Here, the EU granted investment subsidies amounting to 50 million euros from the European Energy Programme for Recovery. Many international cooperation projects in the field of offshore wind energy would be all but impossible without the European Union.

Here, the key instrument is the European Regional Development Fund from which projects such as the South Baltic Offer have benefited. Another important tool is the Seventh Framework Programme (FP7). This financed a large part of LEANWIND, a Europe-wide research project to reduce costs in the offshore wind energy industry. Another example of the use of FP7 is EERA-DTOC. In this project, the European Energy Research Alliance – a European network of associations, universities and institutions – works with its industry partners on a tool for design optimisation of wind farms and wind farm clusters. 2014 saw Horizon 2020, the Framework Programme for Research and Innovation, break away from FP7.

The European Strategic Energy Technology Plan (SET Plan) is a key tool for the future-oriented energy policy of the

European Union. Launched in 2008, it promotes the development and dissemination of low carbon technologies, while maintaining the competitiveness and profitability of the industry. In the long run, the SET Plan aims to develop cost-efficient and low-emission energy technologies, and to implement them in the Member States of the European Union, so that by 2050, greenhouse gas emissions in the EU will fall by 80 per cent to 95 per cent compared to 1990. The plan includes measures relating to planning, implementation, resources and international cooperation in accordance with the "Energy Roadmap 2050", adopted by the European Commission in December 2011. The European Union also seeks to promote effective and targeted energy research via the policy plan, in order to avoid duplication in funding and accelerate innovation and economic potential so that the EU internal market can be better taken advantage of.

The SET Plan's implementation rests on two main instruments: the European Industrial Initiatives (EII) – in the field of wind energy research the European Wind Energy Initiative (EWI) – and, the European Energy Research Alliance (EERA). The European Wind Energy Initiative (EWI) has a budget of six billion euros, half of which is provided by the industry. The initiative aims to ensure Europe's technological leadership in the field of wind energy and to develop a fully competitive source of energy through onshore wind energy by 2020 – offshore by 2030. In addition, by 2020, wind power should constitute a 20 per cent share of Europe's electricity supply. While implementing this initiative, the European Commission is advised by the European Wind Energy Technology Platform (TP Wind) – a network of experts and decision makers. It plays a crucial role in the implementation of the SET Plan process. The technology platform is funded by the European Commission and managed by the European Wind Energy Agency.

Germany cooperates with other countries at the European level either through the EU framework programme Horizon 2020 or through ERA-NETs (European Research Area Networks). The latter supports cooperation between national and regional research funding bodies both with and without the participation of the EU. However, the German government is also active at a global level via the activities of the Federal Ministry for Economic Affairs and Energy, and is, for example, involved in the International Energy Agency (IEA). One of the latter's important duties is the organisation of a major global collaboration platform for the research, development, launch and employment of energy technologies.

NorthSeaGrid

The European Commission's Intelligent Energy Europe Programme funds up to 75 per cent of the NorthSeaGrid Project. It analyses the technical, financial and regulatory requirements for an internationally meshed offshore grid in the North Sea. However, the project partners do not focus on an all-encompassing solution. Rather, the analysis is based on three case studies. One of these includes the German Bight and is concerned with the networking of offshore wind farms in Germany, Denmark and the Netherlands.

London Array (GB), with a 1 gigawatt capacity, will be the largest wind farm in the North Sea.

"Offshore wind energy is an international business"

Interview with Andreas Wagner, Managing Director of the German Offshore Wind Energy Foundation, which seeks to promote the expansion of offshore wind farms in Germany and Europe.

What is happening at the EU level to achieve cost reductions in the offshore wind energy sector?
The Prognos-Fichtner study, commissioned by the offshore industry and coordinated by the Offshore Wind Energy Foundation, has shown offshore technology contains significant cost reduction potential in terms of technical innovation and networking of actors and enterprises. The foundation is continuing this approach with partner organisations from the UK, Denmark and the Netherlands, by establishing the industry initiative Seastar Alliance with support from the European Commission. This initiative aims to reveal other European opportunities for cost reduction through the use of best practice models and case studies. Here the development of a European offshore grid plays an important role, facilitating further synergies and energy efficiency benefits.

What makes international cooperation so important?
Offshore wind energy is an international business: the entire supply chain, from project development, and logistics to the construction and service of offshore farms, is characterised by its international nature. In addition, the individual European countries are at different stages in their development of offshore wind energy. Through knowledge sharing and best practice models, regions in Europe at a less advanced stage can benefit from countries with more sophisticated offshore technology. This benefits the entire offshore wind energy sector and the maritime industry, as well as politics and administration.

What other challenges is the offshore wind energy industry facing?
In the past, there was a need for improvement in the synchronisation of network connection and offshore wind farm. Through the establishment of the Offshore Grid Development Plan, operators of wind farms and investors are given better guarantees in terms of network planning. It is important that the infrastructure, i.e. the grid network, is ready before the wind farms can be established. After all, roads and aqueducts are the first things to be constructed in business parks, too.

North Seas Countries Offshore Grid Initiative

Since 2009, ten European Union member states have joined the North Seas Countries Offshore Grid Initiative (NSCOGI): Germany, Belgium, Denmark, France, Great Britain, Ireland, Luxembourg, the Netherlands, Norway and Sweden. Initially proposed by the European Commission in a 2008 report, the aim of NSCOGI is to coordinate the development of a common offshore grid. It works to develop network connections for offshore wind farms in the North Sea. The initiative receives support from national regulators and transmission system operators.

Through the implementation of NSCOGI, the North Sea coastal countries and Ireland are seeking to coordinate further development of the electricity grid and discuss technical, regulatory and licensing issues. NSCOGI is designed in such a way as to develop consistency in national targets for electricity infrastructure.

German-French Renewable Energy Coordination Office

This coordinating body serves as a networking platform for German and French agents active in the field of renewable energy. The organisation was founded in 2006 by the German Federal Ministry for Economic Affairs and Energy and the French Ministry for Industry. The body, which is based in Berlin, sees itself as a knowledge broker, focusing chiefly on solar and wind energy. The Coordination Centre for Renewable Energies organises regular conferences discussing themes including the cost of wind energy. It provides members with surveys, reports and legislation in French and German as well as its own background papers. The aim is to support the expansion of renewable energies in both countries. The association, which has over 100 members, is aimed at companies, industrial and environmental organisations and public institutions. By 2020, France plans to have constructed offshore wind farms with a capacity of six

Rotor blade assembly at the wind farm Global Tech 1.

gigawatts. In order to achieve this objective, offshore wind energy projects are regularly awarded to operators, which subsequently, receive financial support from the government.

Cooperation in the Field of Research on Offshore Wind Energy Deployment

In 2007, Germany, Denmark and Sweden signed the Joint Declaration on Cooperation in the Field of Research on Offshore Wind Energy Deployment. Two years later, Norway joined the agreement; the United Kingdom holds an observer status. The focus is placed on joint environmental and ecological research. The cooperation enables the exchange of data and research. Scientists from one country can carry out research on wind farms located in one of the other countries.

South Baltic Offer

The central aim of the project is the rapid development of new and improved offshore wind farms in the southern Baltic region. The South Baltic Offer unites public bodies such as local authorities and universities with interest groups and trade associations from Denmark, Sweden, Poland, Lithuania and Germany. The aim is to pool resources across borders and stimulate the offshore industry through knowledge sharing. New jobs will be created in the countries bordering the southern Baltic Sea, and the industry's economic position in the European market should be strengthened. The project partners developed an atlas which provides information on winds strengths in the maritime area. Another map, available online, shows all the companies that have participated in or are currently working on the establishment and operation of wind turbines in the southern Baltic Sea.

NER 300

The European Union's NER 300 programme funds energy projects with low CO_2 emissions. Together, the European Commission and the EIB decide which projects should be supported. The programme is financed by the sale of 300 million CO_2 emission certificates, which are worth a total of four to five billion euros. The German offshore wind farms Nordsee One and Veja Mate receive funding from the NER 300 Programme.

International Energy Agency

Work undertaken by the International Energy Agency (IEA), a key global collaboration platform for the research, development, commercialisation and deployment of energy technologies, constitutes a main focus of the international research alliance coordinated by the Federal Ministry for Economic Affairs and Energy in the field of renewable energy. The IEA's 28 member states work together on cooperation agreements, known as Implementing Agreements (IA) for individual technologies. Duties of thematic working groups are categorised and coordinated into tasks, or annexes by decision-making bodies (Executive Committees, or–ExCos). These are headed by operating agents/annex leaders. The Federal Ministry for Economic Affairs and Energy supports the work via direct and active collaboration, funding of annual contributions to German participation in the tasks and by sponsoring researchers involved in projects.

Established in 1974, the International Energy Agency's Wind Agreement (Implementing Agreement for Cooperation in the Research, Development and Deployment of Wind Energy Systems) has been signed by 20 states, the European Union, the Chinese Wind Association and the European Wind Energy Association (EWEA). The parties exchange information on the planning and construction of wind farms. The focus of the agreement is research: all member states participate in scientific research and evaluate the results together.

International associations

Several international associations have taken on the task of promoting the development of wind energy worldwide. Over 100 countries and the European Union belong to the International Renewable Energy Agency (IRENA) while other countries have applied for membership. The international governmental organisation aims to promote the expansion of renewable energies worldwide, facilitate access to information and offer practical advice. The European Wind Energy Association (EWEA) and the World Wind Energy Association (WWEA) organise conferences and draw up position papers. Both organisations are aimed at research institutes, companies and national wind energy organisations. The Global Wind Energy Council (GWEC) focuses on the industry, and represents more than 1,500 members from over 70 countries. The GWEC also promotes the benefits of wind power to governments, policy makers and other institutions.

International teamwork is also crucial to the expansion of offshore wind energy.

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