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Offshore WIND INDUSTRY

Innovative technologies

FINANCING

Increased investor appetite

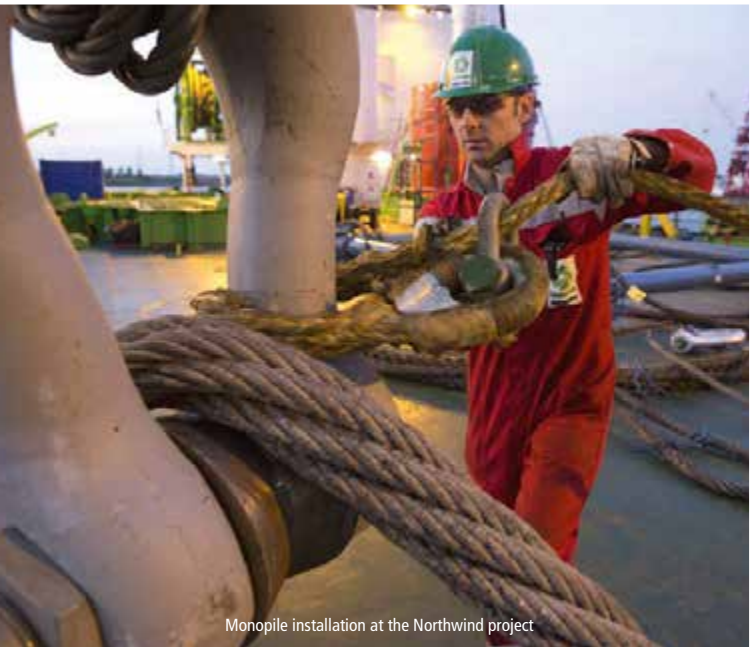
COATINGS

Durable and reliable

ORDNANCE

Dangerous legacy

Foundation Installation with Heavy Lift Vessel 'Innovation' at the Godewind 01 & 02 project



Monopile installation at the Northwind project

First-class offshore contracting solutions

Wind Turbine installation with jack-up vessel 'Neptune' and boom lock system at the Kentish Flats Extension project

GeoSea

Geotechnical & Offshore Solutions

GeoSea nv
Member of the DEME Group
Haven 1025 - Scheldedijk 30
B-2070 Zwijndrecht, Belgium
T +32 3 250 53 12
F +32 3 250 55 41
info.geosea@deme-group.com
www.deme-group.com/geosea

GeoSea is a specialized company for (EPCI) offshore works, focused on the installation of wind turbine foundations and erection of turbines. Large jack-up platforms and drilling and piling rigs are our plants of choice for working in deep waters. GeoSea offers first-class offshore contracting solutions to global clients. We have the skills, the technology and the equipment to perform in the most challenging marine environment. Always working closely with our clients, we understand what it takes to define and deliver a project cost-effectively, safely and on time.

DEME: Creating land for the future

editorial

A sector in motion

The media echo following the announcement of the successful bids in the first German tendering for offshore wind power projects was huge. Suddenly a massive tear cut through the picture of offshore wind power as one of the most expensive electricity generation technologies. And for a short time there really was discussion about the gigantic cost reductions which the industry had achieved across the entire value chain.

This should really have been followed by a discussion of German expansion targets for offshore wind. The sector did push hard to place the question in the media of why the expansion of offshore wind farms was continuing to be capped, given the zero cent support and the almost unreachable national climate protection targets – but the subject of offshore still quickly disappeared from the media's list of topics. It remains to be seen how the future government after the general election in September positions itself on the conflict between capping expansion and the necessary reduction in CO_2 emissions.

Meanwhile, companies are taking the only correct course of action under current circumstances. They are developing new markets abroad, from the USA, which after years of lame performance has finally been able to inaugurate its first offshore wind farm, to Asia, where offshore has been understood by a string of governments as being the cheapest option. The plans for new factory sites in Asia and North America are likely to be ready and waiting in many a filing cabinet.

At the same time, they are continuing to develop the technology: from larger, more powerful turbines, completely new foundation concepts, the expansion of infrastructure and new cooperation between service providers right down to optimisations of minute details in the turbines.

This issue of OFFSHORE WIND INDUSTRY reflects the broad spectrum of development. We talk to a turbine manufacturer about the unbreaking chain of product innovations, show what is happening in the field of project finance, present a method for taking wake effects into better consideration during planning, report on a surprising pilot project in which a gravity foundation is being combined with a so-far unique telescopic tower, show how the rescue chain can be made more efficient by companies working together, throw a light on the development of ports for the offshore industry, study what effects Brexit could have on the development of the sector in Europe, and look at how individual states in the USA aim to set up their own value chain for the offshore industry.

Things remain exciting.

Dr. Volker Buddensiek

Volker Buddensiek
Editor-in-Chief
vb@offshorewindindustry.com

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Increasing performance while reducing CO_2 transforms wind into an asset for sustainable living.

Offshore wind power is a dependable clean energy solution. Our proven offshore direct drive platform delivers greater efficiency and higher power output, which reduces project risk and makes it a profitable investment. Meanwhile, people can enjoy cleaner energy to power their cities.

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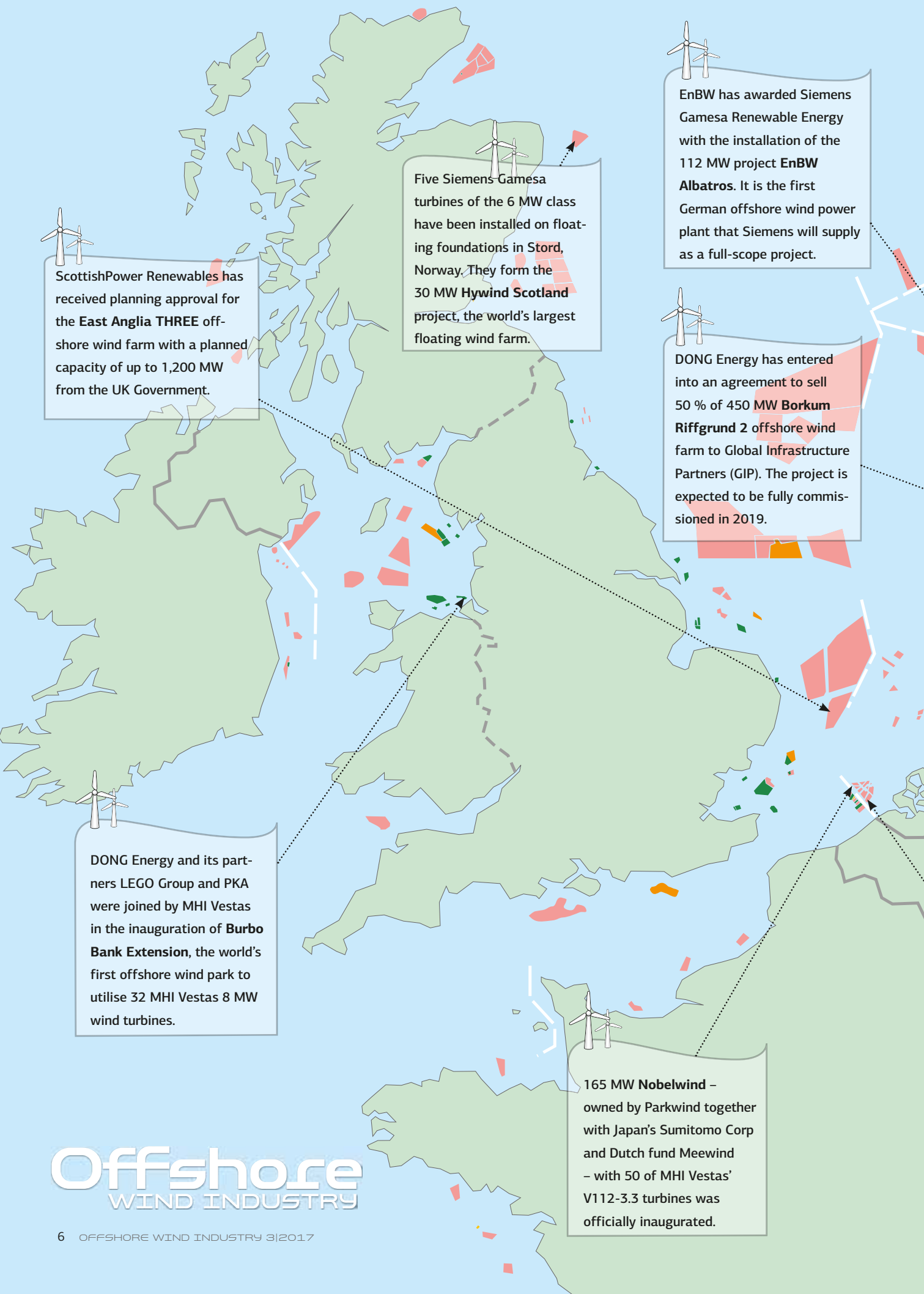
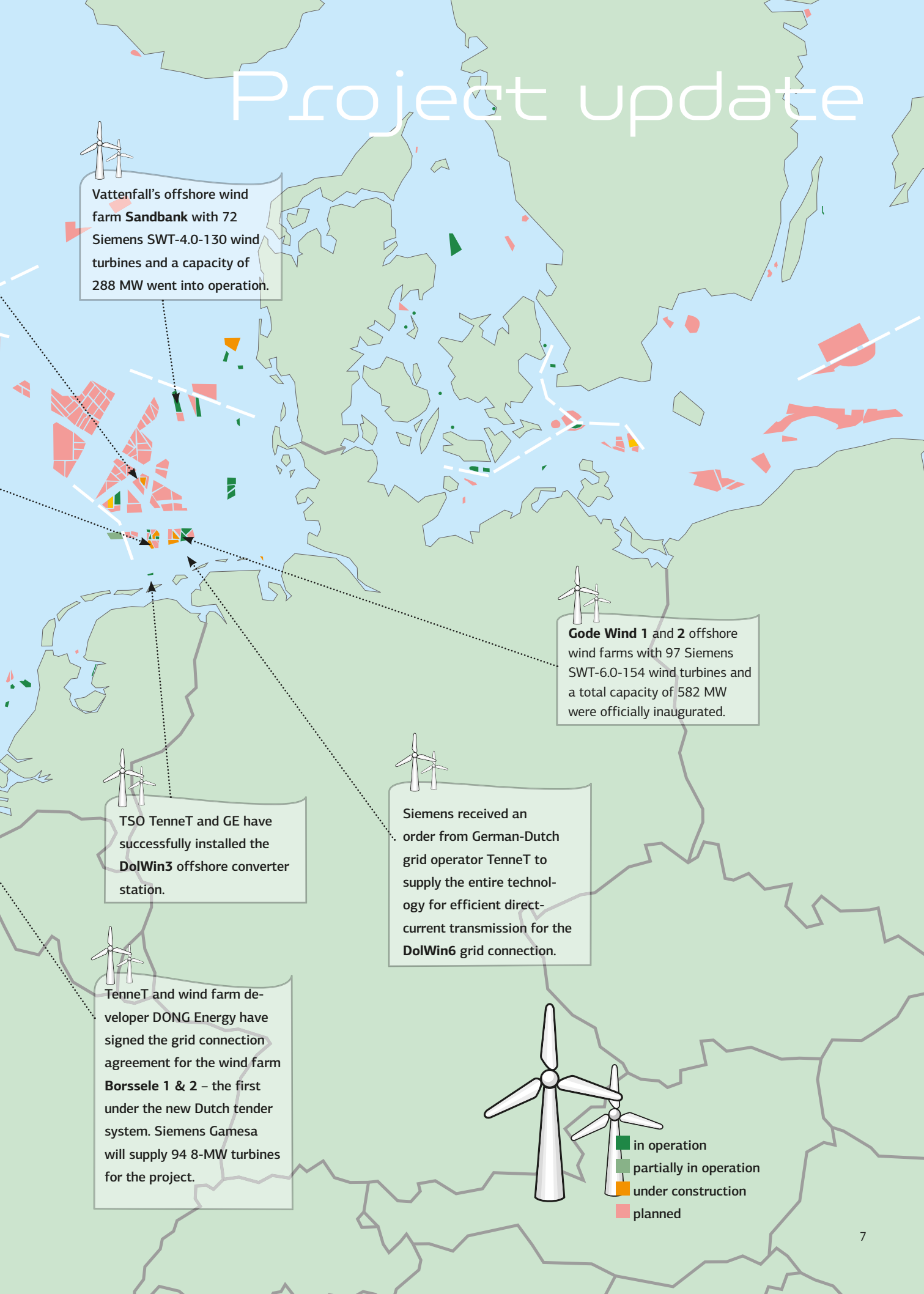

ScottishPower Renewables has received planning approval for the **East Anglia THREE** offshore wind farm with a planned capacity of up to 1,200 MW from the UK Government.
Five Siemens Gamesa turbines of the 6 MW class have been installed on floating foundations in Stord, Norway. They form the 30 MW **Hywind Scotland** project, the world's largest floating wind farm.
EnBW has awarded Siemens Gamesa Renewable Energy with the installation of the 112 MW project **EnBW Albatros**. It is the first German offshore wind power plant that Siemens will supply as a full-scope project.
DONG Energy has entered into an agreement to sell 50 % of 450 MW **Borkum Riffgrund 2** offshore wind farm to Global Infrastructure Partners (GIP). The project is expected to be fully commissioned in 2019.
DONG Energy and its partners LEGO Group and PKA were joined by MHI Vestas in the inauguration of **Burbo Bank Extension**, the world's first offshore wind park to utilise 32 MHI Vestas 8 MW wind turbines.
165 MW **Nobelwind** – owned by Parkwind together with Japan's Sumitomo Corp and Dutch fund Meewind – with 50 of MHI Vestas' V112-3.3 turbines was officially inaugurated.

Project update



Vattenfall's offshore wind farm **Sandbank** with 72 Siemens SWT-4.0-130 wind turbines and a capacity of 288 MW went into operation.

Gode Wind 1 and **2** offshore wind farms with 97 Siemens SWT-6.0-154 wind turbines and a total capacity of 582 MW were officially inaugurated.

TSO TenneT and GE have successfully installed the **DolWin3** offshore converter station.

Siemens received an order from German-Dutch grid operator TenneT to supply the entire technology for efficient direct-current transmission for the **DolWin6** grid connection.

TenneT and wind farm developer DONG Energy have signed the grid connection agreement for the wind farm **Borssele 1 & 2** – the first under the new Dutch tender system. Siemens Gamesa will supply 94 8-MW turbines for the project.

- in operation
- partially in operation
- under construction
- planned

ROMEO project: reducing cost for offshore wind farm operators

The kick-off meeting of the ROMEO project (Reliable O&M decision tools and strategies for high LCoE reduction on Offshore wind) with representatives of all partner organisations took place in Madrid.

The new flagship European project ROMEO is seeking to reduce offshore O&M costs by developing advanced monitoring systems and strategies. It aims to move from corrective, calendar based maintenance to a condition based maintenance, analysing the real behaviour of the main components of wind turbines.

ROMEO is an industry based consortium made up of 12 key players from six different EU member states and one associated country led by Iberdrola Renovables Energia. The consortium includes large companies (EDF, Adwen, Siemens Gamesa, Ramboll, IBM Research-Zurich, Indra, Bachmann Monitoring,), SMEs (Laulagun Bearings, Uptime Engineering, Zabala Innovation Consulting) and the Cranfield University. The project is awarded by the European Commission with a Horizon2020 Programme grant of € 10 million and a total budget of approximately € 16 million running for 5 years.

The main objective of ROMEO project is to reduce O&M costs through the development and demonstration of an O&M information management and analytics platform, capable of improving decision making processes by OWF operators. At the same time, renewable energy technology will be improved.

A flexible and interoperable Cloud and IoT platform will provide an advanced analytics ecosystem for failure diagnosis and prognosis models to better understand the real time behaviour of the main components of turbines under operational conditions – maximising their life span and minimising O&M costs. The project will also develop third-generation CMS for some wind turbine components and low-cost structural condition monitoring systems.

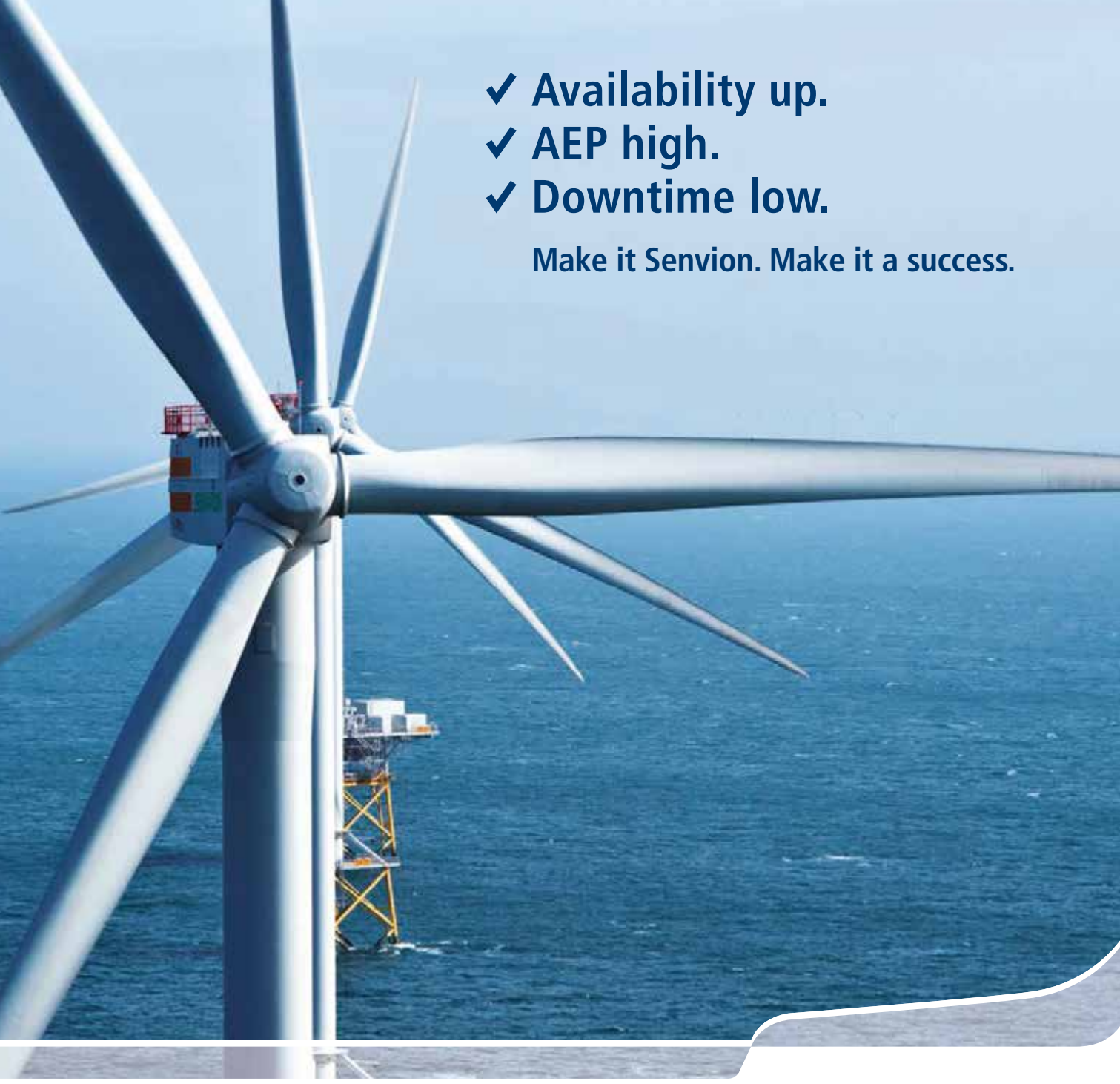
The innovations developed will be tested by the wind farm operators in three projects: Teeside (UK), Wikinger (Germany) and East Anglia 1 (UK).

First private U.S. offshore wind farm

Dominion Energy is planning the first U.S. offshore wind project owned by an electric utility company.

The Coastal Virginia Offshore Wind project is going to be the second offshore wind project in the United States of America and the first one to be owned by an electric utility company. Engineering and development work is expected to begin immediately to support the targeted installation by the end of 2020. The phase one development of two wind turbines will be built by DONG Energy approximately 43 km off the coast of Virginia Beach on a 8.6 km² site. The project will provide the critical operational, weather and environmental experience needed for large-scale development in the adjacent 456 km² site leased by Dominion Energy from the Bureau of Ocean Energy Management (BOEM). Full deployment could generate up to 2,000 MW of energy.

Photo: ROMEO Project



Whether near-shore in tidal waters or on the high seas – we relish challenging offshore projects. We develop and produce wind turbines with rated outputs from 2 to over 6 MW and rotor diameters from 82 to 152 meters. With over 25 years of experience and over 150 installed turbines in the 5 and 6 MW class, we are wind-power pioneers. From the first German wind farm - Alpha Ventus - to our next generation turbine, we have always been in the vanguard of innovative wind energy solutions.

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Major offshore wind contract for Peterhead Port

Peterhead Port has been awarded a major EOWDC contract.

Suction bucket jacket foundations and one of the world's largest floating cranes will be harboured at UK's Peterhead Port for Vattenfall's European Offshore Wind Deployment Centre.

Peterhead Port Authority is set to support the start of offshore construction work for the European Offshore Wind Deployment Centre (EOWDC), off Aberdeen Bay, after signing an agreement to harbour suction bucket jacket foundations for the 11-turbine scheme. The contract will see the port moor one of the world's largest floating cranes, with a maximum lifting capacity of 5,000 tonnes. Up to six barges that will transport the 11 foundations – the heaviest of which weighs around 1,800 tonnes and is about 77 m high. The installation vessel will be moored alongside the barges for heavy-lift operations. When offshore work starts, more than half the foundations will be installed under the water within the seabed. The EOWDC is believed to be the first UK offshore wind project to deploy suction bucket jackets of this kind on a large scale. Through being paired with one of the world's most powerful turbine models, they also represent an industry first. The buckets enable faster offshore installation of the EOWDC, while keeping noise to a minimum, and allow easier decommissioning as the installation process is reversed.

Peterhead Port offers more than 3 km of deep-water berthing while the harbour is sheltered which helps minimise the impact of weather conditions for loading.

The Swedish energy group Vattenfall is developing the EOWDC. Adam Ezzamel, Vattenfall's Project Director for the EOWDC, said: "We are sure the sheer scale and prominence of the pioneering technology and work involved with the EOWDC will create a positive renewables momentum."

Photo: EOWDC

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Editors:
Dr. Volker Buddensiek (responsible)
Silke Funke, Ralf Ossenbrink, Philipp Kronsbein

Freelance authors:
Claudia Delpero, Kai Eckert, Katharina Garus, Jörn Iken, Detlef Koenemann, Anja Limperis, Katharina Wolf

Advertising:
Christine Michalsky, Phone: +49/521/595525
christine.michalsky@offshorewindindustry.com

Customer Service:
Phone: +49/221/25 87 173
service@sunwindenergy.com

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Jeremy Heighway, Thomas Schickling,
Mark Wigfall

Website:
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New ownership of Dogger Bank projects announced

The ownership arrangements for the four consented Dogger Bank offshore wind projects have been agreed and signed by the three Forewind shareholders, innogy, SSE, and Statoil.

Offshore wind consortium Forewind was awarded consents for 4.8 GW of offshore wind development at Dogger Bank in 2015. The consents comprised four individual 1.2 GW projects. According to Forewind, SSE and Statoil together will each own 50 % of these three projects: Dogger Bank Creyke Beck A, Dogger Bank Creyke Beck B and Dogger Bank Teesside A. The remaining project, Dogger Bank Teesside B will be owned 100 % by innogy. The new ownership agreements mean the projects will now be progressed towards Financial Investment Decisions by their respective owners. The Forewind consortium will no longer be involved. However, it will oversee the decommissioning of the two met masts and removal of the suction-installed mono bucket foundations later in 2017. Forewind General Manager, Trevor Baker said that the consortium successfully delivered on its objective to achieve the consents and now that the projects have been allocated, the respective owners will determine how the four projects, each a significant development in its own right, will be taken forward.

The 4 consented Dogger Bank offshore wind projects have been assigned to the 3 Forewind shareholders, innogy, SSE and Statoil.

"Inn2POWER" project strengthens small and medium enterprises

The four-year EU Interreg project "Inn2POWER – Innovation to Push Offshore Wind Energy Regions" was officially launched during the London Offshore Wind Energy 2017 event.

Inn2POWER is an initiative of eleven partners from the five leading offshore wind clusters in the North Sea Region. It is the first project in which regional clusters from the UK, Denmark, the Netherlands, Belgium and Germany will work closely together to link small and medium enterprises (SMEs) across borders to foster their involvement in innovative business collaboration.

The four-year project was presented for the first time at the end of 2016 and will conclude in October 2020. It is supported by the European Union with funding from the European Regional Development Fund within the framework of the Interreg North Sea Region Programme. Inn2POWER's goal is to expand innovation capacity and improve access to the offshore wind industry for SMEs. The project will provide targeted support to SMEs for developing transnational business connections and collaboration on innovation. Moreover, it will move to improve access to relevant infrastructure such as research test sites and harbour facilities in particular, and to increase the availability of skilled workers in the North Sea Region's offshore wind clusters.

"We are looking to encourage German companies to enter more readily into cooperative efforts with partners in the North Sea Region, adding to regional strengths and stimulating new systematic innovations," said Andreas Wellbrock, Managing Director of WAB, Inn2POWER's German partner. "We look forward to intensifying our support of offshore wind SMEs facing far more challenging conditions, compared to larger companies, for gaining a foothold and staying in business in Europe's very dynamic market," he added.

"Final sprint for all the players"

Siemens Gamesa is using no less than eight innovative technologies for the pilot project Nissum Bredning Vind. OFFSHORE WIND INDUSTRY spoke to Bent Christensen about the rapid pace of development in the industry.

OWI: Hardly a large trade fair goes by without Siemens Gamesa presenting a product innovation. How do you perceive the innovation pressure?
Bent Christensen: We are not alone with this pressure: The entire offshore industry is running through a rapid development to meet cost-out targets. With the low bids for projects in Denmark and the Netherlands and zero-bids for German projects, this race has been further accelerated. But we are also proud to drive a technology with such an outstanding success story in fast development.

OWI: Has the pressure changed in recent years?
Christensen: Some years ago, we set ourselves ambitious cost-out targets with an LCoE of 10 ct/kWh by 2020, and now we are running ahead of this goal. The momentum in offshore wind is driven by new opportunities and options that are discovered with every milestone we reach. In this context, the most important change in recent years was the awareness that we have now really arrived in the league of main technologies for the future energy supply.

OWI: What impact does competition have on the pace of development?
Christensen: The consolidation processes of the last years clearly show that a certain size is vital to survive in this competitive environment. Only a highly industrialised company will be able to overcome the challenges of the changing market environment. There will also be a highly competitive situation in the future – but the number of players is decreasing. Also the market regimes in several European countries with auction models are a strong trigger for cost reduction through innovations. So my prediction for the next decade is that we will have to keep up the pace of development that we are currently seeing.

OWI: Siemens stopped the sale of the 7 MW plant in favour of the 8 MW plant last year, before the first 7 MW plant had even been built. New products are launched on the market before existing ones can deliver long-term experience. Isn't that an immense risk on the technical side?
Christensen: First of all our customers can select the best turbine for their site specific wind conditions between all ratings of our Direct-Drive Offshore platform. In addition to comprehensive testing, this platform strategy is precisely what ensures the reliability of our products. By retaining most of the components and improving what is necessary to enhance the output, we make sure that the long term experience is incorporated in the genetic code of our products. That is how we connect innovation and evolution in our product development.

OWI: Wouldn't it be more effective in the end to do fewer but higher jumps?
Christensen: No, there is a learning curve but not a learning staircase for this kind of technological development. Supply chain, substructures, logistics, installation processes and many more elements involved in building and operating offshore wind projects must grow in a synchronised manner. The steps we currently take in higher-rated offshore wind turbines allow the entire industry to mitigate risks and develop by learning.

OWI: In the Nissum Bredning Project, Siemens wants to test new technologies. Which

turbine will we see to be used there?

Christensen: We will install the first serial-built SWT-7.0-154, but this is only one part of the project's innovations: It will be installed on our gravity jacket foundation that can be assembled with standard steel pipes and robot-welded nodes. The design can be seen as a universal toolkit to build jacket foundations for different water depths.

OWI: Are foundation manufacturers so behind in the area of innovations that Siemens must also be active in this field?

Christensen: This is not meant as criticism of the colleagues at the foundation manufacturers but rather as a proposal for future concepts. Since the turbine counts for less than 30 % of the offshore wind LCoE, it is quite natural that we also take other elements of the supply chain into consideration. At Nissum Bredning we will also be using our cable-in-pipe concept, which allows us to use cheaper onshore cables by placing them in plastic pipes. But this is not an attack on cable suppliers, we are simply testing a new idea.

OWI: The foundations of the Danish wind park Vindeby, the first offshore wind farm in the world, are currently being disassembled. As one of the original turbine suppliers, how satisfied are you when you look back on the project?

Christensen: This project makes us all very proud. With 25 years in operation, Vindeby has shown proof that offshore wind is reliable and sustainable. In the meantime we have learned so much, we have improved our technology and provide turbines that are nearly 20 times larger in rating and size.

Photo: Siemens Gamesa

Bent Christensen

is in charge of project management in the offshore business at Siemens Gamesa Renewable Energy.

OWI: What is the most important lesson learned for you?

Christensen: That the codes and standards used for the design of main components, corrosion protection and so on were sufficient. The turbines were designed for a service life of 20 years, and they were in operation for more than 25 years with high reliability.

The interview was conducted by Katharina Wolf.

Pilot project Nissum Bredning Vind

Although the economic prospects of offshore wind energy are now very good, the industry is working tirelessly on innovations, among other things in the pilot project Nissum Bredning Vind. Siemens Gamesa is not only supplying four SWT-7.0-154 turbines but also new types of jacket foundations, towers and a 66 kV internal cabling for the 28 MW project on the north-west coast of Denmark.

Siemens Gamesa hopes to achieve the most significant cost savings, 40 %, by using its new Gravity Jacket Foundation. It consists of standard steel tubes, whose connection nodes are to be manufactured in large series by welding robots in the future. This will allow inexpensive foundations for different water depths to be built using a modular system.

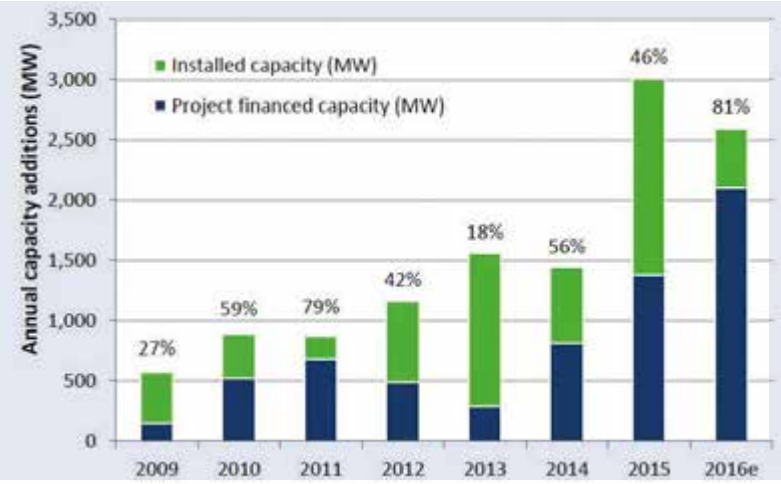
A transition piece (TP) made of concrete is placed on the foundation. It will be poured at the installation port. The heavy weight of the concrete TPs dampens vibrations in the entire carrying structure and allows further savings: the Slender Towers, which are also being tested at Nissum Bredning, have thinner walls than conventional towers and get by with less steel.

Further innovations will be tested in the area of cabling. The cables will have a capacity of 66 kV instead of 33 kV. This saves a lot of copper. Siemens Gamesa estimates that the cost savings due to the higher voltage will be up to 15 %. "This upgrade may seem like a small step toward lowering electricity generation costs, but we believe it will be a standard in the future because the benefits will increase with increasing project and turbine size," said Peter Esmann, Product Manager at Division Wind Power and Renewables at Siemens Gamesa. A "cable in pipe" solution will also simplify cabling at Nissum Bredning. Less expensive onshore cables will be laid inside of plastic pipes for this purpose.

The commissioning is planned for the autumn. (kg)

The wind has changed

The yield from an offshore wind farm is not as high today as it used to be in the early years. The risks, however, have become more manageable. This makes offshore wind power interesting for investors with lower margin expectations.



Project financing is growing in importance in the implementation of offshore wind power projects.

There were times when it was hard to get the financial means together to build an offshore wind farm. Guaranteed infeed yields may have created certainty on the income side, but the cost sides of the projects were uncertain. Investors shied away from the risks associated with the still new technology in the early years of the industry.

Things are different today. Offshore wind farms have definitely become an interesting investment. Banks are certainly willing to open their coffers if the project planning is sound. Project financing is also making an ever-stronger parallel entrance into the offshore wind power sector. The investors themselves are becoming more diverse too; today they range from large energy companies, independent power producers (IPP) and local utility boards to insurance companies, investment companies and pension funds. Mostly the financing is achieved through a mix of institutional investors, development banks and commercial banks. One remarkable point to note is the increased interest of Asiatic investors in the European offshore wind power market, mostly supported through a view towards offshore activities in the relevant home market. The Japanese conglomerate Sumitomo, for example, is involved in the Belgian offshore wind farms Belwind, Northwind and Nobelwind. Or take the China Three Gorges Corporation: the Chinese energy company has invested approx. € 1.6 billion in the German offshore wind farm Meerwind Süd|Ost.

Option for local utilities

The majority of investors still come from Europe, however, although their character has changed in the last few years. In the early days of offshore wind power it was mainly companies expecting high yields which were active, ones which were willing to accept higher risks in return. Nowadays,

Graphic: Green Giraffe

companies are increasingly coming into play which are looking for more secure investments, and are thus willing to accept lower margins.

Take local utilities, for example. The communities behind these generally put security above yields. An example of such an investment is the German offshore Trianel wind farm Borkum 2 (TWB 2). The total investment for the 200 MW second expansion phase comes to approx. € 800 million. In with a 37.5 % share of the project expansion is EWE AG, but the local utilities partnership Trianel holds a higher 37.99 % together with 17 other German local utilities. The cooperation partners were able to convince the electricity utility company for the city of Zurich (ewz) to bring in the remaining 24.51 % into the project via a joint venture with the Swiss company Fontavis.

One of the 17 German local utilities involved is the Allgäuer Überlandwerk GmbH from Kempten, Bavaria. "So far we have tried to get to a target 20 % renewable electricity in our portfolio from lots of small projects," says Managing Director Michael Lucke, "but an offshore wind farm is a big gulp in one go, which brings us considerably further than several photovoltaics plants, for example." This not only convinced investors and partners of the local utility, but also its supervisory board. The reason for this is that local utilities see offshore wind power not only as a purely financial investment, but also as a strategic one. They want to generate offshore wind power electricity over the long term. Lucke thus appeals to project developers looking for investors: "Local utilities can also be good partners!"

While TWB 2 is the first offshore participation for Allgäuer Überlandwerk – although it should also not be the last – ewz has already invested in several relevant projects, such as in the wpd wind farm Butendiek. It was also interested in the Danish near-shore tendering, but pulled out of the bidding because Denmark demanded open-ended guarantees for the decommissioning, which ewz was not able to provide like that. However: "We can still take part in the project development phase with a double-digit million euro sum," says Michael Sommer, responsible for Business Development at ewz.

Pension fund shares the construction risks

The Danish pension fund PKA is also willing to take a share of the construction risks. When PKA first became involved in offshore wind power in 2011 within the framework of DONG Energy's Anholt offshore wind farm, the company made a good profit as there were only a few financial investors like PKA. As investment competition is now growing and the yields are dropping in turn, PKA is increasingly willing to increase the risks and enter the projects at an earlier stage. According to Managing Director Peter Damgaard Jensen this is the only way to still get "healthy returns". But he expects that a growing number of companies will also be interested in investing in early project stages – which will thus lose their appeal in the long term. Damgaard Jensen is therefore already looking towards the USA and Asia for his business development.

His reasons for doing so are good, for PKA's investments in offshore wind power have paid off. In 2013 the pension fund invested in Butendiek, and last year sold its 22.5 percent share to a Japanese consortium led by the trading company Itochu for almost 1 billion Danish kroner (approx. € 135 million). According to PKA this was more than double the investment sum which the pension fund had originally put into the project. *Katharina Garus*

Key funders in addition to developers

Group	Key players
Owners / equity providers	
Investments / equity / infrastructure funds, institutional investors	Copenhagen Infrastructure Partners, Global Infrastructure Partners, Infrared Capital Partners, Black Rock, Masdar, PGGM, Blackstone, Macquarie, Partners Group, Caisse de dépôt et placement du Québec (CPDQ)
Pension funds	PKA, Pension Denmark, Industriens Pension
OEMs	Siemens, GE, Van Oord, Deme
Corporations with sustainability targets	Lego
General trading corporations	China Three Gorges, Marubeni, Sumitumo
Debt providers / lenders (may or may not also provide equity)	
Institutional lenders / development banks / export credit agencies	EIB, KfW IPEX, GIB, Development Bank of Japan, Eksport Kredit Fonden (the Danish export credit agency), GIEK (the Norwegian export credit agency)
Commercial banks	Commerzbank, BNP Paribas, Rabobank, Dexia, LBBW, SEB, Siemens Bank, Société Générale, Bank of Tokyo-Mitsubishi, ING, Sumitumo Mitsui Banking Corporation, KeyBank

Source: IEA-RETD

“New technologies promise higher returns”

OWI talked to Udo Schneider from Green Giraffe about the current appetite for investment in offshore wind power and expected developments here.

Udo Schneider has 15 years of infrastructure and energy finance experience and joined Green Giraffe in early 2015 to head their German office in Hamburg. He has worked on several onshore and offshore wind projects, advising investors, developers and industry players on multiple renewable energy projects focusing on offshore wind.

OWI: How has the appetite for investment in offshore wind developed in recent years and what are you forecasting for the future?
Udo Schneider: Most offshore wind parks have performed well to date. Considering such reliable performance in combination with substantial liquidity in capital markets there is great interest in financing offshore wind assets. Certain investors cannot – yet – take construction risks and will only invest following construction completion. The competition amongst investors is more intense for projects with higher feed-in tariffs. This competition also leads to a reduction in required equity returns – which helps to reduce the levelized cost of electricity.

OWI: How freely (or unfreely) do banks currently use money for offshore wind?
Schneider: Banks still follow a rigorous assessment process for each project. Well-structured projects have little difficulty in finding sufficient credit at attractive terms. The number of banks with experience in offshore wind financing is steadily increasing, as are the amounts they are willing to lend, but there is no “silly money” in the credit market.

OWI: In the first German call for tenders several projects didn’t need support at all. Does this fact already have an impact on the financing of future projects?
Schneider: The “zero bids” by Dong and EnBW imply that these utilities are happy to accept market risk for projects in the future – as they do for their other generating assets. It should be noted that commissioning of the relevant projects is still many years away. Still, it does trigger a new way of thinking for other market participants and banks are challenged to find new solutions. The current German tender rules favor utilities over independent players and financial investors. A stable long-term fixed-price mechanism matching the asset life would provide a much better basis for achieving greater diversity of participants to the industry – which was actually an explicit policy

Photo: Green Giraffe

objective in Germany – at a very low levelized cost of electricity.

OWI: Large construction projects are currently becoming more expensive than planned. Have you had this experience with offshore wind farms as well?
Schneider: A few pioneering projects experienced cost overruns, but the track record of offshore wind is actually a lot better than other infrastructure sectors, as demonstrated in a recent Ernst & Young report. The complexity of the works undertaken at sea, far from shore, in relatively deep waters and with hostile weather, should never be underestimated, but the lessons have been learnt quickly and we now see multiple projects being completed ahead of schedule and below budget. That is great news for the industry and is also helping cost reduction as investors become comfortable with smaller capital buffers.

OWI: Why can the offshore wind industry manage this better than other industries?
Schneider: The market is reasonably small, so lessons learnt are shared reasonably quickly. The key players have now also done several projects similar in nature. They know what they are doing and try to actively avoid making the same mistake twice.

OWI: In an interview, your colleague, Jérôme Guillet, expressed an optimistic attitude towards the marketability and financial viability of floating wind. Do you also see this technology positively, as developed thus far?
Schneider: Sure! Although there is still a huge potential for ground-mounted offshore wind projects in the North Sea and the Baltic, reasonably shallow waters along coastlines are a rare feature in the world. To tap into the substantial offshore wind resource globally, new technical solutions just like floating wind turbines are required. The race for the best approach has started.

OWI: But why should investors invest in new rather than proven technology?
Schneider: Good question. New technologies promise higher returns or offer solutions that past technology did not, such as building projects in deeper waters. Whether they deliver on that promise in the long run is an open question. Project finance is built on the principle of financing proven technology. This is clearly being challenged with the constant innovations the industry has delivered in recent years. The providers of such technology are asked to "put their money where their mouth is" and offer solid guarantee levels as to the performance of their products to protect investors.

OWI: Is there a crucial point that makes new technologies interesting for investors?
Schneider: In the new tendering environment, a participant cannot afford to ignore technologies that may lead to a lower levelized cost of electricity. This is not just limited to turbine capacity but involves all aspects of a wind farm, from installation methods, foundation and cable designs to offshore accommodation and turbine access & service options.

The interview was conducted by Katharina Garus.

Answers from outer space

The German Aerospace Center has developed a method that can be used to measure the wake effects of offshore wind farms on the basis of satellite data.

Very little is known about the impact that an offshore wind farm has on the winds. The fact that turbines within a wind farm can be in each other's slipstreams is known. But how strong is the impact on the wind field in the larger vicinity of an offshore wind farm? How far do the slipstreams stretch out?

Satellite images give answers

Radar measurements by satellites could provide answers to these questions in the future. The German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt, DLR) has developed a process that can create images of wind fields using synthetic aperture radar (SAR) measurements. There are a large number of civilian SAR satellites in orbit around the Earth, including the ESA's Sentinel-1 or the TerraSAR-X, which is an Earth observation satellite that was put into orbit by a public-private partnership between DLR and EADS Astrium GmbH.

Satellites that are equipped with SAR scan the Earth's surface and create a two-dimensional model. The DLR can calculate wind speeds using the collected data and a special algorithm. The slipstream effects of offshore wind farms can be seen in the resulting images of the wind fields. "The wind field resolution is even sufficient to detect gusts of wind", Björn Tings of the DLR said.

The data needed to calculate the SAR wind fields is available 30 minutes after the corresponding satellite flies by overhead. In the case of the Sentinel satellite, the data is even available free of charge. According to Dr. Sven Jacobsen, Head of DLR Maritime Safety and Security lab, images captured by the TerraSAR-X cost around € 2,000. The raw satellite data is hardly enough to draw any conclusions. As a registered non-profit organisation, the DLR also has no commercial interest. "However, we can provide the evaluations for testing or for scientific purposes at a cost price," Tings said.

Verification with comparison measurement

In order to verify the methodology, the DLR conducted a comparative measurement in the Alpha Ventus wind farm. The wind was measured on-site using Doppler LIDAR and at the same time an analysis was carried out using satellite data. "The direct comparison showed a remarkable correspondence between the data sets also in relation to small-scale wind variations," Jacobsen said.

But the new methodology is not the only interesting aspect. The knowledge that has been gained is also quite important. Alpha Ventus may only have 12 wind turbines, but their effects can still be measured 20 km downstream. Larger wind farms in the North Sea are causing a drop in winds of 20 % up to 80 km behind the offshore turbines.

In Jacobsen's view, the new methodology has a very obvious benefit: "With SAR-based wind data, the winds can be measured and statistically examined to improve the reliability of yield forecasts for existing and planned offshore wind farms." However, the satellite data could also provide answers to environmental protection issues. It is still unclear whether the altered wind conditions caused by offshore wind farms have any influence, for example, on the Wadden Sea, ocean currents or the mainland.

Katharina Garus

Graphic: ESA

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First float, then sink

In the Atlantic off Gran Canaria, a unique wind turbine is being installed: A floating gravity foundation carrying a turbine on top of a telescopic tower. The foundation is lowered and the tower with turbine is extended at the installation site.

In the Atlantic off Gran Canaria, a unique wind turbine is being installed: A floating gravity foundation carrying a turbine on top of a telescopic tower. The foundation is lowered and the tower with turbine is extended at the installation site.

Large installation vessels, equipped with heavy lift cranes, are among the most expensive components of an offshore wind turbine installation. "Every wind tower in the world up to now has depended for its installation on scarce heavy-lift vessels which install the foundation on the seabed and lift the turbine and tower elements to their final position", says Lara Cerdán Aznar, Project Manager in offshore wind energy projects for the Spanish engineering and consulting company Esteyco. The company has developed the Elisa technology that aims at facilitating crane-free installation of foundations, towers and turbines out at sea.

The technology consists of an innovative telescope tower and a new type of gravity foundation. The foundation base can temporarily act as a self-stable floating barge. It is manufactured in a low depth dry-dock, combining precast concrete and in-situ manufacturing. After being floated out of the dry-dock it is completed and equipped with a telescopic tower.

This in turn consists of three tower segments that can be extended like a telescope. The three segments themselves are manufactured from three to six precast concrete pieces. All assembly connections happen in-harbour. The later erection of the telescopic levels is performed by a set of strand jacks. "Jacking is a relatively common practice within the civil sectors, and particularly for bridges, which is part of our background", says Cerdán and adds, "The lifting capacity of these jacks is equivalent to that of a crane, but for a much lower price."

An Elisa prototype is currently being set up in Gran Canaria, as part of the Elican project funded by the EU's Horizon 2020 Programme. Foundation and tower have already been installed in the port of Arinaga in the southeast of the island. In the near future the nacelle, a Gamesa G132-5MW, and the rotor blades will be assembled in the harbour berth, before the entire turbine is towed out with barges to the installation site. Esteyco is planning for the prototype to be launched in the first quarter of 2018.

Ballasting the base

At the final installation place an auxiliary floating system, using buoyant elements, is installed temporarily around the

Using temporarily attached floats (yellow) the turbine is stabilised while the foundation is lowered.

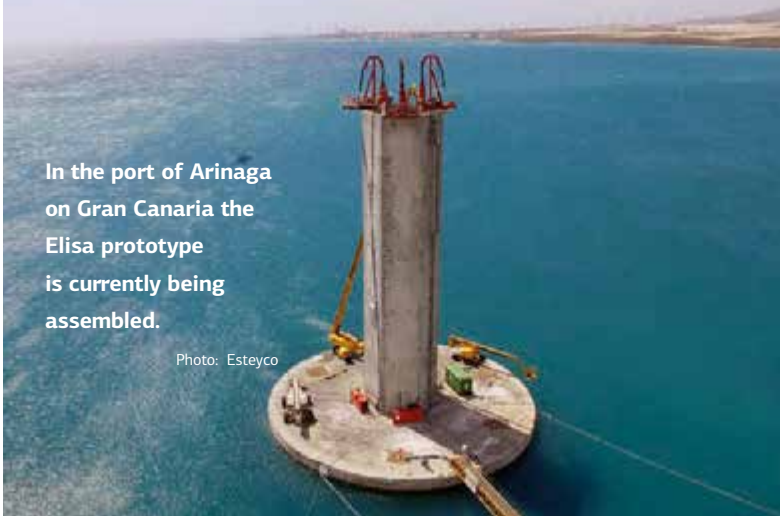
Graphic: Esteyco

tower to provide the required stability during the water ballasting of the assembly. In order to ensure water clearance to the blades, the tower top level is lifted using the hydraulic jacks. Afterwards the foundation cells are filled with water, allowing the controlled ballasting of the base, down to the seabed. Once reached the final position, the solid ballasting can take place, displacing the inside water with solid ballast. Finally the last telescopic tower segment is lifted.

The horizontal joints of the telescopic tower have two resisting mechanisms: prestressing bars and grout. Bars are preinstalled in the port and come to position during the erection. The grout is poured offshore once the bars have been prestressed. It adds stiffness to the joint and protects the tower, as it also acts as waterproofing. "All the lifts and horizontal joints can be executed from the same single working platform at sea level", points out Cerdán Aznar.

However, this is just one of the benefits of the Elisa technology. Pre-assembly in the harbour is considerably more cost-effective than an offshore installation." The full in-shore pre-assembly of the complete system is a key factor to generate a highly industrialized manufacturing process with high production rates and optimized risk control, plus significant local content," says Cerdán Aznar.

She adds: "The market shall set its eyes on the capacity of the substructure supply and of the installation means, which can become critical bottlenecks preventing low-cost solutions." In addition, thanks to the telescopic tower, all works are performed at a maximum height of 40 m. Elisa does not even require large cranes onshore to lift the nacelle or the rotor blade for example.



In the port of Arinaga on Gran Canaria the Elisa prototype is currently being assembled.

Photo: Esteyco

Potentials in both Europe and overseas

The Elisa technology is suited to water depths of 15 to 55 m and this is precisely where Cerdán Aznar sees market potential in the North Sea and the Baltic Sea – especially at sites where soil composition is unfavourable for jackets and monopiles. "Besides, China and the US are two countries shifting to offshore wind, having large continental shelves with shallow depths and without the constraints of an existing industry; they can start from scratch," she says.

Although, as a first step, the final installation of the prototype now has to be completed. "Prototypes are mainly meant for learning," says Cerdán Aznar, "having said this, of course, if everything goes right, it will be a sound demonstration of the technology, which should encourage developers to use it, at least at a test site as a first reasonable step". Various prospective project developers and EPC contractors have already approached Esteyco, confirms Cerdán.

Esteyco would certainly be pleased to receive active support because "the project as a whole is a challenge in itself for a company of our size, as we are neither developers nor contractors but designers. Winning consecutive R+D calls, both national and from the EU has allowed us to invest nearly 25 million € on this, which is above our annual turnover," Cerdán is pleased to say.

Katharina Garus

Glass fibre reinforced composites from PET structural foam and epoxy coatings strengthen the loading capacity of the rotor blades (enlargement 145:1).

Confronting the forces of nature

Offshore wind turbines are exposed to the most extreme wind and weather conditions and still need to function reliably. If proper coatings are used, the components can be protected.

Offshore wind energy is an attractive business field, because stable revenues can be generated thanks to constant wind regimes. Durability and reliability are the defining factors to achieve this. However, turbine components are exposed to huge environmental stresses at sea. Significantly higher wind speeds, salty sea air and extreme weather conditions such as lightning strikes or hail put a lot more stress on the turbines than in onshore farms. Corrosion protection is vital to ensure the proper functioning of the turbine components and therefore its safe operation. Ultimately, it also reduces necessary maintenance measures that are significantly more laborious and therefore costly out at sea. In order to prevent surfaces from being damaged by external influences, coating systems must protect against corrosion for as long as possible.

Photos (2): BASF SE

Avoid costly repairs

"Offshore repairs are very costly. Because damage needs to be remedied on site, repair costs can be up to 100 times higher. Modern coating systems must therefore warrant turbine protection for at least 25 years," says Hendrik Müller, Managing Director of Helmut Müller GmbH in Emden. Since the Alpha Ventus project, Müller's company has been providing consultation and monitoring services for offshore wind farms, including an assessment of the research platform FINO1 north of Borkum.

Between 2002 and 2004, three platforms were installed in the North Sea and Baltic Sea to collect meteorological measurement data amongst others. At that time a coating system was applied that had been examined and authorised by the Federal Waterways Engineering and Research Institute (BAW). The platforms and especially corrosion systems applied at the time can be used as negative and positive references, as these are some of the first and oldest facilities in the German offshore wind industry. "Almost no damage occurred in the surface areas," Müller sums up his observations and expects almost no corrosion to occur in offshore wind farms installed thereafter, if processed in compliance with the technical specifications, standards and regulatory frameworks.

Precisely because offshore repairs are extremely cost and time intensive, careful attention needs to be given to corrosion protection in the planning, manufacturing, transport as well as final installation phases at the construction site. The best corrosion protection is useless if mistakes are made in the planning stage, or during processing, transport and installation. Müller reports that no system or material related damage occurred in anti-corrosion coating systems that had been tested and certified.

"The weak spot are areas subject to mechanical strains, such as boat landings. This is also true for heavily stressed high and low water exchange zones, areas with bolting connections, mounted parts, difficult structures and flanged elements, where the passive corrosion protective system is exposed to special stresses and planning and processing errors become quickly visible due to ensuing corrosion," explains Müller.

A traditional anti-corrosion system consists of several coatings. A zinc or aluminium pigment based primer is used to protect the steel due to its cathodic effect. The intermediate coatings are layers that build up a barrier effect for the coating system. Finally, the top coat protects against environmental impacts and resists UV radiation and is also responsible for the colour.

Trend towards two layer solutions

Alongside traditional multi-layer coatings that are generally based on solvents, "the trend is going from multi-layer systems to two-layer systems," points out Müller. Such two-layer systems have many advantages. Since fewer coatings are needed, corrosion protection can be applied more time and cost effectively. "So-called high-solid products can be classified as solvent free," says Müller.

The decision about which organic anti-corrosion system is to be ultimately used, depends on several factors. Constructive specifications imposed by the authorities such as the German Federal Maritime and Hydrographic Agency (BSH) also play a significant role, as their aim is to prevent the discharge of solvents and similar substances into the sea.

"Multi-layer systems lower the danger of pore formation, since pores can simply be closed by several layers," observes Müller. In addition processing at difficult-to-reach areas can be done more easily with multi-layer systems, due to the thinner thickness of single-layers. However, two-layer system suppliers have responded and adjusted the viscosity of their products so that the product can be processed by hand during pre-coating.

Special solutions for rotor blades

Coating of steel elements is primarily done at the foundation and the tower of a wind turbine. However, coating system suppliers also have special solutions available for rotor blades. Modern rotor blades are made of glass or carbon fibres that are bonded using faster hardening epoxy resin systems that enable them to maintain their strength. "In principle this works like a two-component adhesive. The first component is composed of artificially fabricated resins, the second is the curing agent. When

they are mixed, they interlink," explains Gregor Daun, Head of the BASF team for development and marketing of epoxy systems for composites.

During operation at sea, rotor blades are subjected to severe stresses. They must not only withstand rain, snow, hail, sand and UV radiation, but must also resist extremely strong external forces at the blade tips with wind speeds of up to 300 km/h. In rotor blade coating, the blade surface is ground before the multi-stage coating process and release agents are removed from the production process. In the next step, a gelcoat is applied, which protects the blade from environmental impacts, humidity and UV radiation. Minor irregularities can be levelled out using a spackling compound. The coating process is completed by applying an edge protection against wear and a top coat layer. The suppliers affirm that the manufacturing process of large rotor blades can be significantly accelerated by using two-component systems consisting of epoxy resins and curing agents. First, they say, the curing agent responds more slowly, enabling more complete and rapid filling of the tool moulds. After filling the mould, the curing speed is accelerated by heating. The mould is thus released more quickly for manufacturing of the next blade, and production volumes are increased. According to BASF, its coating system for rotor blades can generate time savings of 30 %.

Corrosion protection also on the inside

Offshore wind turbines are not only impacted by external forces. Owing to high temperature fluctuations and high air humidity, offshore turbines tend to form condensate water which can provoke damage to the electronics or lead to mould and rust on the inside. Maintenance or inspection work on the turbines can therefore only be executed with protective clothing or respiratory protection. The Finnish company Tikkurila, for instance, intends to counteract these effects with the help of a special coating for the tower inside. "We have found that very many existing turbines are contaminated and require urgent action," says Uwe Volk of technical sales at Tikkurila. He recommends coating solutions using micro-pores, which enlarge the surface of a coated component, allowing the surface tension of water drops to break up and the water to evaporate more quickly. Due to the physical effect of the coating, he says, no additional fungicides or biocides are required to fend off mould.

Securing engineering strength

To safeguard the operation of turbine components in the future, further developments are required to extend the turbines' lifespan. The Federal Institute for Materials Research and Testing (BAM) is looking into these issues in their research project "Life Extension and Engineering Strength of Offshore Wind Turbines" (LeBeWind). Alongside feasibility studies and the evaluation of methods for repairing damage to supporting structures, the application of anti-corrosion coatings and the sustainability of potential repair concepts for these coatings are being investigated in a sub-project. New technical instructions will be derived from the scientific findings. The BAM expects to have the first findings in mid-2018.

Kai Eckert

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Structural change

Something is happening on the coast. A number of port cities are seizing the opportunity to strengthen their economies and introduce structural change by expanding their port facilities into bases for offshore wind energy.

After decades of economic decline, which manifested itself in dying shipyards and declining fishing, renewable energies are now being seen as a new hope by many regions. It is growing particularly strongly in coastal areas close to offshore projects.

The best example of this is Cuxhaven. Here, right at the mouth of the Elbe in the North Sea, great things are taking shape. The technology group Siemens has built a new production plant for offshore wind turbines for € 200 million. The 360 m long, 160 m wide and 30 m high production facility, which went into operation in the summer, will ship the first 7 MW offshore turbines at the end of October. "When we decided in favour of Cuxhaven, we had already tested a number of harbour areas. What we found here was an area that was already prepared and had the necessary access to the sea. With its nacelle production facility, Siemens Gamesa is also launching a new logistics concept for offshore wind power plants", said Project Manager Carsten-Sünnke Berendsen.

This is the first time in 20 years that the technology company has set

Wind energy takes the place of containers: Tower elements, nacelles and pre-assembled rotor stars are shipped from the Eurogate area in Bremerhaven for the wind farm Nordergründe in 2016.

up a complete plant in Germany, and it was also able to take the new logistical requirements into account. The facility in Cuxhaven includes all nacelle components: "The generator, the rotor hub with the hydraulic pitch system and the 'back-end' are manufactured on three assembly lines. This largest of the three components contains the entire electrical system, including the inverter and the transformer, as well as the controller and the main frame, which is equipped with yaw drives. The back-end then merges with the generator and the hub in the 'marriage line' and is then combined into a finished nacelle", Berendsen described the principle. "When all technical and electrical functional tests are completed, we load the completely tested nacelle onto the transport ship. The result is a compact, tested system, and this saves us a considerable amount of time on commissioning at sea", Berendsen said.

In Cuxhaven, the heavy nacelles can be loaded directly onto the transport ship via a Ro/Ro ramp. "This allows us to avoid expensive road transport, which is already reaching its limits due to the increasing size of the nacelles and rotor blades. By rolling the nacelles directly onto the ship using SPMT heavy-load transporters, we also save crane work and increase work safety", Berendsen said. At the same time, the company can serve the entire Baltic Sea region and Scandinavia via the nearby Kiel Canal.

Revitalising the Cuxhaven region

The new production facility is making a significant contribution to Cuxhaven's economic recovery. The city administration of Cuxhaven is expecting Siemens and the presence of other suppliers to create approximately 2000 jobs in the region. Further jobs are expected to be created in the service sector, logistics, commerce and technician work. Ambau had already come to Cuxhaven in 2008, long before Siemens arrived. The company manufactures steel towers for offshore wind farms at two buildings near the new production facility.

Offshore potential recognised early

With its industrial settlements, Cuxhaven has become one of the most important centres of the offshore wind industry. By contrast, the region had been threatened by economic disaster just a few years earlier. A heavy load platform had been available at the port since the summer of 2007. Pre-assembled wind turbines were kept ready for transport on an area of 1,500 m². With financial support from the state of Lower Saxony, the facility was expanded by 2009 into the Offshore Terminal Cuxhaven, which covers an area of 10,000 m².

Cuxhaven Steel Construction GmbH (CSC) was established in the same year. The subsidiary of the German offshore pioneer Bard intended to build foundation structures for wind turbines at sea. Ambau had already begun manufacturing in Cuxhaven a year earlier. The Austrian construction company Strabag announced that it wanted to manufacture gravity foundations right at the port. With all these projects, Cuxhaven could have become an important offshore base port. But then everything changed. At the end of April, the CSC closed down its business and 360 employees lost their jobs. Shortly after that, Strabag also abandoned its offshore project.

Flexibility in Bremerhaven

Instead, the wind energy business in neighbouring Bremerhaven seemed to be flourishing. The wind power companies REpower Systems (now Senvion), Multibrid (today Adwen), PowerBlades and WeserWind had their production plants here. Germany's second-largest seaport also has the necessary infrastructure. The terminal operator Eurogate has freed up space at its container

Photo: Eurogate

terminal. "We can react very flexibly to customer requests here and offer full-service logistics with handling, storage and other services, such as pre-assembly", Eurogate Director of Operations Nina Distler said. The company has approximately 25 hectares at its disposal in Bremerhaven for wind power. Last year, approximately 1,500 onshore components were handled for Vestas and the 18 fully pre-assembled 6 MW Senvion turbines for the offshore wind farm Nordergründe were shipped. In 2014, 48 wind turbines for Nordsee-Ost were delivered via the terminal.

Slowing down large-scale projects

In Bremerhaven, however, the municipal BLG Logistics group had created approximately 10 hectares of space for wind energy at the site of a car transport terminal. The area, which is called the ABC Peninsula, is currently being used for vehicle shipping again. Bremen ultimately abandoned other project goals as well, even though the city definitely had higher aspirations.

Based on a Prognos study, the city administration decided in 2011 to close a regional airfield in Bremerhaven and build an offshore terminal on the site. The prerequisites were good because local equipment manufacturers had their factories in the immediate vicinity of the site. However, due to its tight budgetary situation, the small German federal state needed to find a private investor to be able to carry out the planned 180 million Euro project. This delayed the initial commissioning of the Offshore Terminal Bremerhaven (OTB), which was originally scheduled for 2014. At the same time, the framework conditions also changed. Legislative changes in funding for renewable energy and a reduction in the political expansion targets for offshore wind energy in Germany caused uncertainty in the industry.

When the new factory that Siemens was planning to build in Bremerhaven did not materialise and WeserWind simultaneously went bankrupt, doubts began to grow about whether the planned OTB would be used at capacity. Even though a 30-year concession agreement was signed in February 2016 with the port company Bremenports and the city terminal operator BLG Logistics Group to operate the OTB, construction work cannot proceed because the environmental association BUND has gotten a court injunction to stop construction.

Mistakes were made in the planning process. Neither licensing-related aspects nor nature conservation had been taken into account. Conservationists also criticise the fact that the economic goals of the OTB do not justify the negative effect on nature because there is already sufficient capacity for loading wind turbines in the areas of the Jade, Weser and Elbe rivers. In addition, the estimated number of 160 offshore rotors to be loaded each year could be too high.

Even though the project has not been rejected, the prospects for Bremerhaven have deteriorated further due to market consolidation. At the end of June, Adwen announced that it is closing down its production facilities in Germany. When the last of 70 turbines for the Baltic Sea wind farm Wikinger have left the factory in Bremerhaven, production is shutting down due to a lack of follow-up orders. Even though the company is still active in French projects, the facilities for this have to be built in France. For this reason, Adwen is setting up a new plant in Le Havre, France.

At the moment, wind energy handling in Bremerhaven is concentrated at the Eurogate container terminal. "We see ourselves as a supplementary solution to the OTB and also as a transshipment terminal for onshore wind energy plants", Distler said. Nevertheless, the team is not letting anything get in the way of its commitment. "We are talking to different onshore and offshore customers to bring further cargo handling business to Bremerhaven", she added.

Great plans were also once forged in Emden. The Bard Group had its headquarters at the location, and with the expansion area at Rysumer Nacken at the west tip of East Frisia, there were potential areas available for a central base port for offshore wind energy.

In the end, however, preparations took too long, and because of the competitive situation with other port cities, the new construction projects which would have cost millions to build, was no longer economically viable. According to the Lower Saxony Ministry of Economic Affairs, the plans are currently on ice, but the project has not yet been completely abandoned.

By contrast, business is booming in the Dutch city of Eemshaven. The open tide port serves offshore wind farms as a construction, storage and base port. The wind farms Bard Offshore 1, Trianel Borkum and Global Tech I are supplied from here, and the location is also the base port for the German wind farm Gode Wind and the Dutch offshore wind farm Gemini.

In danger of losing market shares

Denmark's most important North Sea port Esbjergis is leader in handling and shipping of wind energy components across Europe. According to the operating company Port of Esbjerg, 1,100 MW of offshore wind power were shipped via the port in 2016. A total of 80 % of the wind power installed in European seas was handled in Esbjerg. The new Siemens Gamesa plant in Cuxhaven may cause Denmark to lose market shares. Even though the operator is keeping its cards close to its chest regarding production figures for the Cuxhaven plant, industry experts are expecting at least 300 turbines to be built and shipped from Cuxhaven each year, based on the current order situation. This would amount to nearly double the capacity that was shipped via Esbjerg last year.

Hull also benefits

And if Siemens has anything to say about it, this is not the end of the line. "We assemble nacelles for the gearless Siemens Gamesa offshore wind turbines that are used in projects worldwide. Currently, the focus is on countries with North Sea and Baltic Sea coasts, but we also see signals for market developments in Asia and the United States", Berendsen said.

However, other locations on the North Sea are also benefiting from the investment. Siemens Gamesa is having the rotors for its new turbines manufactured in Hull, UK. Renewable energies are now moving into areas where people used to earn a living in the coal and fishing industries. Hull recognised the potential early on.

The Green Port Hull Initiative was launched in 2010, and the port was expanded into a base and supply port for British offshore wind farms. Siemens took note of these structural changes, so it built its new rotor factory here. The new building in the UK cost the company approx. € 430 million. "The United Kingdom and Germany are among the most important markets for offshore wind turbines. It therefore seems logical to create regional value in both countries", Project Manager Berendsen explained. Siemens operates two specialised transport vessels: the Rotra Vente for transporting nacelles and the Rotra Mare for rotor blades. The ships transport finished components to the installation ports. "Cuxhaven and Hull are two important points in our location and logistics strategy, which covers offshore projects throughout the North Sea and the Baltic Sea", Berendsen said. But the concept does not just reduce transport costs. "We work very closely and successfully with the authorities, business development programmes and employment agency here in Cuxhaven. We can reach a large number of local specialists in the structurally weak coastal region who are eager to work. They quickly acquire the necessary knowledge through training courses," Berendsen said. However, the new plant also offers attractive working conditions that attract specialists from other parts of Germany. "We are contributing to the revitalisation of the entire Niederelbe-Cuxhaven region", the Siemens manager said.

Kai Eckert

Success through cooperation

Stemming from a cooperation between partner companies, a service to the offshore wind power sector has been set up which can secure fast aid for conditions ranging from minor illnesses to life-threatening emergency rescue situations.

The helicopter is equipped as a flying intensive care unit.

At times, the German Bight has been a huge construction site, with thousands of workers constructing one offshore wind farm (OWF) after another – and the massive expansion continues. Where work is carried out under time pressure, hundreds of tonnes of steel are moved around and complicated technical operations are carried out at heights of 100 m in the tightest of spaces, more or less serious accidents are bound to happen. The offshore wind energy sector is not particularly prone to accidents; statistically it is in line with comparable industrial sectors. The particular issue with accidents in the offshore wind energy sector is the individual siting of accidents and the distances to a transfer point for the victim over to rescue infrastructures on land.

The situation is not yet satisfactory. In a lot of cases the concepts up to now have only included single components of medical care for workers on the platforms and the OWFs. The "WINDEAcare" concept is now countering this with care from a single source. From minor illnesses which can be diagnosed and treated via telemedicine to life-threatening injuries and difficult rescue situations, the relevant aid can be provided here.

Cooperation between experts

The idea is simple; such a comprehensive service can only be successfully mastered through a relevant partnership. WINDEAcare is not an independent company, but a product borne of a cooperation between the respective partner companies, which is marketed by WINDEA Offshore GmbH & Co. KG. Each partner brings in its own expertise and experience from its core business here. All do not do everything, but rather each does what it can do best. "This cross-company knowledge base from the fields of medicine, emergency services, nautical sciences, aviation and wind power is unique on the market," claims the product brochure.

The central element is the helicopter. It is several dozen kilometres to the furthest of the OWFs. Transportation by ship would take far too long. "WINDEAcare is specially tuned to the needs of the offshore wind power sector. The helicopter, for example, is a flying intensive care unit and our rescue personnel pretty much stand alone

Photo: Northern HeliCopter

WINDEAcare was honored with this year's Duty of Care Award: From left to right: Dr. Peter Schiessl (Managing Director CBM), Katja Rehage (Project Manager WINDEA Offshore), Klaus Graf (Managing Director IQ.medworks), Caspar Spreter von Kreudenstein (Managing Director WINDEA Offshore), Herbert Jansen (COO Northern HeliCopter), Dr. Walter Eichendorf (Head of Awards Jury)

Photo: WINDEAcare

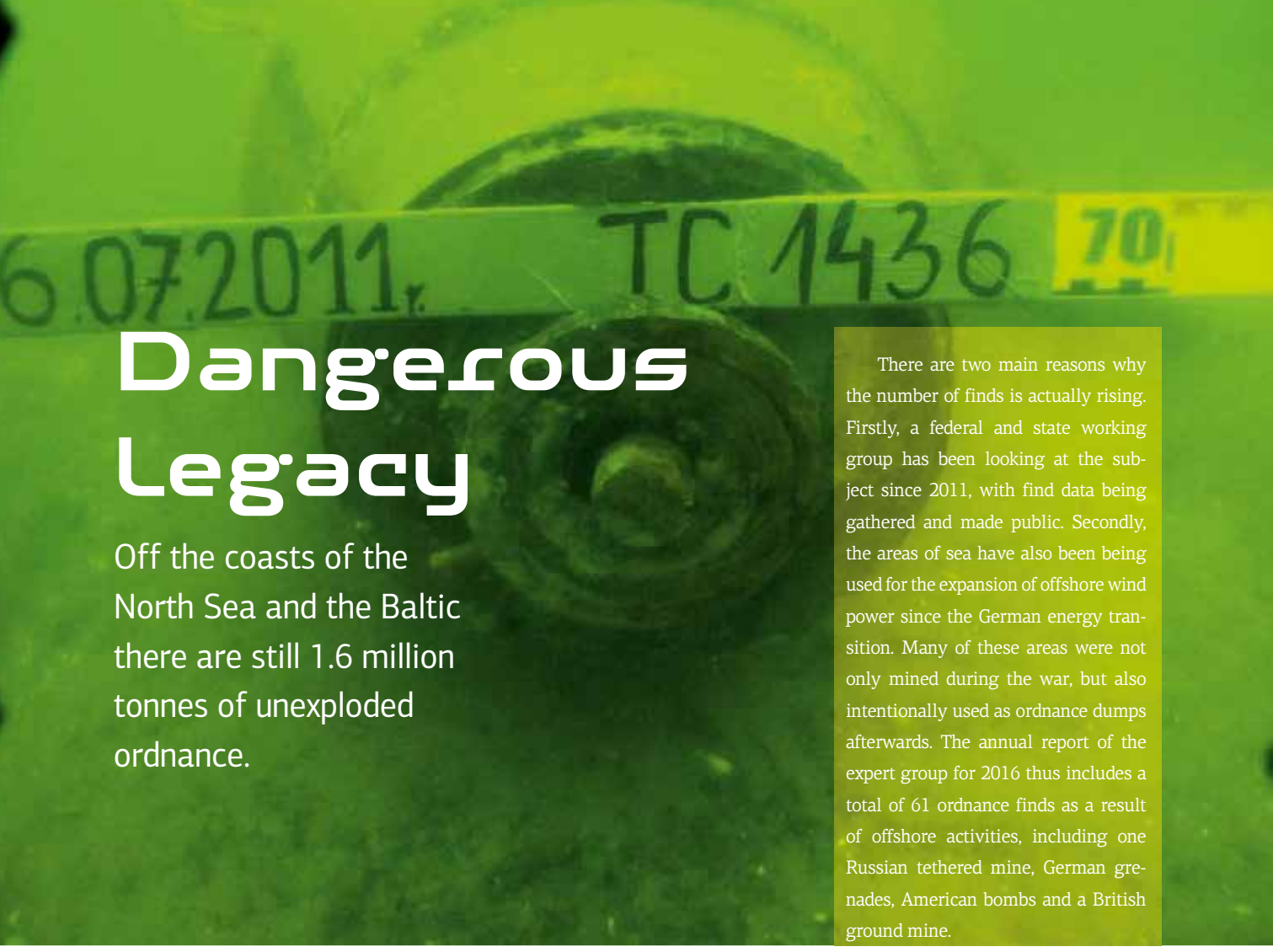
in having had additional training for heights, water and confined-space rescue," says Frank Zabell, Head of Northern HeliCopter GmbH. The use of a helicopter is not only a question of the speed of reaching the coast but also one of potentially adverse weather. "The wind is not the limiting factor," explains Zabell: "It is much more the weather conditions at the rescue site. Weather such as fog or freezing rain is a no-go."

Additional partners

Additional partners apart from Northern HeliCopter are: Johanniter-Unfall-Hilfe e.V., Regional Association Weser-Ems (emergency control centre VENTUSmedic/ emergency paramedics, offshore first aid training); Klinikum Oldenburg (medical lead/telemedicine); IQ.medworks GmbH (interdisciplinary emergency management/implementation/telemedicine services); and EMS Maritime Offshore GmbH (nautical expertise).

WINDEAcare was presented the Duty of Care Award at the end of June 2017. The International SOS Foundation initiated this award, which is bestowed annually. It honours companies and individuals who make a significant contribution towards the health and safety of people working abroad or in remote areas.

Jörn Iken



Dangerous Legacy

Off the coasts of the North Sea and the Baltic there are still 1.6 million tonnes of unexploded ordnance.

It's 10th January 2017, at the construction site of the offshore wind farm Gode Wind 2 in the German North Sea. A security vessel discovers a sea mine in the outer area of the wind farm. The Central Command for Maritime Emergencies is informed; the mine must be blown up. A team of experts from the bomb disposal team flown out that afternoon by marine helicopter decides against a detonation at sea due to the difficult weather conditions. The multi-purpose ship Mellum takes the German tethered mine in tow and takes it to the planned explosion site at the Watt mud flats off Horumersiel. The explosive power of the mine from WWII is between 150 and 250 kg. The detonation is carried out the following day. Animals must be scared away and the detonation area extensively evacuated. Taking part in total: four ships, a helicopter, bomb disposal experts and the German police.

1.6 million tonnes of munitions

This may have been the first ordnance find in 2017, but it won't be the only one for sure. According to the expert group "Munitions at Sea", alone in the German North Sea and Baltic there are still an unfathomable 1.6 million tonnes of munitions. Loaded onto a goods train this would be 3,000 km long. But the finds are more or less random; in 2016 the central reporting centre for ordnance at sea received a total of 264 notifications of ordnance finds, while 2015 saw 218.

There are two main reasons why the number of finds is actually rising. Firstly, a federal and state working group has been looking at the subject since 2011, with find data being gathered and made public. Secondly, the areas of sea have also been being used for the expansion of offshore wind power since the German energy transition. Many of these areas were not only mined during the war, but also intentionally used as ordnance dumps afterwards. The annual report of the expert group for 2016 thus includes a total of 61 ordnance finds as a result of offshore activities, including one Russian tethered mine, German grenades, American bombs and a British ground mine.

"Our work begins even before the first find with research in historical records about the future construction site," explains Melanie Abbondanzieri. She is a Project Manager in the development department at Heinrich Hirdes EOD Services GmbH. In this way it can be clarified in advance to what extent the offshore site was along the flight path of an aerial attack on a big city, for example, which often means such a site is particularly affected.

Following this, the construction site is scanned using the corresponding technology. "One of the biggest challenges is making really precise finds," says Dieter Guldin, COO at SeaTerra. A ship tows the required sensors 150 m behind it, in order to find magnetic anomalies. "At 40 metre water depths, plus wind and waves, you can get into the range of centimetres, depending

Photo: Heinrich Hirdes EOD Services

on the technology used," says Guldin. But not every anomaly comes from ordnance: "96 percent of what we find is simply junk." To determine without doubt what it is, multi-sensor platforms are also used depending on the water depth, which can analyse the object using various methods. If these also do not deliver clear results, then ordnance divers are sent in.

"Once it is clear what we are dealing with, there are various options," explains Abbondanzieri. Can the ordnance be recovered or taken to another contaminated area? Must the find be blown up on site or can it be left where it is under certain circumstances? "Especially when cables are being laid, taking a different route can be an alternative."

But a lot of the time the find must be recovered or blown up. At the construction site of the Veja Mate wind farm alone, 95 km off Borkum, this was true for two incendiary bombs, two explosive bombs, a ground mine and two training bombs. "Whenever a live fuse is in place we have to detonate," explains Guldin.

Fully automated munitions search

Looking for ordnance is thus complex and expensive. You have to assume three to four million euros for a medium-sized wind farm, according to Guldin. In order to reduce costs in this area too, and to relieve divers of this dangerous work, the RoBEMM research project has been under way since the end of 2015. The aim of the three year project is to develop a prototype machine which can fully automatically disassemble ordnance on the seabed and then dispose of it in an environmentally friendly way. "We are still at the concept phase," says Abbondanzieri. The company Heinrich Hirdes EOD Services is the leading party in the consortium consisting of companies and research bodies. The system to be developed, made up of a platform with a processing unit, should in the future be able to do everything automatically which today can sometimes only be carried out by a dangerous diving mission. This sounds simple but is actually complicated, for the system must be capable of clearly identifying the various ordnance and making it safe. "We do not have the documentation for some of the dumping grounds," says Abbondanzieri. These are sometimes in various archives of the wartime "attackers" and not all countries have made such information available.

However, even a fully automated system cannot prevent the need for blowing up unexploded ordnance at sea – with consequences for the maritime environment. Heavy metals and suspended solids pollute the sea, and each detonation is at the same time dangerous for aquatic mammals such as porpoises, which use their hearing for orientation. In order to protect them a bubble curtain is used, similar to when ramming foundations. "Noise levels are thus reduced by up to 96 %," says Cay Grunau, Head of Hydrotechnik Lübeck. However, when detonating, approx. 20 % more air must be used than when ramming. He bemoans that as opposed to ramming, there are no clear guidelines for detonations: "For ramming there is an upper threshold by the BMUB (Environment Ministry) of 160 dB at a distance 750 m from the sound source." There are no such boundary values for detonations and thus no regulations on the nature of the bubble curtain. "We have carried out tests with the navy and developed our own standards here," says Grunau.

And there is even more – and fundamental – criticism. The problem of ordnance in the sea was talked down for decades, criticises marine biologist and environmental assessor Stefan Nehring. In 2003 he looked at anthropogenic pollution of the North Sea on behalf of the states of Lower Saxony and Schleswig-Holstein. "During this, I came across irregularities concerning statements on ordnance contamination, looked for old documentation on ordnance dumping at the Federal Archive in Koblenz, and got a result." Since then he has regularly published work on the subject of ordnance finds. So far there is still no adequate knowledge about what ordnance lies exactly where, and what condition it is in. "Nautical maps are still not up to date on the ordnance sites," complains Nehring. In the 1990s, details were even specifically deleted in order to play down the problem. He demands – so far unsuccessfully – the systematic identification of ordnance hotspots and a clean-up of these. Until then the finds will have to remain a matter of chance.

Katharina Wolf

The curse was lifted

After the first U.S. offshore wind farm went online last December, the U.S. market is lining up the next projects hoping to create momentum for a local supply chain and manufacturing.

On December 12, the U.S. became an offshore wind nation when Deepwater Wind announced that the first offshore wind farm, five 6 MW turbines on the northeastern coast, had begun its commercial operation. And it was as if a curse was lifted. "Our success here is a testament to the hard work of hundreds of local workers, and to the Block Islanders and the thousands more around the U.S. who've supported us every step of the way of this amazing journey," said Deepwater Wind CEO Jeffrey Grybowski in December.

According to NREL analysts, the U.S. is poised to become a big player in the offshore wind market, after a decade ago an offshore wind energy potential of 86 GW by 2050 had been identified in five major offshore wind (OSW) areas located at the Northern Atlantic Ocean, the coast of Oregon and California, and the Great Lakes with the highest winds, but also including the Southern Atlantic Ocean, and Hawaii. The two state departments involved have indicated to support wind power, besides a strong commitment to oil & gas.

Proactively, the Massachusetts Clean Energy Center (MassCEC) started to update the design of the New Bedford Marine Commerce Terminal years ago to support the construction, assembly, and deployment of offshore wind projects, making it the most versatile heavy-lift cargo facility in the nation, according to MassCEC. Last September a Letter of Intent for a two-year lease was signed with lease holders DONG Energy, Deepwater Wind and ffshoreMW to use the terminal as a staging and deployment location for future wind projects, a clear indication the companies will be one of the first developers to land projects in the offshore waters. The Massachusetts's energy legislation had set stage to require utilities to competitively solicit and contract offshore wind power for approximately 1.6 GW. Three different utilities have called for 400 MW of OSW power proposals by December; at least three bids are expected.

Massachusetts is in the unique situation where load centers are close to shore. At the same time about 8 GW of old power plants, mostly fossil fuel and nuclear, are about to be retired starting in 2019. Currently MassCEC is working on infrastructure assessments and just published a comprehensive port report, detailing five ports in the Fall River and Somerset Area, and another four ports in the Boston area, and one more in Quincy, which with additional investments would be suitable for construction and staging of foundations, manufacturing of components, and long-term operations and maintenance.

Massachusetts also has the largest indoor wind blade testing facility in the country, where blades up to 90 m can be tested. Bill White from MassCEC feels he can finally celebrate: "We are here, the market has arrived."

After New York's Governor Andrew Cuomo announced in January to develop 2.4 GW of offshore wind power by

Photo: Deepwater Wind

2030, New York might become the next offshore wind state in the country with the South Fork Wind Farm (90 MW), Deepwater Wind's 2nd project. The project will be located about 30 miles South of Montauk and not visible from shore, a crucial detail in the area, where the developer Cape Wind for years has struggled with local resistance from property owners on the shore line.

While costs of European projects have been going down since 2012, analysts, agencies, and developers have gotten ready to make the leap now. "When the analysts ran the numbers for Long Island, offshore wind was the most economic," said John Rhodes, CEO at the New York State Energy Research and Development Authority (NYSERDA) at the 2017 U.S. Offshore Wind conference. NYSERDA is working on a comprehensive Offshore Wind Master Plan "which will detail the needs of the market, highlighting those that can best be served locally," says Kate Mueller from NYSERDA. Large-scale offshore wind commitments, like those from New York State, will drive the emergence of local manufacturing."

Unique for New York is the close proximity of potential OSW power sites to load centers, mainly on the coast, where energy demand is high and power outages are a constant threat. With a long-term plan for New York state to produce 50 % electricity by 2030 from renewables, just the OSW cut-out would provide 1.25 million homes with electricity. Kate Muller emphasizes the need of sectors that "also generate long-term economic benefits of additional jobs." She sees the highest potential to scale up quickly in the "existing footprint of onshore wind and offshore platform manufacturing in the U.S.. Local expertise exists for turbines, cables, substations, and foundations. However, given the transportation constraints of many of the large offshore wind components, there is a need for manufacturing facilities along or near the water where they can be loaded onto ships and transported to project sites."

The third player, Maryland, with the Offshore Energy Act in 2013 created a "carve-out" for offshore wind energy in the state's Renewable Energy Portfolio Standards, beginning in 2017 and extending beyond 2022, for up to 2.5 % of total retail sales. Maryland combined a RFP which was awarded this May to US Wind (248 MW by 2020) and Skipjack (120 MW by 2022) with a large commitment to support the development of in-state businesses. Besides a local content requirement of 19 % (US Wind, a subsidiary of Renexia and part of Italy based Toto group), and 34 % (Skipjack, a subsidiary of Deepwater Wind New Jersey), both developers will also pay US$ 6 million each into the Maryland Offshore Wind Business Development Fund as well as they will invest in a steel fabrication plant (US Wind: US$ 51 million; Skipjack: $ 25 million) and a shipyard upgrade (US Wind: US$ 26.4 million; Skipjack: US$ 13.2 million), all well planned steps by the Maryland PSC to help the industry scale up manufacturing.

Andy Geissbuehler, Managing Partner at Renewable Resources International, who held executive positions with Alstom and GE and has been involved in the Block Island Wind Farm, describes it as triangle of collaboration to generate scaling benefits: "1. Building on the European learning curve, 2. Leveraging from the strong U.S. oil and gas industry and 3. Enabling the U.S. large project capabilities. The U.S. pipeline will evolve favorably by the state driven energy policy and the federal infrastructure advancement programs."

With a large oil- and gas industry located in the Gulf of Mexico, companies like Gulf Island Fabrication (GIF) have been watching closely for this new industry to emerge. Roy P. Francis, Senior Vice President at GIF, says for him the only difference between oil platforms and wind foundations will be the serial manufacturing of a number of foundations. "Currently, we see it as a potential growth area out of our existing business until there is scale. We are committed to the industry and will consider the support and investment required that benefits the project and our shareholders," says Francis.

When the second wave of projects will start in 2020, major components will still heavily rely on European imports. Although the big turbine manufacturers, like Siemens, Vestas, and GE Renewable Energy, have already been very active in the U.S. market, no announcements have been made so far, Siemens and Vestas preferred not to comment for this article.

Tim Brown at General Electric (GE), who delivered the five Haliade turbines for Block Island, says "(as) for new offshore sites in the U.S., we will leverage the company's industrial capabilities, and we will pace our growth in the U.S. depending on the market evolution."

Anja Limperis

A trade fair in **turbulent** times

Rarely has a trade fair occasion been so beleaguered by changes in the general conditions faced by the wind energy industry, as it is for this year's HUSUM Wind. The exhibitors have announced quite interesting new products and services. OWI presents a selection of the offerings.

It will be a special occasion this year when the wind energy industry meets from the 12th to the 15th of September in Husum for the German wind energy trade fair richest in tradition. Not only because of the more than 650 exhibitors from all over the world but also because the year 2017 is particularly significant for the wind energy industry. Aside from being about new products or services, discussions in the exhibition hall aisles and at exhibitor booths will also concern the issue of how the industry can and will deal with the changes that are happening in its framework conditions.

And there are indeed plenty of changes, including the transition from the EEG funding to a tendering model with 0.00 cent bids for offshore wind farm projects in German waters and consequences for future projects. Furthermore, the German Bundestag election will be held nine days after HUSUM Wind. Even though climate protection and renewable energies have only played a small role in the election campaign so far, the offshore wind energy industry has to brace itself for the possibility that there may or may not be changes to the tendering regime and the cap on megawatts for each tender after the Bundestag election.

So there is a lot to discuss, especially since topics such as ever larger turbines, evolving concepts like gravity foundations or floating turbines, streamlined maintenance concepts, and the merger of companies doing business in the offshore sector are also on the agenda. The HUSUM Wind trade fair organisers are taking this into account, for example by arranging special events for both onshore and offshore wind energy, or by organising a political panel discussion on the Bundestag

Graphic: Messe Husum & Congress

Deutsche Windtechnik wants to divide the North Sea into three clusters and synchronise its services within each of the clusters.

election. But of course the core of Husum Wind is made up of companies and their new offerings.

New products and services

Even though most companies were still very reserved at our editorial deadline at the beginning of August with announcements about their trade fair participation, some exhibitors have published exciting and promising information about new products and services. OFFSHORE WIND INDUSTRY has summarised some of these new announcements:

In a combined effort, service company **psm** and **eolotec**, specialist firm for roller bearings, have developed the "Blade Bearing Guard". The early warning system for blade bearing monitoring can be installed on all common wind turbines and is available from January 2018. It is the only system on the market offering a permanent wear monitoring. On the one hand deviations of the blade bearings are detected immediately, on the other hand it enables the maximization of the operation time and intervention just in time when necessary. "By monitoring these important bearings constantly the gathered results are the base of well-founded decisions reducing service and operation cost and making

The Blade Bearing Guard installed on a MM92 wind turbine Photo: eolotec

Small discs with bigs effect for wind turbines

Photo: 3M

further operation just possible", says Wolfgang Losert, General Manager of eolotec. The Nuremberg based company has developed the BBG and supplies the system hardware. Its market maturity was proved within test series on wind turbine types GE 1.5, REpower MD70/77, Senvion MM92 as well as Vestas V80 during an extended period.

Customers can order the system as well from eolotec as from psm. As a certified partner psm takes over the installation of the system. Delivery and commissioning are possible all over Europe.

eolotc: Hall 1, Booth A19
pms: Hall 4, Booth A09

The **3M** Friction Shim is a small disc with a big effect for wind turbines. This friction-increasing shim is only one tenth of a millimetre thick and light as a feather. Embedded diamond particles on the shim enable a microform closure between two components in the case of structural screw connections. This allows manufacturers to use fewer screws in wind turbines, resulting in weight and cost reduction

Hall 2, Booth D09

If you are dealing with category A bolted connections in a wind turbine – defined in VDI/VDE 2862 sheet 2 as 'safety-critical connections' – a standard hydraulic screwdriver or a conventional electric screwdriver with a drill drive will no longer suffice. Generally speaking, the directive prescribes two directly measured values for these cases, a control value and a monitoring value. In practice, this means the tool must have one sensor for torque and one for the angle of rotation. For this purpose, **Atlas Copco Tools** will be presenting the Tensor Revo HA electronic screw tightening system, which is currently available in five models with a maximum torque of up to 6,500 Nm. With its two sensors, it is suitable for installation of safety-critical screw connections. According to the company, one special feature of these assembly tools is their high working speed, which makes the tool up to four times as fast as other systems currently on the market.

Atlas Copco Tools is also introducing a hydraulic screw tightening system for the first time that automatically monitors the tightening process while documenting all corresponding data. The compact and robust RTA system achieves torques of up to 11,000 Nm. It has an angle-of-rotation encoder that takes measurements directly at the position where the screw is being tightened, and it can be easily repositioned.

Hall 3, Booth B04

The onshore and offshore service company **Reetec**, which is a subsidiary of the EDF Energies Nouvelles group, has acquired **OWS Off-Shore Wind Solutions GmbH** (OWS). Reetec and OWS want to build an O&M competence centre in Emden

Munitions aboard the clearing ship, prepared for transport to the port Photo: SeaTerra

together. The centre will offer cost-effective full-maintenance services and modular offshore wind solutions that are tailored to the customer's needs. Reetec has been working with OWS since 2015 for the maintenance and operation of the Bard 1 offshore wind farm in the North Sea, and has just signed a 10-year contract with Ocean Breeze Energy GmbH (OBE) for service and maintenance of Bard 1. The extended O&M service offer will certainly also be a primary focus of the trade fair appearance at Husum Wind.

Hall 3, Booth A23

SeaTerra investigates and cleans up land and water areas suspected of containing munitions (see page 32). The company has become specialised in offshore wind farms and cable routes during recent years. As commissioned by wind farm developers and supply grid operators, SeaTerra has examined more than 10,000 seabed hectares of the North Sea and Baltic Sea for munitions in the past few years. Around 4,000 suspicious objects were exposed and identified during these investigations. 160 large munitions (naval mines, bombs, grenades) were secured or relocated. 50 non-transportable munitions, mostly marine mines, were blown up under water on site by SeaTerra's explosives specialists and munitions divers. For the protection of marine mammals,

deterrent and sound protection measures were carried out with the help of a big bubble curtain.

For conducting a munitions search, the company uses high-resolution magnetometer probes along with side scan sonar, a multi-beam echosounder and a subbottom profiler, and then interprets the data.

Hall 2, Booth E24

Due to the seawater climate, there is very high humidity at offshore facilities inside of the tower and nacelle, as well as from condensation caused by temperature differences between the outside air and the interior of the nacelle. The high salt content of the air also accelerates corrosion. **August Mink KG**, better known under their brand name Mink Bürsten (Mink brushes), is developing sealing concepts with brushes in close co-operation with companies in the wind power industry.

Due to the flexibility and the numerous selectively working fibres, the brush differs significantly from comparable materials, such as rubber or foam. Reliable protection is provided against effects from the seawater climate, while at the same time managing to repel condensation moisture, which is not (or not optimally) managed with rubber or foam.

For example, brush seals are used to seal the gear wheel settings of rotor blades. According to Mink Bürsten, because of the fibres' adaptability to the most varied conditions, it is no problem to use them for any gear size or gap size – gaps with high dimensional tolerances are reliably sealed. Colour abrasion on the contacted components as well as freezing-up of the fibre bundles is avoided via selective contact. The Mink Flex System brush body consists of flexible, durable, high-quality thermoplastic rubber, and it is UV and ozone resistant. The system does not absorb water and is certified in accordance with fire protection class UL94 HB (V0 is possible), so it may be used with wind turbines.

Mink Bürsten can also provide a reliable solution in the area of diverting lightning. Lightning will usually strike a rotor blade. This can cause damage and system failure. By using conductive brushes, the electricity can be routed from the rotor hub to the main grounding cable. The dangerously high voltage is thus safely diverted into the ground.

Hall 3, Booth A06

Apart from all the exciting announcements, the HUSUM Wind trade fair continues to have an advantage in terms of its location: In the midst of North Friesland, the cradle of the German wind energy industry, HUSUM Wind is and remains more than just a trade fair – the atmosphere, convention, events and its special spirit make it unique. Anyone who has been here knows this combination of business and pleasure, politics and enthusiasm, and is always happy to return.

Brush profiles offer a wide range of sealing solutions for all design-related openings, such as the opening in the nacelle for the rotor shaft or inspection openings.

Photo: August Mink KG

A career in wind energy

However, if you are looking to experience what Husum has to offer for the first time, you should mark 15 September 2017 in your calendar. The Windcareer will take place on an additional exhibition area on the last day of the HUSUM Wind.

This job fair offers both specialists from the industry as well as students and newcomers the opportunity to get an overview of employers and occupational fields in the wind energy sector. Among the exhibitors are manufacturers such as Enercon and Nordex, the wind farm developer UKA, the engineering and IT service provider Ferchau, operators such as Deutsche Windtechnik along with personnel consulting companies such as RTS Wind AG, QRC Group AG, or Convent Energy. Universities, polytechnics, and training institutes are also represented. In total, there are more than 300 attractive job openings at local companies and throughout Germany.

Volker Buddensiek

Like new

When the 13th Windforce Conference took place in Bremerhaven at the beginning of May, the results of the first German tender round were the number one discussion topic. The zero-cent bids have revived the self-confidence of a whole industry.

The 13th Windforce Conference was held from 9 to 11 May in Bremerhaven under the lingering impression of the first tender round for offshore wind energy projects in Germany. Exploring the complexity of the entire offshore wind industry is, of course, not possible in two days. Instead, the organiser WAB e.V. succeeded in focusing on relevant topics and was able to encourage industry representatives to take part in lively discussions.

Number one on the agenda was, of course, the first round of German tenders. Three of the four approved projects will be completed without feed-in tariffs. This signals a turning point that promptly triggered demands in Bremerhaven for raising or even abolishing the expansion cap. "Offshore wind energy has impressively demonstrated its competitiveness. That is why the industry is calling for the expansion targets to be increased," said Andreas Wellbrock, Managing Director of WAB.

The political representatives in Bremerhaven, however, rejected this demand as expected. "Abolishing the cap is not on the agenda," SPD Bundestag member Bernd Westphal said. One reason for this is that the expansion of the grid is proceeding much too slowly. "We are not progressing fast enough with the expansion of the grid," Westphal admitted. Wellbrock agrees: "We are calling for policymakers to drive the delayed grid expansion and the necessary sectoral integration forward," he said. After years of complaining, the German offshore wind industry is once again making demands. A sign of renewed self-esteem, thanks to the zero-cent bids.

In addition to the German offshore industry, developments in offshore wind power in Massachusetts were another topic in Bremerhaven, as was the British offshore market, regardless of Brexit. Since the consequences are not foreseeable anyway, the industry has decided to ignore the upcoming British exit for the time being. British industry representatives praised the opportunities offered by European companies in the UK. In addition, WAB member companies provided insights into technological innovations and optimised service and maintenance concepts.

Katharina Garus

Photo: WAB

Still going strong

The expansion of wind energy is hugely important to the energy transition. Who are the key players and most innovative German companies in the market?

It all started with project engineering – in more ways than one. wpd is both one of the largest German project engineering companies and one of the oldest. It began in 1995 with the Grebenhain wind farm and four Micon M-1500 turbines. Now that number has risen to 2,163 turbines with a total nameplate capacity of some 4,000 MW, mostly onshore. Later came project and construction management, and finally the company became a stakeholder in projects, some of them offshore. wpd offshore GmbH is active in all fields of the offshore wind industry, from traditional project engineering and construction to operations and service for multi-MW turbines. The company has a European network with offices in Bremen, Rostock, Helsinki, Paris and Aarhus. It also holds equity stakes in offshore projects and is thus also an operator.

In March 2017, wpd announced the completion of a successful refinancing. The senior secured loans amount to more than € 950 million, a sum provided by a consortium of national and international banks. Helge Rau, Head of Mergers and Acquisitions at wpd, adds, "The package was attractive for the banks, which meant that the transaction was significantly oversubscribed."

Average output rises

Following some initial hesitation, German companies a few years ago took the initiative and participated in the construction of offshore wind farms. In 2016 turbines with a total capacity of 830 MW were installed, many of them by German companies or with their involvement.

The average nameplate capacity of the 156 wind turbines with a total capacity of 830 MW is 5.4 MW. This average turbine capacity – and thus also the length and, viewed over the long term, the head weight – has grown steadily. According IWES the average nameplate capacity of newly installed offshore wind turbines worldwide rose from 1.9 MW in 2000 to 3.6 MW in 2014. The rotor diameter increased in the same period to 150 m and the hub height to 85 m.

The trend is clearly toward higher output and larger systems. Water depth also has a significant impact on the design of the foundation structure. German offshore wind turbines have moved beyond the technical threshold of 30 m of water depth.

New dimensions for monopiles

Currently, monopiles for turbines with 8 to 10 MW nameplate capacity

A 10 metres segment: It is welded inside and out in a longitudinal seam welding plant.

are technically feasible. The larger diameter rotor, the deeper water and the higher weight also require larger diameter monopiles. There is now a push to increase the size of piles to dimensions not previously achieved. At the beginning of the 2000s, for technical production reasons, the diameter of steel pipes was limited to some 5 m under the best of circumstances. Currently, pipes of up to 10 m in diameter are feasible.

Not many companies can do that. One of the ones that can is EEW Special Pipe Constructions GmbH in Rostock. "State-of-the-art machine parks make it possible to professionally implement the technical requirements of customers," says EEW Managing Director Michael Hof: "Currently, we are getting requests for diameters of 8.5 meters and unit weights of 1,300 t. In the future, monopiles 12 meters in diameter and weighing 2,500 t will be needed. We don't see any limits on wall thickness. We can process walls up to 170 mm thick," he says. Hof sees logistics and handling in both production facilities and in logistics ports as limiting factors along with the availability of storage area and limited transport and installation options.

Therefore, it is essentially economic and logistical factors that may place constraints on even larger steel pipes for monopile foundations. From a technical standpoint, further development is no problem, according to Hof.

Photo: EEW Special Pipe Constructions

Steelwind Nordenham produces mega-monopiles

The topic of mega-monopiles also a key focus of Steelwind Nordenham, a subsidiary of Dillinger Hüttenwerke and focussed specifically on mega/XL monopiles. A monopile manufactured in 2014 with a diameter of almost 8 m and a total weight of 1,000 t was at the time the largest steel pipe foundation. Now the company can produce diameters of up to 10 m, lengths of 120 m, and wall thicknesses of up to 150 mm. The piles can be used in water depths of up to 45 m. Extending their use to areas with water depths beyond the 40 m mark puts monopile foundation structures at a clear cost advantage when compared with the competing tripod or jacket technologies.

Dillinger Hütte is one of the main suppliers for heavy plates. Thermomechanically rolled steels are used. With four to five roll-bending machines the plates are rounded into segments, then welded inside and out in a longitudinal seam-welding plant. This is followed by connecting the individual segments in a production line for large segments. "There is no electric annealing following the welding," explains Steelwind managing director Ralf Hubo. The dimensions of the monopiles are too big for that.

The production of large-diameter monopiles follows the same general principle at EEW SPC. "At EEW SPC, we have an automated production process for series production. At present, we can produce an average of 7 to 8 XL monopiles per week. The output of XXL monopiles will then be 4 units per week," explains Managing Director Hof.

World market leader Siemens Gamesa

Germany's Siemens AG is one of the largest manufacturers of offshore wind turbines. The wind power business, Siemens Wind Power, completed its merger on 3 April 2017 with the Spanish manufacturer Gamesa to form Siemens Gamesa Renewable Energy. The company is the world s largest manufacturer of wind turbines, with a market share of 14 % – and thus more than the previous leader Vestas.

The turbine manufacturers are under considerable pressure. The industry has seen a wave of consolidation, which has left just nine major producers. Four Chinese companies and two German ones form the backbone of the industry, but only one German company – the same Siemens Gamesa – has developed offshore activities (see interview on page 12). Following a failed offshore experiment, the German market leader Enercon has put a total stop to its offshore activities. The extent of competitive pressure is also evidenced by the problems Senvion (until 2014 REpower) faces. The company is shuttering the turbine production facility in Husum. With this step, Senvion has largely pulled out of Germany. The cause: foreign workers are cheaper. *Jörn Iken*

UK betting on offshore wind

The UK is undergoing one of the biggest transformations of its recent history. What will be the impacts of its decision to leave the European Union on the offshore wind industry?

In May 2017 the world's largest wind turbines went online in the UK. Burbo Bank Extension wind farm employed for the first time MHI Vestas V164. Each 8 MW turbine is 195 m tall and one rotation alone of its 80 m blade is able to produce enough energy for the average British home for 29 hours. In all, the wind farm is expected to generate power for 230,000 homes.

The project is in many ways a symbol of the wind energy developments in the country: large, innovative, delivering lower electricity costs, and away from the British countryside. For the first time, it also uses blades manufactured in the UK.

"Burbo Bank Extension showcases the rapid innovation in the offshore wind industry, said Henrik Poulsen, DONG Energy Chief Executive at the launch of the project. "Less than ten years ago at Burbo Bank, we were the first to install Siemens 3.6 MW wind turbines and in this short time, the wind turbines have more than doubled in capacity."

These developments are in line with the policies announced in the Conservative Party election manifesto, ahead of the June election. The document said: "While we do not believe that more large-scale onshore wind power is right for England, we will maintain our position as a global leader in offshore wind."

The newly re-elected government also promised an independent review into the cost of energy. Their goal is to increase competitiveness by offering "the lowest energy costs in Europe, both for households and businesses."

"A positive future"

The UK currently has 5,355 MW of offshore wind capacity, more than any other country, reminds RenewableUK, the trade and professional body representing the industry. In the first quarter of 2017, offshore wind capacity increased by 160 MW. Cost has fallen dramatically – by 32 % between 2012 and 2016 – due to a combination of government policy, increased volumes and technological innovation.

"We see a very positive future for the sector," says Guy Dorrell, PR and Government Affairs Consultant for Wind Power at Siemens UK. "Four years ago the government gave us the target to reduce the cost of energy to 100 GBP/MWh by 2020. The goal was achieved last year and the cost is now on course to be 75 GPB/MWh by 2020. This is because of large-scale generation and offshore is a good place to start when looking at these dynamics."

He explains: "About 4 years ago the London Array development included 175 turbines. If we were to do it today, we would be able to achieve the same capacity with 70-75."

The UK is already a world leader in the sector. According to an analysis by Douglas Westwood energy group the country is, with China and Germany, one of the three largest contributors to

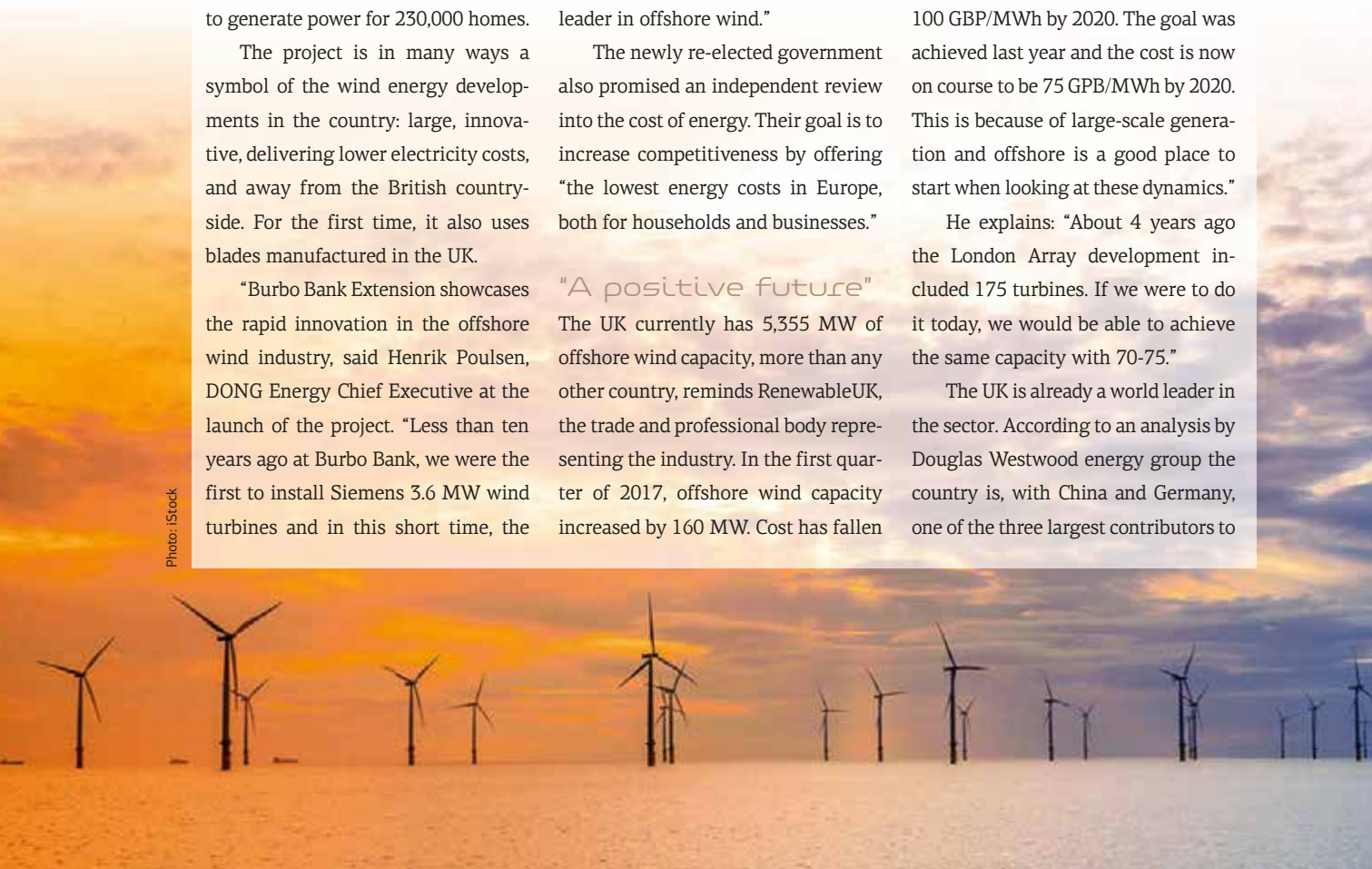


Photo: iStock

total capacity additions globally. And a report published in June by WindEurope shows Britain can go even further. The study "Unleashing Europe's Offshore Wind Potential" shows that at least 25 GW of offshore wind (about five times the current capacity) can be installed in UK waters by 2030.

"This report shows what our innovative offshore wind industry can deliver in the years ahead, securing economic growth and cheaper electricity," commented Emma Pinchbeck, Executive Director of RenewableUK. The study adds that the country has the most economically attractive offshore wind resources anywhere in Europe, "nearly three times better than Denmark, which is in second place."

The disruption of Brexit

But the UK is also undergoing one of the biggest transformations of its recent history. What will be the impacts of its decision to leave the European Union? The EU just started discussing the revision of the renewable energy directive, which has been key in promoting clean energy. Will London continue to participate in these and other efforts at EU-scale?

Despite the pervasiveness of "Brexit", the most discussed topic in Britain at the moment, no one seems to be keen to comment or make predictions on how the disentanglement from the EU will affect the sector in the future. In part, this is because no one knows yet which direction the Brexit negotiations will take. "There are so many variables," says Guy Dorrell. "No one could predict this decision as a start. Our business modelling has a span of 3 years, so the current Brexit timeframe is business as usual for us. We will then decide as we go along the best we can."

In May the Energy Institute at the University of Durham published a study on the impacts of Brexit on the UK energy system. This is about factors that affect the entire energy sector, including renewables and wind. But three key themes emerge. The first is about research collaboration and funding. "Achieving a resilient UK energy sector requires continued research and collaboration with European partners. It is therefore a priority to protect and support collaboration with EU partners on Research & Development and Demonstration projects and to identify ways to minimise the risks and barriers to collaborative working in the post-Brexit era," says the report.

The second concerns the increased interconnection across EU energy systems that helps manage intermittent generation by renewables. The UK, for instance, benefits of cheaper electricity when the wind is blowing hard in Norway or Denmark and can download to other countries its excess production too. Rules about these exchanges are likely to be reconsidered.

Finally, there is the question mark over investors' confidence. "A long drawn-out Brexit process with little clarity on the direction of energy policy will have a significant impact on investments from the private sector," says the report. The authors therefore call for "a consistent, long-term energy policy [...] based on an open debate about whether the UK should aim to develop a more independent UK energy sector."

How can the sector thrive in this context? In the midst of the existential questions Brexit has opened for the country, Dorrell says that all the industry needs is clarity. "If the government signals how many projects and how many GW it plans for the future, it will give a strong signal and increase the confidence of companies to invest." This will weather the uncertainty the country is set to face for the coming years.

Claudia Delpero

Energy trends

The UK Department for Business, Energy and Industrial Strategy published on 29 June the Energy Trends with data from the first quarter of 2017. The essentials:

- The share of renewables in electricity generation increased to 26.6 %, compared to the 25.6 % in the first quarter of 2016.
- The total amount of renewable electricity generated was 24.8 TWh, an increase of 5.1 % compared to the same period the year before.
- Total wind generation increased by 10 % to 12.7 TWh. Solar increased by 16 %, to 1.7 TWh (20 %) to 7.7 TWh. Offshore wind capacity increased by 0.4 GW (7.1 %).
- Low carbon electricity (including hydro, biomass and nuclear) increased to 45.6 % from 44.4 % in the first quarter of 2016.
- The production of oil and coal decreased (of 4.6 % and 11.7 % respectively), while natural gas increased (4.7 %).
- The UK exceeded its third interim target in compliance with the EU renewable energy directive, reaching 8.5 % instead of 7.5 % renewables in final energy consumption on average over 2015 and 2016. The target for the country is 15 % renewables by 2020.

OEEC: Transformation through Collaboration

Offshore Energy Exhibition & Conference (OEEC) on 9 to 11 October in Amsterdam brings together the oil & gas, offshore wind, and marine energy industry. With the industry in transition OEEC offers offshore energy professionals the ideal meeting place to network, discuss and learn about the future of energy.

Offshore Energy features an exhibition where over 650 companies will showcase their products and services. The Offshore Energy Conference addresses topics of interest to all levels of the industry ranging from young professionals to seasoned industry leaders. Guided by this year's theme "Transformation through Collaboration", the three-day programme consists of Technical Sessions, Keynotes, Master Classes, the Offshore WIND Conference, the Marine Energy Event, and the Community Square covering a spectrum of topics from technological innovation in various disciplines to industry wide strategic challenges. Offshore Energy attracts a global audience of more than 11,500 offshore energy industry professionals. With 667 exhibitors, 25,000 m^2 floor space and visitors representing 99 nationalities, Offshore Energy Exhibition & Conference 2016 was a great success.

Offshore WIND Conference

The 8th annual Offshore WIND Conference (OWC) on 9 and 10 October 2017, part of Offshore Energy Exhibition & Conference, convenes an international audience to discuss the latest developments in large scale offshore wind energy deployment. The conference will focus on the opportunities for the offshore wind sector over the next ten years and beyond – What will upcoming tenders offer the supply chain (short term)? What are the trends and opportunities after 2023? – while also tackling subtopics such as cost reduction, innovations, subsidy and cooperation with the oil and gas industries.

Selected topics

- **Can electricity market cannibalisation be cured?**
  A renewable generation is on the rise. Market demand is met as the wind will always continue to blow. Yet, with market prices falling is the offshore wind industry set to get caught in cannibalising its own investment? A kick-off to show the bigger picture within the industry.
- **The road up to 2023**
  How can the industry prepare for the long-term? Which steps will need to be taken to ensure future demand, regulations and energy agreements? This session will also focus on human capital issues.
- **Trial and triumph in bidding systems**
  Tenders and bidding are hot topics in the industry. The Netherlands have presented a solid case and many countries stand to follow suit. Where lie the challenges? Can cost reduction be met by taking important technological steps. What works in other countries?
- **Future forecast: reading the map**
  What is the road for 2023 up to 2050 and beyond? Can the industry turn agreements into reality? Leading players from the industry offer their forecasts.

Contact: Navingo BV, Philip Mulder, Phone: +31/10 209 2674, pmu@navingo.com, www.offshore-energy.biz

HUSUM Wind 2017

September 12 - 15, 2017

Husum, Germany

As the platform for the cutting-edge technology, variety and the innovative power of the German market and surrounding regions, the exhibition reflects the whole value chain. In 2017, there will also be current political and technical topics on the agenda, such as the tendering process, maintenance concepts and repowering. The special exhibitions Offshore Wind Energy and Sector Coupling & Grid Integration will also focus on pioneering areas. The partner state of the trade fair in 2017 is North Rhine-Westphalia, which is the business base of many suppliers and one of the leading states in the expansion of wind energy.

www.husumwind.com

Composites Europe 2017

September 19 - 21, 2017

Stuttgart, Germany

Composites Europe combines tried and tested solutions and efficient innovations. The trade fair reflects the variety of goods and services and the innovative strength of the entire industry. Major topics at the fair are state-of-the-art production and processing technologies focussing, among others, on concepts for lightweight construction and automotive applications.

www.composites-europe.com

Baltic Clean Technology

September 28 - 29, 2017

Rostock, Germany

The CleanTech network is hosting the international Baltic Clean Technology Conference at the HanseMesse Rostock together with its partners from Germany, Lithuania, Poland and Sweden. This conference explores new paths: Ocean technology and resource management appear hand in hand, following the conference's main idea of a sustainable use of resources in the Baltic Sea region.

www.baltic-clean-technology.com

Wind Integration Workshop

October 25 - 27, 2017

Berlin, Germany

Participants from power system operators, transmission and distribution grid operators, wind turbine manufacturers, universities and research institutes, and consulting companies will convene in Berlin for the 16th Wind Integration Workshop. The experts on renewable grid integration solutions will review and discuss recent advances in technology and exchange ideas on how to jointly tackle the challenges of the coming years. The primary objective is to stimulate interdisciplinary thinking between industry and research by providing a platform for discussion and for ideas and knowledge regarding the key issues in the field of large-scale integration of wind power.

www.windintegrationworkshop.org

4th International Conference 66 kV Offshore Wind Digital Data Integration and Management

November 14 - 16, 2017

Bremen, Germany

This international event with special focus on all aspects of 66 kV for offshore wind will give the opportunity to share experience with leading OEM and Tier1 companies. Next to expert presentations, this conference focuses on networking sessions to exchange ideas, panel discussions to get answers to the most recent developments and three interactive workshops to help you face challenges, discover solutions, and make decisions to crucial business excellence.

www.66kv-offshore-wind.iqpc.de

Five good reasons for more Offshore Wind Energy

Working together with other industry organisations, the Offshore-Wind-Industrie-Allianz (OWIA), WAB's voice in Berlin, has mapped out five key reasons why energy policy should clear the way for the installation of more offshore wind power.

• **Costs:** Since 2012, the cost of generating power at sea has dropped by as much as 50 percent. The most recent tendering procedures in Europe have shown that the cost of a kilowatt-hour now ranges from 5 to 7.3 euro-cents (ct/kWh). The offshore wind industry has seen some rather drastic reductions in costs since 2016 due to the installation of more and larger turbines and a very good learning curve for construction and operations. As of 2024, the first wind farms at sea will begin operations without having relied on state subsidies.

• **Employment:** Some 20,000 employees work in the offshore wind industry today. Job growth is particularly high in service and maintenance. The number of jobs in offshore wind energy increased fivefold between 2010 and 2015. Germany is currently the leader in the global market and in technology. Companies all across the country, including many small and medium-sized enterprises, are part of the value chain.

• **Climate and the environment:** There is no doubt that we are already experiencing climate change. According to the most recent report from the Intergovernmental Panel on Climate Change (IPCC), more than 90 percent of greenhouse gas CO_2 is generated by burning fossil fuels, which is why utilising renewable energies is key to protecting the climate. Offshore wind already supplies reliable and cheap CO_2-neutral electricity. Stringent regulations guarantee that the construction of offshore wind farms complies with nature conservation.

• **Energy:** Wind power at sea generates large amounts of electricity very reliably and steadily. Because offshore wind power is so predictable, its contribution to ensuring energy supply is essential. Many small and medium-sized enterprises as well as large German and European energy suppliers and public utilities are involved in the expansion of wind power at sea.

• **Grids:** Major sections of Germany's power grid were built when just a few coal and nuclear power plants supplied the country with electricity. The expansion of renewable energies in general and the large share of wind energy generated in northern Germany mean that the grid must be rapidly modernised and expanded. Innovative approaches to capacity management and sector coupling offer opportunities to bridge bottlenecks.

More information on the "Offshore – Deutschlands Windstärke" initiative run jointly by the Arbeitsgemeinschaft Offshore-Windenergie (AGOW), the Offshore-Wind-Industrie-Allianz (OWIA) and the Stiftung Offshore Windenergie is available at: www.wab.net

Photo: Wolfhard Scheer

Save the date: WAB Wind Energy Agency at the 2017 HUSUM Wind trade fair

At the HUSUM Wind trade fair from 12 to 15 September WAB will sponsor a large joint stand (2-E14 in Hall 2) . Co-exhibitors include the BIS – Bremerhavener Gesellschaft für Investitionsförderung und Stadtentwicklung, convent energy, Fassmer, GMA-Werkstoffprüfung, GÖRG Partnerschaft von Rechtsanwälten, WFB Wirtschaftsförderung Bremen and ForWind, the joint Centre for Wind Energy Research at the Universities of Oldenburg, Hanover and Bremen.

A special highlight at this year's fair will be WAB's patronage of the popular "Windkraft Zulieferer Forum" hosted by Plarad – Maschinenfabrik Wagner at wind energy trade fairs since 2012. The central idea of the forum is to bring suppliers and manufacturers in the wind industry together around one table. For the first time, the forum will focus solely on offshore wind. Andreas Wellbrock, WAB's Managing Director, is looking forward to welcoming visitors to the forum at 2.05 p.m. on 14 September.

Photo: Siemens

outlook

Preview WindEurope

This year, November 28-30, the wind industry will meet in Amsterdam. The conference will feature around 35 sessions over three full days. It will open with high-level politicians and C-level industry leaders debating industry trends and outlook. OWI gives a preview on both the conference and the exhibition.

Floating turbines

Five Siemens Gamesa turbines of the 6 MW class have been installed on floating foundations in Norway for the 30 MW "Hywind Scotland" project – the world's largest floating wind farm – to be towed to the site off the Scottish coast. It is the first project with floating turbines of this size. And there's more to come.

Graphic: Statoil

Photo: LM Wind Power

Rotor blades

During operation at sea, rotor blades are subjected to severe stresses. They must not only withstand rain, snow, hail, sand and UV radiation, but must also resist extremely strong external forces at the blade tips with wind speeds of up to 300 km/h. What is the best compromise between swept area, energy production, and the weight as well as the loads transferred to the wind turbine?

The next issue will be published on October 30, 2017

For further information see www.offshorewindindustry.com

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