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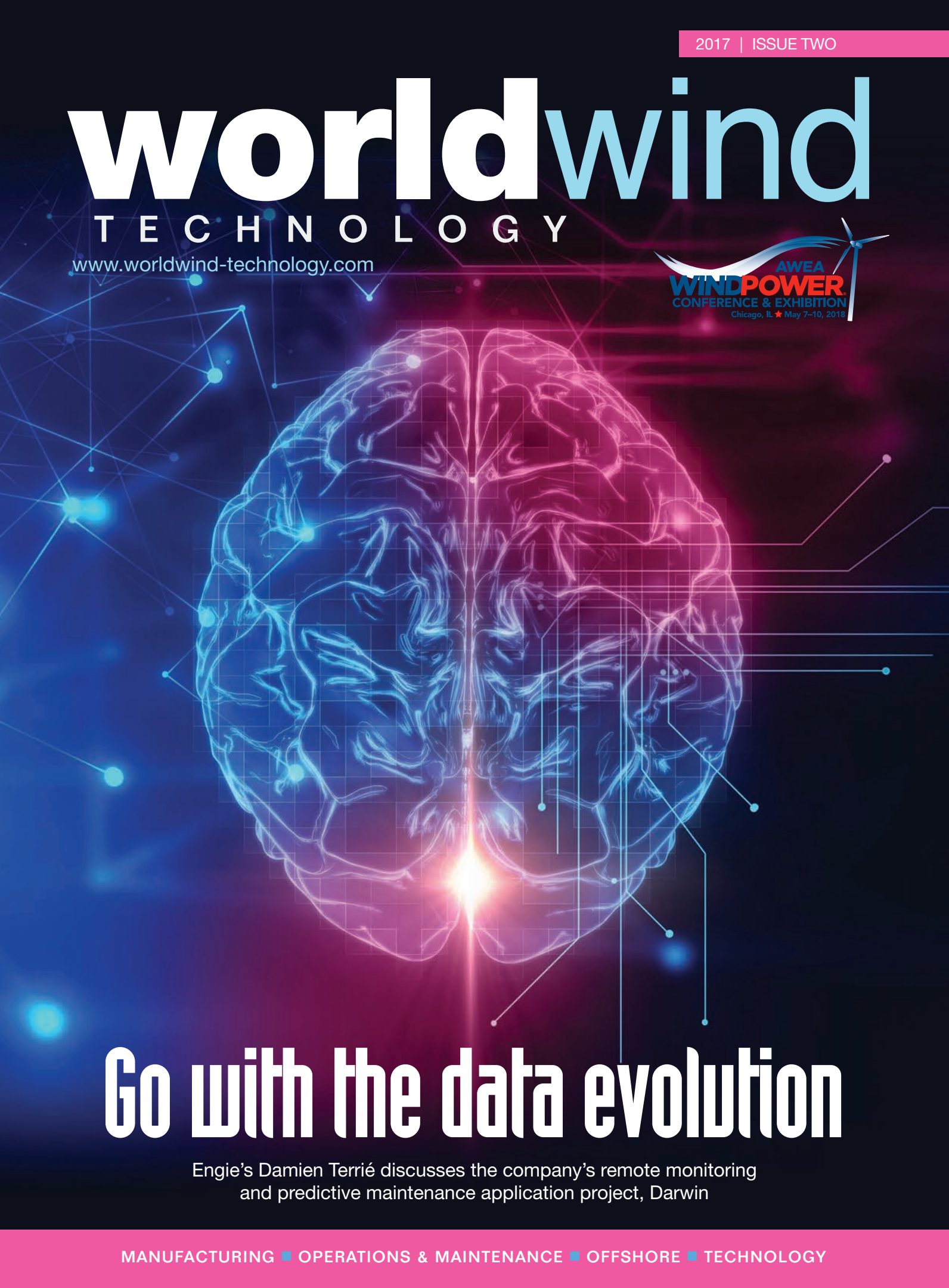

# Go with the data evolution

Engie's Damien Terrié discusses the company's remote monitoring and predictive maintenance application project, Darwin

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Issue 2 2017

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**Andrew Tunnicliffe**
**Editor**

# Where's the windy nimby gone?

If the state of the global wind power market could be described in meteorological terms, at the turn of the millennium it was a gentle breeze. Today, as you'll likely know, that breeze has picked up considerably, arguably reaching gale force.

Contained between the covers for your coffee break read, on page 7, you'll read about New York and its big ambitions to be the wind capital of North America, if not the world. You'll also read of one turbine blade manufacturer that's tapping into new markets – an essential business step to take as the desire for renewables continues to grow.

It's a far cry from where we were 20 years ago. Then, I had never heard of the acronym – or even the word – 'nimby'. It remains unrecognised by my spell check, but it is something that most of the UK population will be aware of. The term means 'not in my back yard', and first came to prominence in the mid-to-late 1990s.

I can distinctly remember the news bulletin I was watching at the time and, I'm afraid to say it, the term was used by an advocate of wind power, speaking of residents that had significant objections to a proposed wind farm. The earmarked location was a hillside in the northern UK countryside.

Today, the UK boasts 6,616 onshore wind turbines across 1,280 locations according to RenewableUK. The trade association also says that, according to numerous opinion polls, support for onshore wind power projects across the UK is high, with rural areas proving to be very supportive. This is a stark change to how the public viewed this form of power generation but a few decades ago.

In fact, my hometown is also home to a small onshore wind farm, something my neighbours and I find captivating. Almost 11.5 million homes receive their energy from wind, onshore and offshore, in the UK.

On this evidence, and New York's manoeuvring to become a hub for wind power, its clear the industry has the potential to grow beyond any of our expectations of yesteryear.

Enjoy the read and come back for more from future editions to make sure you stay up to date on everything wind related.


## In this issue



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# In this issue

## Cover story





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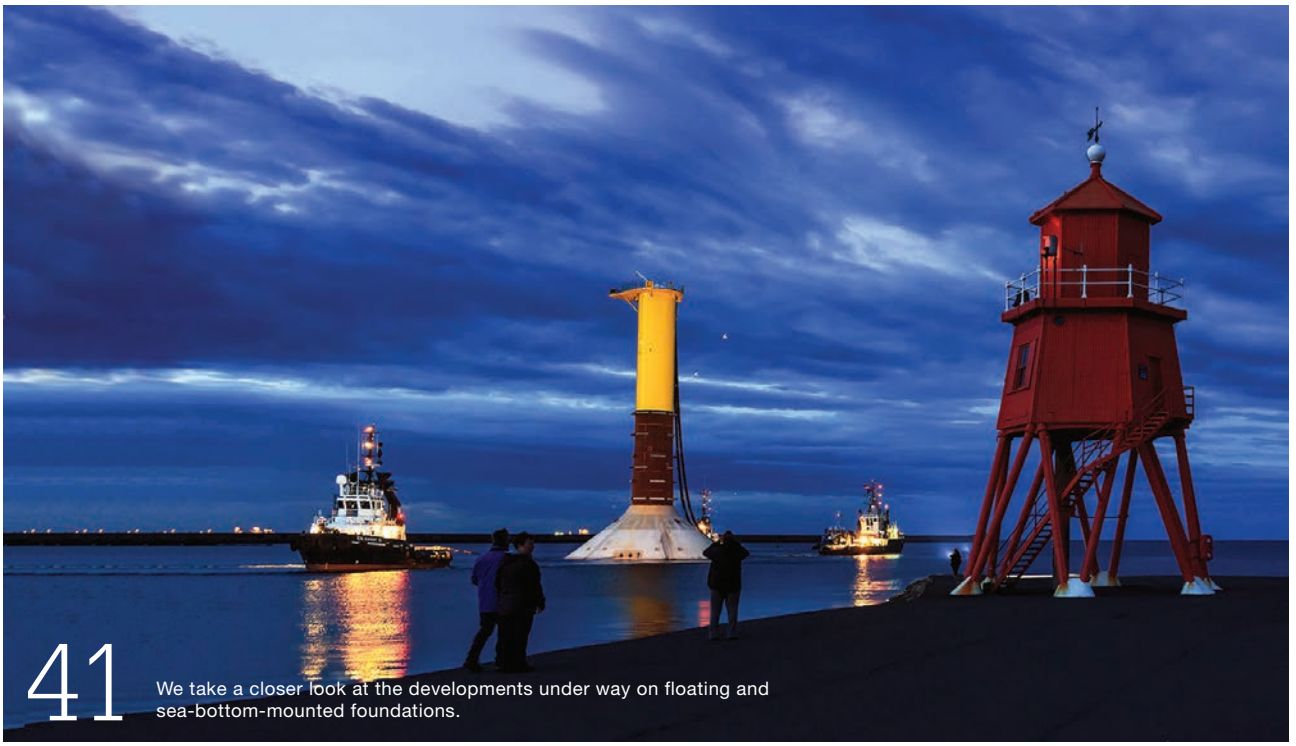
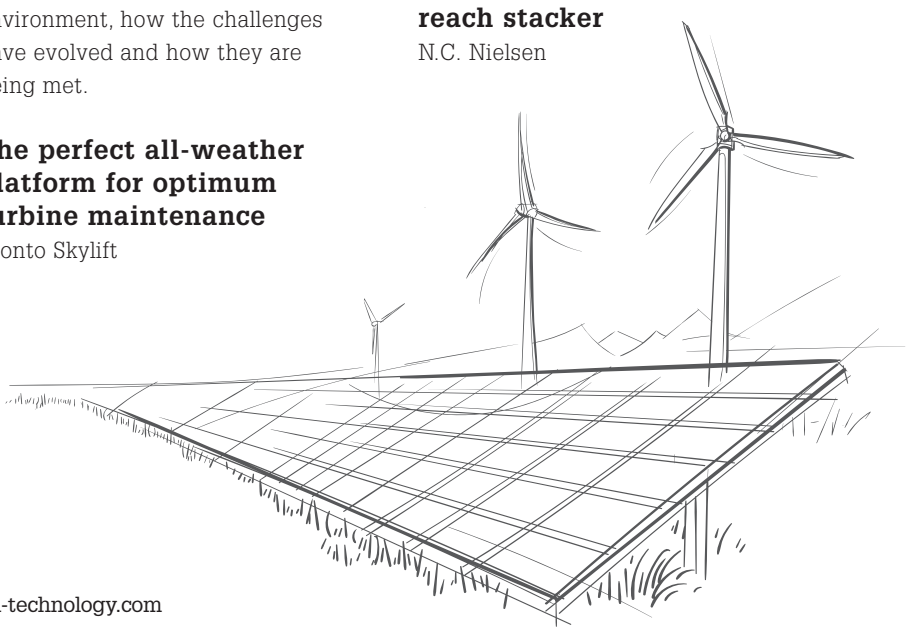






# Another windy city

New York is positioning itself to be the US capital of wind power. Andrew Tunnicliffe examines its difficult history, and looks forward to what might lie ahead.

In October 2017, New York played host to the AWEA Offshore WINDPOWER 2017 Conference, bringing together some of the industry's leading lights, including legislators, industry representatives and business leaders from around the world.

Among the 1,000 or so in attendance were: Kathy Hochul, lieutenant governor of New York; Lars Christian Lilleholt, Denmark's minister of energy, utilities and climate; Dr Timothy Unruh, deputy assistant secretary for renewable power at the US Department of Energy; and Tom Kiernan, chief executive officer of the AWEA.

The event was the tenth of its kind, having been first held in 2008. It boasted what the organisers termed a "top notch" networking event, supported by a "timely and relevant" education programme that included an update from those involved with the ongoing development of the 90MW wind farm project of the city's coast.

Speaking during the event, Hochul told visitors she believed New York had the potential to lead the way in global wind power. "New York intends to be the pre-eminent global hub for the next generation of the wind industry." She continued with her address, detailing a plan to develop 2.4GW of offshore wind power.

"Offshore wind is essential to meet New York's ambitious energy goal," she said, adding that the project would help create thousands of jobs. "We're making unprecedented investments in infrastructure and laying the groundwork for the offshore wind industry, which is primed to benefit from New York's talented, ambitious workforce. The


New York has an ambitious renewable energy goal.

economic and environmental benefits offshore wind will provide is a win-win for all New Yorkers."

Hochul also took aim at US President Donald Tump and his much-criticised decision to withdraw the country from the Paris Climate Accord, saying the state was committed to tackling climate change despite what was happening in the country's capital. Her statements were warmly received, particularly as she spoke of the operational wind turbines in the state already.

Coming to the end of her address, she revealed state officials had been working on an offshore wind master plan. "New York is accepting the challenge, but doing the legwork for you," she concluded.

## Private push

The news is good for the state as it continues to push its renewable energy ambitions. The state government's enthusiastic approach to renewables is matched by that of the private sector. Earlier this year, the Long Island Power Authority gave its approval for the US's largest offshore wind farm. The facility, to be developed by Deepwater Wind, would be home to as many as 15 turbines across its 256-square-mile spread, with capacity for a further 200 turbines later.

Speaking at the time to an audience of jubilant onlookers, the authority's chief executive, John D McMahon, said the project wouldn't be the first for the state, as it strives to meet Governor Andrew Cuomo's ambitious target of generating half its consumed power from renewable technologies by the end of the next decade.

However, although state lawmakers have been determined in their efforts to make New York a hub for renewable energy, there has been opposition from residents and some in the business sector. Among the concerns has been the impact large-scale wind farms would have on sea views and fishing.

Deepwater has come under increasing pressure from the fishing community. In an effort to address those fears, senior representatives from Deepwater addressed a packed town hall meeting in East Hampton. The company's president, Chris van Beek, and vice-president, Clint Plummer, spoke with residents after hearing their concerns. Among the hot topics were fishing, as well as the damage the farm's construction and operation might have to sea life in the region.

Both men insisted the impact would be negligible, not impeding fishing areas through restricted access, nor as a result of the installation of turbines or seabed cabling. The company has experience in the field, having constructed Block Island Wind Farm in the face of similar opposition. Speaking to the audience about fishing stock and their previous experience, Van Beek said, "So far, it's the conclusion that the fish habitat is as good as it was, or perhaps a little bit better."

However, the meeting continued in a heated manner, with attendees continuing to grill the men on the impact that they believe the project will have on the community. Deepwater has, however, attempted to incentivise the local community with financial gains and the promise of local work. It has committed to $600,000 as part of the establishment of a fisheries habitat and marine environment improvement, with a further $200,000 offered as part of an energy sustainability and resiliency fund.

The Cape Wind project, which was going to be situated off Cape Cod at Horseshoe Shoal, suffered what some called "death by a thousand cuts", having been opposed by numerous parties, including Massachusetts Senator Ted Kennedy who argued it would have been detrimental to his enjoyment of the ocean.

Planning for the project began in 2001, when Cape Wind's president Jim Gordon said he wanted the 25-square-mile project, which boasted 130 wind turbines, to ultimately provide power to Cape Cod, Martha's Vineyard and Nantucket. Following years of hold-ups and failed contracts, Gordon informed the US Bureau of Ocean Energy Management he was withdrawing its offshore lease it had held for seven years.

## Casting a wide net

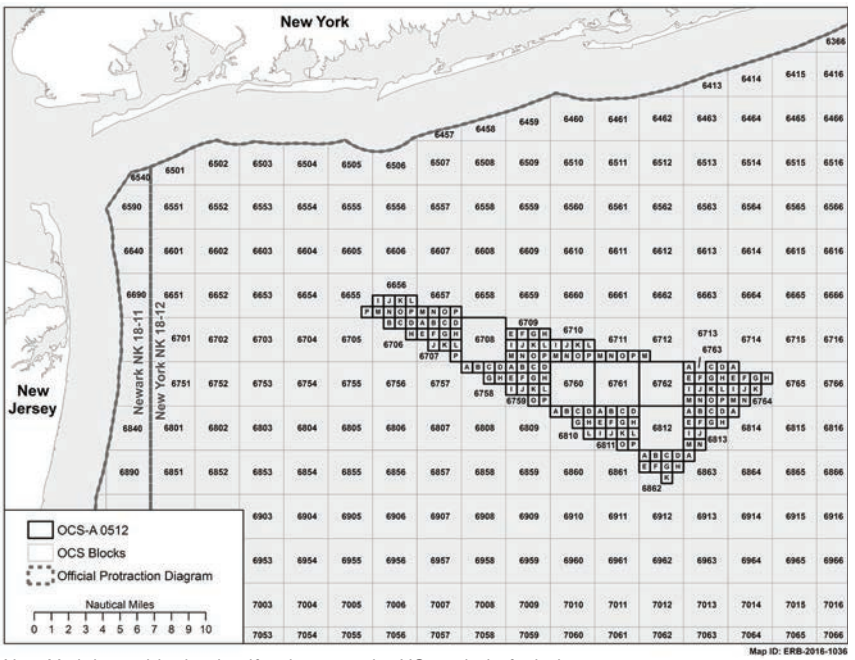
Despite the seeming gloom surrounding offshore renewable, the Cape Wind project doesn't appear to be symptomatic of a wider lack of enthusiasm for offshore projects. In 2009, following authorisation through the Energy Policy Act 2005, the Department of the Interior announced it had determined the regulatory parameters under which the Outer Continental Shelf Renewable Energy Program could operate. The programme, to be administered by the Bureau of Energy Management, would oversee proposed developments off the Atlantic and Pacific coasts, and in the Gulf of Mexico.

The North Atlantic Planning Area, which stretches along the Atlantic coast north of Delaware to Maine, has garnered particular interest from the renewables sector and is now gaining political support across much of the area.

Following a 33-round auction, the New York lease area was finally awarded to Statoil Wind US at the end of 2016 with the lease coming in mid-March 2017. Speaking at WINDPOWER, the company said the project had been titled 'Empire Wind'. The company's Empire Wind project director, Christer af Geijerstam, said, "The name Empire Wind captures the pivotal role that this important project will play in helping New York achieve its ambitious renewable energy goal." He said the project's name "also speaks to the leading role that New York state is taking in advancing the deployment of offshore wind technology in North America". The 124-square-mile project could produce up to 1GW of power once operational, although much has still to be done, with the project only now in its assessment and planning stage.

Dong Energy, now Ørsted, is also showing its interest in the region, itself securing leases. The Danish company has been a long-time supporter of renewable green and appears to be moving towards obtaining a strong foothold in the region. For the first time, 2016 saw offshore wind accounting for the single biggest business operation for the company.

It currently has two US wind farms in development: Bay State Wind and Ocean Wind. Both are situated in the North Atlantic Planning Area. Bay State Wind is located 15–25 miles south of Martha's Vineyard and will have capacity to produce 200MW once completed. Ocean Wind will produce 1,000MW and is situated off the Atlantic City coast.




New York is positioning itself to become the US capital of wind power.

## What lies ahead?

The future potential for wind energy is clear for the US, particularly in the north-east. According to OilPrice.com, Massachusetts, New York and Rhode Island authorities believe the sector could help create up to 16,000 jobs via direct employment, and support a further 20,000 jobs in other industry sectors by 2030. They also say the renewable resource could well produce as much as 8GW annually, enough to power four million households.

Those views were supported by a statement issued from Governor Cuomo's office on the announcement of approval for Deepwater earlier in the 2018. He said, "This project will not only provide a new, reliable source of clean energy, but will also create high-paying jobs, continue our efforts to combat climate change and help preserve our environment."

Deepwater's chief executive, Jeffrey Grybowski, said, "We think that thousands of megawatts are going to be built off the coast of the US in the coming decades. It's an enormous clean energy resource. It's easy for us to tap into it, but we need projects to get from essentially one project to these thousands of megawatts."

Because of that, other states are known to be looking into wind farm development. AWEA's Kiernan said, "You can feel the urgency to harness this new ocean energy resource coming from states and businesses competing to be first movers." He went on to say that unlocking the country's vast offshore wind potential will "reliably deliver large amounts of clean power, grow jobs and cement US energy dominance".

It seems New York is making a concerted effort to harness the energy of offshore wind, with the New York State Energy Research and Development Authority announcing it has identified more than a million acres of sea for development. The sites are situated off the coast of Long Island. The authority, perhaps mindful of previous opposition, has carried out an extensive consultation process involving the fishing industry and other interested parties. It has registered its recommendations with the Bureau of Ocean Energy Management (BOEM).

The authority's chief executive Alicia Barton said, "The pool of eligible bid facilities represents a pipeline of renewable energy projects that could generate more than 9.5 million megawatt hours a year – more than six times the quantity sought under the solicitation. This robust developer interest in New York is exciting to see, and we expect that this level of competition will drive very attractive prices when the bids come in."

New York's ambition to lead the way in offshore wind may very well come to fruition, with what now seems to be a meaningful push to establish the region as a known supporter of this type of energy production. However, the challenges that have beset the sector in recent years remain, albeit now with an understanding from political leaders and businesses that while the technology is hugely appealing, it has to be accountable to those it's hoping to serve. ■

# Powering up

The wind power market witnessed significant growth from 2006 to 2016. Global installed capacity reached 496.7GW in 2016 and is expected to hit 1,024.1GW by 2025. **GlobalData** reports.

Wind power has evolved from its position as an emerging fuel source 20 years ago to become a commercial generating technology in more than 80 countries.

Technological developments paved the way for more effective, reliable equipment and machinery, making wind one of the fastest-growing energy sources in the global market. The exponential growth of the wind energy market is fuelled by depleting fossil fuel reserves, the declining cost of wind energy generation, and growing financial support for environmental initiatives from governments across the world.

The global wind power market witnessed significant growth from 2006 to 2016. Global installed wind power capacity increased from 74.6GW in 2006 to 496.7GW in 2016, at a compound annual growth rate (CAGR) of 20.9%. There was a total addition of 57.6GW in 2016 alone and global capacity is expected to reach 1,024.1GW by 2025.

### China, US lead global wind power market

China, the largest wind power market in the world, had a total installed capacity of 170GW in 2016. China overtook the US as the number one wind power market in terms of new annual installations in 2010, adding 19GW of wind capacity that year. Supportive government policies, including an attractive concessional programme, and the availability of low-cost financing from government banks, are the main reasons for the success of the Chinese wind power market. It is expected that China will continue to promote wind power in order to reduce its carbon footprint and increase rural electrification.

The US was the second-largest wind power market in 2016 by cumulative installed capacity base and annual capacity addition. It was the largest until 2009, but was surpassed by China in 2010 after a 43% decline in its annual installations. The effect of the economic slowdown and uncertainties due to lack of long-term policies supporting the wind sector are responsible for this decline. The US recorded annual wind power installations of 8.2GW, and reached a cumulative installed capacity of 82.8GW by the end of 2016.

The key growth drivers in the US market are federal tax credits, loan guarantees, federal grants, state-level renewable portfolio standards, and state-level feed-in tariff (FiT) programmes, as well as other state and federal support initiatives.

Germany, the third-largest wind power market globally, and the largest market in Europe, had a total installed capacity of 50.3GW at the end of 2016. The country has a well-structured support system for the promotion of wind power and offers separate incentives for onshore, onshore repowered and offshore wind projects. Germany is promoting wind power on a large scale, with more than 15GW expected to be added between 2015 and 2020.

## Emerging markets

Major wind power markets like the US, Germany, Spain and the UK are expected to experience a slowdown during the 2017–25 forecast period. Emerging markets from Asia-Pacific, and South and Central America such as Thailand, Argentina, South Africa, the Philippines, Ukraine, Brazil, Republic of Korea and Mexico are among the nascent wind markets that are set to expand rapidly in the forecast period.

The global wind power market has grown from a cumulative installed capacity of 74.6GW in 2006 to 496.7GW by the end of 2016. The market grew at a CAGR of 20.9% during 2006–16. The global wind power installed capacity is expected to grow at a CAGR of 8.0% during 2017–25 and reach a cumulative installed capacity of 1,024.1GW by 2025.

The Asia-Pacific region is the largest market in terms of cumulative installed wind power capacity, with 216.4GW in 2016, and is expected to reach 445.6GW in 2025. Europe and North America contributed significant capacities too, with 163.7GW and 98.2GW respectively in 2016. South and Central America, and the Middle East and Africa had fewer capacities, but are expected to grow in the coming period.

China is currently home to more than a third of the world's wind power capacity. The country had exceptionally good capacity additions during 2009–11, and also in 2014 and 2015. Being the largest manufacturing centre for turbines and components, and abundant in high-wind-speed sites, China has become a world leader in terms of installed capacity.

The US and Germany have had large capacities since the early 2000s, and have excelled in terms of wind power technology and achieving better efficiencies. It was only in 2009 and 2010 that China overtook Germany and the US, respectively, in terms of installed capacity.

Cumulative wind power installed capacity has grown across the world and is set to expand further during 2017–25.

## Global wind power generation

The increased number of installations has augmented wind power generation globally, which increased from 136.8TW/h in 2006 to 977.2TW/h by 2016. Offshore generation accounted for 43.0TWh of total wind generation in 2016. Global wind power generation is expected to grow during 2017–25 to reach 1,996.1TWh in 2025, with 90.9% of generation expected to be accounted for by onshore wind farms and the remainder from offshore wind plants. .

Global power demand has increased considerably from 2010. It is estimated that it will increase from 21.584 million GW/h in 2017 to 26.690 million GW/h by 2025 – meeting this demand will require an increase in the pace of the capacity additions. The planned capacity additions would suitably need to fulfil peak demand requirements, meet emission control and provide the affordable power. This drives the need of generating power from all possible sources including wind. Cumulative global wind power installations totalled 496.7GW in 2016, and by 2025 the wind power capacity installations are expected to reach 1,024.1GW.

The wind power market, like other renewable sources, is also primarily driven by government support policies and regulations. Across all regions, governments have introduced, or are in the process of formulating, policies to promote renewable energy development.

These support policies are the main force behind market growth. For example, in North America the wind market is driven by federal tax credits and state-level renewable portfolio standards protocols. Production tax credits have traditionally played a vital role in boosting wind power capacity in the country, helping make it the second-largest wind power market in the world. Different countries set renewable energy targets to secure a stable energy supply, promote economic efficiency and enhance environmental compatibility.

## Growth drivers and costs

Financial incentives such as FiTs, tax credits, rebates and accelerated depreciation have been the main methods by which governments drive the growth of wind capacity installations in most major markets. FiT schemes have been deployed in most countries to increase grid-connected wind installations.

Better FiT rates in the UK and Germany have resulted in increased wind installations. Tax credits and

exemptions are used to promote investment related to renewable energy, including wind.

Global energy demand is rising quickly, especially in developing countries. In order to meet this demand, it has become necessary to explore renewable energy sources, as conventional sources are becoming expensive due to depleting supplies. Wind energy provides an excellent and abundant source of power generation and does not involve continuous fuel purchase. It is emerging as one of the most promising solutions for ensuring reliable and affordable energy supply in the long term.

This rising energy demand across the globe will result in increased levels of $CO_2$ emissions, posing a serious threat to the global environment. The growth of wind power is therefore even more desirable as it is a clean and emission-free power generation technology. Many countries are keen to promote the generation and use of wind power in order to reduce carbon emissions and achieve the Kyoto Protocol targets.

The cost of wind power installations and maintenance has declined in recent years. Offshore turbines, with a capacity of more than 6MW, are being developed and manufactured, which means the amount of electricity generation per turbine will increase. The investment needed for wind power is therefore much lower than for most fossil-fuel systems. Wind power does not require considerable further investments following the initial investment, other than for maintenance. Wind resources are freely available and offshore wind is consistent. The development of new technology turbines is expected to further reduce the costs of operating and maintaining wind turbines.

Upgrading old electricity infrastructure and constructing new infrastructure to meet future transmission and distribution (T&D) demands will be a major challenge for wind power development. The existing grid infrastructure is deemed insufficient and there is also an urgent need for modifications to be made to the existing grid and its regulations to accommodate specific wind power characteristics. The development of new grid infrastructure requires massive and time, which could reduce the market's medium-term growth.

**Growth in global onshore and offshore wind capacity**

| Year | Onshore capacity (GW) | | Offshore capacity (GW) | | Total capacity (GW) | |
|---|---|---|---|---|---|---|
| | Onshore | Annual | Cumulative | Annual | Cumulative | Annual |
| 2006 | 73.8 | 14.5 | 0.8 | 0.1 | 74.6 | 14.5 |
| 2007 | 93.7 | 19.9 | 1.1 | 0.3 | 94.8 | 20.2 |
| 2008 | 119.6 | 26.0 | 1.5 | 0.4 | 121.1 | 26.3 |
| 2009 | 157.6 | 38.0 | 2.2 | 0.7 | 159.8 | 38.7 |
| 2010 | 194.9 | 37.3 | 3.2 | 1.0 | 198.1 | 38.3 |
| 2011 | 235.3 | 40.4 | 3.8 | 0.6 | 239.1 | 41.0 |
| 2012 | 279.1 | 43.8 | 5.5 | 1.6 | 284.5 | 45.4 |
| 2013 | 313.7 | 34.7 | 7.1 | 1.7 | 320.8 | 36.3 |
| 2014 | 363.9 | 50.2 | 8.8 | 1.7 | 372.6 | 51.8 |
| 2015 | 427.1 | 63.2 | 12.1 | 3.3 | 439.1 | 66.5 |
| 2016 | 482.8 | 55.8 | 13.9 | 1.8 | 496.7 | 57.6 |
| 2017 | 536.3 | 53.4 | 17.2 | 3.4 | 553.5 | 56.8 |
| 2018 | 592.7 | 56.4 | 21.4 | 4.2 | 614.1 | 60.5 |
| 2019 | 648.2 | 55.6 | 26.9 | 5.5 | 675.1 | 61.1 |
| 2020 | 696.9 | 48.7 | 33.7 | 6.8 | 730.6 | 55.5 |
| 2021 | 746.0 | 49.1 | 40.4 | 6.6 | 786.4 | 55.7 |
| 2022 | 795.7 | 49.7 | 49.4 | 9.0 | 845.1 | 58.8 |
| 2023 | 846.5 | 50.8 | 59.2 | 9.8 | 905.7 | 60.6 |
| 2024 | 897.5 | 51.0 | 67.3 | 8.1 | 964.8 | 59.0 |
| 2025 | 948.3 | 50.8 | 75.8 | 8.6 | 1,024.1 | 59.4 |

Source: GlobalData Power Database [Accessed on 30 September 2017]

Various countries have taken measures to upgrade grid infrastructure, but this could take a long time to reach the same pace of development as power generation from renewable sources. In addition, wind farms are usually developed in remote areas that are sparsely populated and do not have adequate transmission lines to connect this capacity to the grid properly. This has led to idle capacity in many countries such as the US, China and India.

## Environmental impact

In many countries, wind power has not been accepted completely, and some residents in areas with proposed wind farm installation plans have displayed heavy resistance. Wind farm installations are said to cause environmental, economic and health problems, including sleep disturbances, headaches and irritation. could also have an undesirable impact on marine life and bird migration. The developmental stages of offshore wind farms that may cause the most disruption to the surrounding environment are construction and decommissioning. The operating stage can also cause disruption as the foundation of a turbine can act as an artificial reef and attract fish towards the new food supply. This, in turn, attracts birds that can collide with the turbines and towers. The noise pollution and illumination of turbine towers can also cause navigational disorientation for migrating birds.

Administration procedures delay the project executions, which impact the stakeholders of the value chain. These delays lead to longer gaps in return on investments, which lead to further drops in investments. Administrative issues must be minimised for the correct and punctual execution of projects. ■


In-Depth Know-How

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# Manage wind uncertainty

As the financing of wind projects rapidly changes, industry players must adapt in order to continue to succeed. Commercial insurance company **Swiss Re Corporate Solutions** illustrates how certain market tools can permit wind farm operators to manage the risk of wind uncertainty, and how hedging wind may lead to increased profits.

Suppose a business was paid €100 by the government to produce a product. What would happen if that company went away and had to compete to sell said product at a dropping and unknown market price of around €35?

This is not an unfair description of how the European wind market is evolving. The wind power production industry has been supported by government schemes designed to nurture and encourage the growth of young businesses, and it has worked – producing electricity from wind is now competitive with producing electricity from almost every other source, particularly fossil fuels. As public policy efforts go, this has to be judged a highly successful one.

### Flying the nest

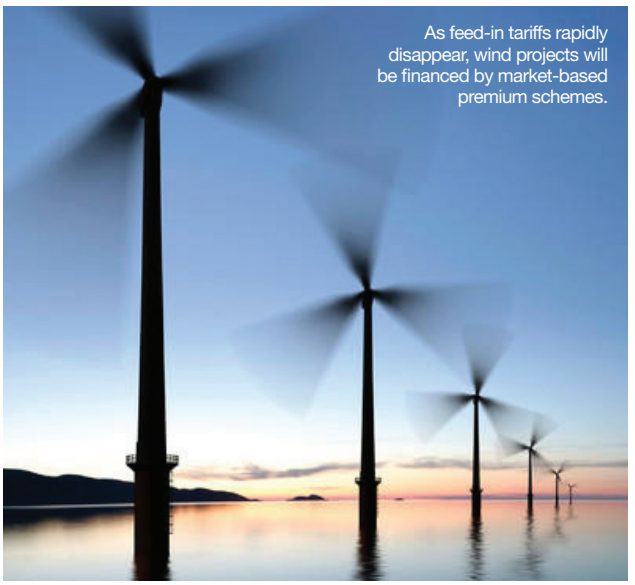
Now, however, the industry is being asked to graduate from being taken care of, to going out and making it in the harsh environment of market-based pricing. To date, the response has been to do this by driving down costs, which has been very effective. New auction sales of production licences, where the price is set by competitive bidding, are the best evidence yet of the industry's ability to make electricity at prices of €50/MWh or even less. But this innovation curve can only take us so far, and the pressure on economics has already had an impact.

A new study by WindEurope, supported by Swiss Re Corporate Solutions, puts all this into perspective, and points out that the industry may be missing a trick by not taking advantage of the market tools that permit wind farm operators to manage the risk of wind uncertainty. In the study, researchers reviewed the growth forecast for wind power development in Europe from now to 2020, and on to 2030. They then looked at the history of wind variability, which developers and owners have generally absorbed in the economics of their project rather than hedging. Finally, using an estimate of value that can be created when hedging wind increases debt capacity, it concluded that wind investors are leaving a good deal of value on the table by choosing not to hedge wind: it estimates that potential to be €2.5 billion between now and 2020, and €7.6 billion by 2030.

### Market-based premium schemes

According to the study, industry plans are to create another 44GW of wind power, on and offshore, by the end of 2020, bringing Europe's total to an estimated 204GW, and that could grow to 323GW by 2030.

But the economics of the business may get in the way of that growth. In 2005, 80% of new wind capacity was supported by feed-in tariff arrangements, where a generous fixed price was paid by a low-risk counterparty to a wind producer for whatever the farm could generate. But feed-in tariffs are disappearing rapidly. They supported only half of the new capacity by 2015 and, by 2020, they will be gone as a support for new development.



As feed-in tariffs rapidly disappear, wind projects will be financed by market-based premium schemes.

They are rapidly being replaced by market-based premium schemes, where governments still support – in part – the payment of the price for power, but at a price that is determined not by fiat, but by competitive auction. Market-based premiums will dominate the production support by 2030, and the market will be increasingly pushed towards taking pure merchant price risk – making the MWh and selling them for whatever the market will pay at the time. That kind of price risk, which is new to the wind power industry, makes projects very difficult to finance with debt and, without that leverage, financial returns are harder to deliver. For the past three years, 60–70% of new wind farm investment has been supported by project finances with non-recourse debt representing a large part of that.

Non-recourse debt needs predictable cash flows. If the price of the product and the quality of the buyer is known, that cash flow certainty makes leverage possible. When that certainty was the order of the day in wind development, the only real uncertainty was the wind variability. A wind farm in Europe's wind resource fluctuates 10% more or less than the average production from year to year; the shorter the period, the higher that variability. If the power price is fixed, and high, wind variability does not affect revenue uncertainty enough to hurt a project's ability to service its debt.

### Taking a risk

For this reason, using financial instruments – wind index swaps or options – has been rare in wind project financing and

development. Lenders have not demanded the certainty, so the market has been able to grow rapidly without owners needing to hedge the wind risk.

But what happens if price and counterparty certainty is replaced by merchant risk? That puts the value of getting rid of the resource variability in a new light. If the price is no longer fixed, then something else has to be fixed to deliver equally safe cash flows – and that something else is wind uncertainty.

In a wind hedge, a hedge provider agrees to take the underproduction risk. The wind producer fixes a level of wind production based on the tolerance of the project stakeholders, and then the hedge contract compensates the producer for MWh that is not produced because the wind was below that threshold. With this, lenders don't have to worry about severe downsides, and equity investors protect a minimum level of financial return.

Using the analysis provided by Swiss Re Corporate Solutions, the WindEurope study looks at a typical project-financed wind farm, and the impact of increased leverage and reduced lending costs on that project. On a 120MW project, the hedge increases the net present value of the cash flows from €20 million to €24 million. Different project lenders will assign different values to projects but, as deals get harder to do in the more-merchant-price energy world, the industry is moving towards, and hedging the wind risk can go a long way towards easing the stress in the system.

By simply mapping the potential for added value across the anticipated growth in the industry, WindEurope sees hedging as a potential €2-million to €3-billion solution in the next few years, with another €7 billion to €8 billion by 2030.

## Meet the challenge

Meanwhile, the hedging industry is developing new tools to manage a more subtle risk in wind production: when does the wind actually arrive? When feed-in tariffs were a reality, it didn't matter. In a merchant energy regime, where spot prices change by the hour and forward prices can only be fixed to a limited degree, it matters a great deal. Hedgers are creating products that pay for underproduction based on the market price when the underproduction occurs. That can address what the industry calls the 'shape' risk of wind power production – a key feature of enabling corporate buyers to enter power-purchase agreements.

So as the market risk increases in wind power development, the industry is moving to meet the challenge. According to WindEurope's new study, supported by Swiss Re Corporate Solutions, that could create quite a lot of value for fuelling the continued growth of the business.

Hedging solutions to protect low profits against low winds are increasingly available and offer a cost-effective way to manage the biggest risk that every wind producer faces. ■

**Further information**
Swiss Re Corporate Solutions
www.corporatesolutions.swissre.com

# Reach new heights

In May 2018, wind industry professionals from across the globe will gather in Chicago, US, for **AWEA WINDPOWER** – the largest wind energy conference and exhibition in the Western Hemisphere.

AWEA WINDPOWER 2018 is the wind industry's premier North American event, with thousands of wind energy professionals from all over the world gathering in one place.

It's the most effective way for attendees to expand their knowledge base, and connect with thought leaders and industry experts. The 2018 programme is led by chairs Amy Francetic, senior vice-president of new ventures and corporate affairs at Invenergy, and Joe Kishkill, chief commercial officer at TPI Composites.

They are joined by a diverse programme committee that includes representatives from Apex Clean Energy, International Finance Corporation (IFC); Leeward Renewable Energy, LS Power Development, MidAmerican Energy Company, NextEra Energy Resources, NREL, Siemens Gamesa Renewable Energy, and Wilson Sonsini Goodrich & Rosati. More of the represented companies will be announced later in 2018.

Over the course of four days, attendees will experience a robust agenda comprising three general sessions, one each morning, located conveniently in the exhibit hall. Sessions and stand-alone presentations will once again be organised into the five education stations in the exhibit hall, which are open to attendees and exhibitors alike.

The conference will showcase hundreds of exhibitors from across the industry, including representatives from the following sectors: manufacturing, supply chain, finance, insurance, construction, operations and maintenance, resource assessment, project development and utility. The programme will feature speakers with creative and modern ideas that will continue to strengthen wind energy's value proposition, and challenge the current way the industry does business. Attendees will hear about how technology advances continue to lower the levelised cost of electricity (LCOE), and learn lessons from other, more mature industries or sectors that have experienced similar rapid growth. Attendees will also receive updates on state policy support, transmission infrastructure efforts, and emerging and growing offtake trends.

Additional educational opportunities for enhanced learning will be offered via pre and post-conference seminars. Confirmed pre-conference seminars include sessions on the potential for offshore wind in the Great Lakes in the US, a social media boot camp, an introduction to wind energy and wind energy development. Post-conference seminars will be announced in early 2018.

Attending WINDPOWER is critical for anyone working in the industry – it is where business gets done. It is where deals happen. It is where professionals and technicians from across the US and the world meet, learn and work together to grow the wind energy industry.

AWEA WINDPOWER will be held on 7–10 May 2018 at McCormick Place Convention Center in Chicago, US. ■

# Upskill and away

As the pace of renewable energy application hastens, so too does the drive to attract a skilled workforce, resulting in a global push to skill and upskill. Andrew Tunnicliffe speaks with **Carmen Maria Alfonso Sanchez**, senior manager, global training & development, at LM Wind Power.

With a website adorned with phrases such as 'Let us power your career' and 'You own your developments', it is clear that, at least from the outside, placing your professional development in the hands of LM Wind Power is a good career move.

Since the late 1970s, the company has been supplying blades to the renewable power sector, but the story of the company is quite remarkable and didn't start in power at all. Lunderskov Møbelfabrik – which translates to Lunderskov Furniture Factory – was established in the 1940s to produce wooden domestic furniture. Operating out of Lunderskov in Denmark, the business grew quickly, dramatically and in a unique direction.

By the mid 1950s the company was working with new composites such as glass fibre, leading the company to split into two divisions: LM Camping and LM Glasfiber. LM Camping designed and manufactured caravans, while LM Glasfiber produced boats and an array of other glass fibre products. It was in 1978 that LM Wind Power's wind turbine blades were first put to use in Scotland's Orkney Islands.

## Acquired by General Electric

In April of this year, General Electric (GE) completed its €1.5 billion acquisition of LM Wind Power following regulatory approval from several key markets. The move was seen as an extension of the already close working relationship between the two companies, which included the first ever installation of an offshore wind farm in the US. It brought LM Wind Power under the umbrella of the $10 billion GE Renewable Energy unit.

"The completion of the LM Wind Power acquisition provides us with the operational efficiencies necessary to support the growth of our wind turbine business, which is the fastest-growing segment of power generation," Jérôme Pécresse, president and CEO of GE Renewable Energy, said at the time. »

Industry experts work with trainees at the LM Wind Power Centre of Excellence in the Gaspé plant.

"With LM's technology and blade engineering, we are now able to improve the overall performance of our wind turbines, lowering the cost of electricity and increasing the value for our customers. Together, we are set to capitalise on the expansion of renewable energy and be a growth engine for GE."

The benefits of the deal were clear for LM Wind Power too, providing it with greater access to the very latest technology and resources it needed to innovate further.

Wind turbine manufacturing is a complex process, and the construction of the blades themselves is arguably one of, if not the most, skilled elements. Anyone embarking on a career in this manufacturing sector needs to be highly skilled and have an extensive background in engineering, as Carmen Maria Alfonso Sanchez, senior manager, global training & development, at LM Wind Power, explains.

"Sometimes people think that our factories just need operators, unskilled people, but that is not true," she says. "Our operators need to be highly skilled with a well-developed technical background."

Sanchez has been working with LM Wind Power for the past eight years, helping to manage and train its global workforce. The company invests heavily in its people, from the recruitment phase to their very last day with the company, with professional development at the fore. This is particularly important as the company looks to hire people from a mix of backgrounds. Its number one goal, however, is to benefit the communities in which they are establishing new operations.

"The type of people we recruit is mixed," explains Sanchez. "Sometimes we put our plants in places where industrial development may not have been as fast, but this is good for the community as we hire a lot of people from it. In some cases, they can be farmers or from other backgrounds of that kind. In other places, we can find more skilled workers with vocational training, such as electricians. Sometimes, we even find sculptors and other workers that use their hands to work, as we highly appreciate this skill too. They can do things that are really very technical. Because of the differences in the people we recruit, we have to have a global standard."

## The Turkish experience

In July of this year, the company opened its latest manufacturing facility in Bergama, Turkey. The $50-million project would, the company said, create up 450 additional skilled technical jobs for the region, ranging from manufacturing operations to technical engineering, services, administration and ancillary support. Like many other plants that have been established, LM Wind Power also designed and built a Centre of Excellence, providing on-site training facilities for current and new workers.

These centres, Sanchez explains, are crucial to the success of the plant, the company and those working for it.

"When we recruit people, we take them through a six-week training process," she explains. "It is only after that six-week process you can touch a real blade."

During this time new employees get an understanding of the company's culture and processes. But more importantly, given the mixed background of the new intake, trainers are able to assess different abilities and work with individuals on a one-to-one basis.

"At about the third week, you start to fit into a position," Sanchez says. "Trainers might say 'this guy is going to be good at the end or the beginning of the process'. Because the knowledge and skills you bring with you might be transferable to the role that you're going to take on now, but we might not have known that in the first instance."

She continues to say that although some positions are already predetermined, others aren't, and so this training process is a good way of finding out how to get the best out of LM staff.

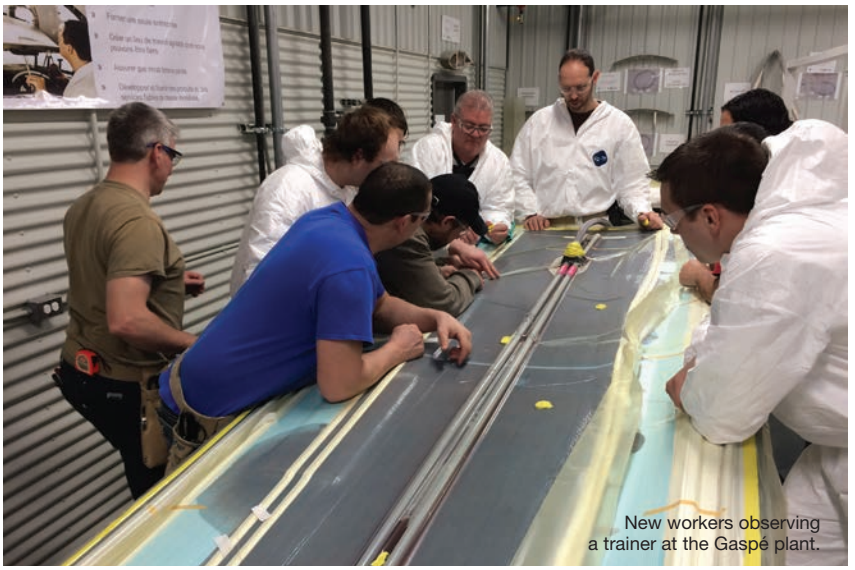
"If you go to the process, how we make blades, we have two elements; before and after the moulding," says Sanchez. "Some things require more sensitivity with your hands while other parts require more strength because of the nature of the work. They need to grind while wearing very heavy clothing for their protection."

Sanchez explains the nature of the roles that need to be filled, including electricians, maintenance workers, drivers and mechanics.

"Take logistics," she says. "A blade's physical movement is very hard work, and needs to be choreographed and

planned weeks in advance. Our blades at their biggest are 88m long, so for this we need a lot of people. Transportation is a very important issue. The customer is responsible for the transportation but we need to be there to provide support. That starts at our plant. So logistics, both theory and practice, is another essential skill we require."

The new Turkish facility, situated in the Bergama Organized Industrial Zone (BOSBI), is expected to manufacture and distribute an annual capacity of 500MW, with the capability to expand to 1.5GW. LM says it was established to address the needs of the growing Turkish renewable energy market.



New workers observing a trainer at the Gaspé plant.

## A global approach

On average, LM Wind Power plants employ in the region of 700 people. The company has facilities around the world, from Canada to India and beyond. Ensuring all plants meet their standard is important, as Sanchez explains.

"One of the most important things to us is that we have a worldwide customer base," she says. "If a client wants to buy a blade from us in China, they must have the same experience as they would when they buy a blade from Canada. We need them to know they can trust us and our products, wherever they are in the world."

That is why the Centre of Excellence formula is so essential. With 15 plants across the globe, each centre operates to a formula, and is designed and developed to help foster a global approach. The training facilities each have a 'dummy' workshop and theory room. In the latter, new employees have access to the latest technology and learning materials by way of tablets, interactive screens and theory sessions, which include virtual moulding and grinding practice. The workshop is designed to represent a plant and its facilities. Here, individuals will be able to work with what are essentially waste materials, meaning any loss is already accounted for.

Once the six-week training programme has been completed new members of staff are placed in the plants, supported by a mentor. Mentors, who can be looking after two to three people at a time, are all certified to the same level, wherever they are. This helps to ensure that LM Wind Power's global reach is based on the same local standards. But reaching those standards can sometimes be a challenge because of the substantially varied geography of LM Wind Power's operations.

Sanchez explains how one plant offered up some unique challenges.

"There is a plant in Spain that was constructed on a hillside, a traditional countryside farming environment," she says. "These sorts of set-ups are extremely important, but they are also difficult. If you're [the plant] not so close to a community, then to attract high-level talents such as directors or technical engineers, the really skilled talent, can often be more difficult."

But no challenge is too big for the global manufacturer.

## An attractive proposition

Sanchez is keen to point to the attraction of LM Wind Power for potential employees, skilled or not.

"We offer opportunities for a great future for those for those with the right talent and abilities," she says. "But people want to work for us because of our concept… for a designer or engineer our technology and the materials we use are a treasure. We are making a better world in renewable energies and that is also an attractive proposition. The product, what we do for the environment and green energy, our ambition to build a better world – all these things are attractive for skilled talent".

And she may well be right. The Spanish plant, on the hillside, won an award for being the best local employer. And attracting skilled talent to a local community is something LM Wind Power prides itself on.

"The skilled talents we attract and develop are good for us and the local community," states Sanchez.

The acquisition by GE won't necessarily change the manufacturing process for LM. The company has been doing what it does for years and is good at it. But it might have a significant impact on the already strong training resources it provides.

"GE has the digital industrial approach and so our working will change," Sanchez says. "To be able to track all the training hours we do, imagine that. Right now we cannot track things person-to-person. Can you imagine how difficult it would be to track all the individuals we recruit at that level? But with all the systems, online tools such as training materials; for me the impact GE can have for us will be huge.

"We are driven to work to excellence, through the network of plants we have, and our centres of excellence work in training people to make world-class blades." ■

# Embracing a new era in wind tower fabrication and assembly

Established in the 1960s, **Davi** is the largest manufacturer of plate and angle rolls in the world. Its new range of machines for the fabrication and assembly of wind turbine cones promises to save time and money.

The fabrication of cone sections to be assembled into wind towers for onshore and offshore applications can be an easy task with the new High-Productivity Davi Smart Line – the ultimate solution to increase productivity.

> "The new Davi Smart Line was introduced to the most important players in wind towers fabrication industry during the Wind Energy 2017 Seminar."

This innovative solution is based on a guide system that adjusts the position of the cone-shaped plate automatically, guiding it along its feeding to the plate roll and slightly rotating it.

This non-stop process enables a cone section to be bent in under ten minutes. It completes the final alignment of the two edges to create a perfect cone section without the need to reroll, and plate set-up is quick and easy.

### The creation process

The process begins by inserting the cone data into the machine via a screen and obtaining the complete automatic process list. Then the plate is placed onto the smart infeed conveyer, where



Left: the Davi Smart Line machine prepares a metal sheet for bending. Right: the bending process is complete, and the metal sheet is precisely curved.

special pushers automatically move the plate to the centreline, guiding it through until the end of the process.

In detail, the new Davi Smart Line includes the Davi four roll, designed in 2015 with intra frames and steel beams. Its heavy-duty infeed conveyor is capable of tilting, and designed to hold heavy plates of different lengths safely aloft while prebending. To guide the cone-shaped plates, the machine uses a continuous cone-forming process enabled by its hydraulic guiding system.

The entire cycle is managed by the Davi iRoll PRO with the new iCone software, specially designed by Davi software developers.

### Development and demonstration

The new Davi Smart Line was introduced to the most important players in wind towers fabrication industry during the Wind Energy 2017 Seminar that took place at Davi headquarter in Cesena, Italy, in October of this year, together with the technical partners PEMA, HGG and Lincoln.


Davi's new machines make plate bending more efficient with its patented tilting conveyer.

It has been demonstrated live, to illustrate how the rolling process can be substantially reduced – to under ten minutes – by using the machine. It also needs only one operator in a CNC-assisted process for inshore towers, and theoretically should even be able to form a cone in automatic mode.

> "Davi's new line is the evolution from the well-known High-Productivity Package. It was conceived in cooperation with the most important wind tower manufacturers in the industry."

The Smart Line is also used to create offshore towers. This process is slightly different due to the size and weight of the plate; a progressive step sequence with repeated repositioning of the plate using the guiding system is used.

Davi's new line is the evolution from the well-known High-Productivity Package. It was conceived in cooperation with the most important wind tower manufacturers in the industry to eliminate the bottleneck of the rolling cycle, to reduce labour and improve the bending process with the patented tilting conveyer.

Today, it is truly possible to have an automatic cycle that improves the quality of the rolled cans within the tightest tolerances requested by the market. ■

**Further information**
Davi
www.davi.com/gb/en

# Modern bending power

Specialising in the design and manufacture of roll equipment, **Faccin** offers the widest range of bending machines available on the international market. The company has identified the ideal qualities plate rolls require for creating wind towers, and its solutions support accurate and efficient production for the wind technology industry that saves time and money.

Faccin's machines enable quick and precise plate rolling for onshore and offshore towers.

Since the 1990s, wind power production has been in constant development. Modern turbines sporting longer blades require the construction of taller and stronger towers, onshore and offshore.

From the beginning, Faccin has been a reference point for the rolling equipment needed to build wind towers, and through years of experience – and working with its customers – it has developed specific solutions for this task. It defined the ideal plate rolls for wind tower production, highlighting the essential qualities they must have:

- **Speed:** the wind tower business is very competitive, and the challenge is to optimise the cycle in order to cut production time and remain competitive. The Faccin machines – thanks to the innovative Advantage Package – have a super-fast hydraulic system, and are highly powerful in order to reach a floor-to-floor production time of 20 minutes per rolled tube.
- **Precision:** effective rolling enables time to be saved during the assembly and welding of the towers. Faccin machines can perform top-quality rolling and prebending of the plates due to their power, delivering perfect cones to the welding stations. The geometry of the machines minimise the need to reroll cones – a common problem with low-quality plate rolls.
- **Consistency:** a rolling machine must work 24/7, and be consistent and reliable to guarantee minimum downtime. With its oversized structure and components, efficient cooling system, and centralised lubrication system, the Faccin 4HEL and 4HEP are the most reliable rolling machines on the market.
- **Coherence:** to enable a job to be fast and precise, the operator must be able to understand the process fully and do it with ease. Faccin has perfected its PGS-Ultra computer numerical control (CNC), which is capable of automatically managing not only the machine, but also the handling system.

Rolling hundreds of cans a month is easier with the Faccin Wind Tower Package. It comprises an automatic feeding table with automatic alignment of the conical shape, a tiltable top support specially designed for supporting cones and side supports with a clamping system for the fast alignment of the plate edges for welding.

> "The Faccin machines have a super-fast hydraulic system, and are highly powerful in order to reach a floor-to-floor production time of 20 minutes per rolled tube."

The advanced PGS-Ultra CNC is supplied with an iPad management application that can be used by managers to monitor productivity and machine status, and to check capacities and production cost evaluation.

Faccin is continually chosen by leading wind tower manufacturers. It offers added value with its broad expertise in the wind tower business, including consultancy on layouts, training carried out by operators specialised in rolling wind towers, fast service and high spare-parts availability.

The company is proud to produce machines that contribute to green energy production. It believes in the future of the wind tower business, onshore and offshore. In the offshore business, the use of plate rolls is particularly important, and, in this sector, Faccin has already supplied main players in Europe, the US and Asia. ■

**Further information**
Faccin
www.faccin.com

# The evolution of data management

Digital transformation is big news at Engie, the French energy giant of which the interests run from natural gas and wind to solar and nuclear. Between 2016 and 2019, it will spend €1.5 billion on more than 30 digital projects, but it is renewables where previous investments are already bearing fruit, as **Damien Terrié**, head of Engie's Darwin project, tells James Lawson.

Engie has been developing Darwin, its own remote monitoring and predictive maintenance application, for the past seven years. In 2010, the French energy company opened its Renewable Energy Management Centre (REMC) at Châlons-en-Champagne in eastern France, which would become Darwin's base.

"We had a wind farm in France that in 2010 we decided to connect to the distribution grid, so we needed 24/7 remote surveillance," says Damien Terrié, head of the Darwin Project.

"We started to develop what became the Darwin software to do that."

The inspiration for Darwin was to provide a standardised way to remotely monitor and analyse equipment that was independent of each manufacturer's often proprietary supervisory control and data acquisition (SCADA) systems. With its ability to connect to virtually any automation system or device, Schneider Electric's Wonderware SCADA suite was ideal for this.

The system is the backbone of Darwin, but the vast majority of subsequent development work has been run

in-house. Working in conjunction with specialist subcontractors, the development team is now 40 strong.

Each farm's SCADA systems connect to an on-site server, which in turn connects to Darwin's cloud-based platform. Most modern turbines come equipped and ready to plug in but legacy fleets acquired from other operators can require some retrofitting.

"Typically, we try to install the least possible equipment for data acquisition but sometimes we have to," says Terrié. "For old turbines, we do have to add additional monitoring equipment, particularly for vibration. Because these wind farms are globally based, it's become a bit of a supply chain nightmare."

Measurements like wind speed and active power are sampled at one-second intervals and transmitted in real time. Other metrics vary far less and are typically collected and processed on-site before sending. For example, gearbox temperature would be sent at ten-minute intervals.

## What is an OPC server?

Built by vendors like Matrikon and Cogent, open platform communications (OPC) servers act as central hubs on wind or solar farms. They connect securely to the SCADA modules linked to the control and automation systems as well as other equipment such as the power management unit or the weather station.

OPC servers gather this dispersed data centrally and then make it available in real time for remote control and performance monitoring. OPC servers support connectivity with a wide range of external systems, from handheld tablets and data loggers to cloud platforms like Darwin.

These servers are also known as IEC servers. IEC 61850 and other allied standards provide open protocols that support monitoring and control of wind power plants along with many other electronic devices. The interoperability this standard confers allows the farm owner to exchange information with different wind power plants independently of a vendor's proprietary systems.

### Creating value through data

Engie is also active in adding internet of things (IoT)-enabled sensors to capture more information on local weather conditions. One application is logging air density directly at the turbine nacelle rather than taking a measurement from a nearby weather station. Rain sensors are another common addition.

> "The inspiration for Darwin was to provide a standardised way to remotely monitor and analyse equipment that was independent of each manufacturer's SCADA systems."

"We keep innovating with what we can put on top of the turbine to make the wind farm smarter," says Terrié. "Air density is directly linked to the power available in the wind so it lets you check your power curve more accurately."

Data typically starts its journey from the farm via a local broadband connection. However, other means are sometimes necessary.

"There's not that much you need to send in true real time, so we don't need gigabytes per second," notes Terrié. "We try to avoid satellite connections because they are so expensive."

To the field, data pouring in from tens of thousands of global feeds is added other external information such as detailed local weather forecasts and energy market pricing.

Maintenance teams use a tablet app to input their reports directly into the Darwin database.

All that data is processed and stored using the MS Azure cloud platform. Managing the terabytes generated is challenging – as is making full and timely use of it to improve operational performance.

"You really have to bring value to the people in the field," says Terrié. "There's no point in telling them something they know already. Darwin can detect an overheated gearbox, whether turbine blades are covered with a layer of ice or whether it is necessary to clean solar panels."

To supply local operation and maintenance (O&M) teams with information, the company employs a browser-based interface customised to each region's needs. Using responsive design means it will work across multiple devices irrespective of screen size. When the team members come into the office in the morning, they can look at personalised aggregated reports and see how the turbines performed overnight or today's wind speed forecast.

When problems do occur, Darwin alerts them to it, using its automated insight to suggest the appropriate corrective action, and then helps choose when to perform it. One example might be identifying a fault that needs to be fixed within the next 30 days. The app helps the operations manager to pick a time when his maintenance team is available, and the wind speed and the spot market electricity price are low – so minimising the impact any downtime has on profit.

### Regional data labs

Data scientists are the ones who build automated analyses like predictive maintenance and underperformance detection in Darwin, using sophisticated predictive modelling and other analytic techniques. Each region has a dedicated "data lab" that gives them access to the full historical database.

From here, they can consider the entire lifespan of a wind turbine, and compare different turbines and farms. Which ones generate the most power from the same wind speed? And which have the lowest overall cost of generation? Terrié points to yaw control as a common example.

"By looking at the nacelle alignment together with the wind direction, we are able to detect any misalignment and see how quickly the nacelle gets aligned into the wind," he says.

Any problem with yaw control inertia might simply be an individual control system issue that needs to be fixed. But it might also be endemic to a particular model or manufacturer. »

Darwin has identified wind turbine settings that caused a delay in orientation response, leading to a 0.5% loss in production. Over ten years of operation, correcting that error would be worth €10 million. Similar calculations apply to everything from pitch control to gearbox reliability.

"We know which manufacturer performs better than another or which turbine we should buy – or stop buying," says Terrié.

Comparing the actual behaviour with theoretical and average behaviour based on the fleet's history is a vital part of analysts' work, letting them detect deviation from the benchmark or from how certain turbines – or solar cells – have behaved in the past.

"We look at the power curve of the wind turbine and check that it behaves as it should," explains Terrié. "Does it cut in where it should, does it reach the nominal power? That sounds easy to do but with the amount of uncertainty in the nacelle anemometry, it's quite tricky to be able to generate a clear signal. In the turbines where we manage to do that, it really brings value."

**Predicting output and performance**

Darwin's intelligence supports non-Engie users too, with an application programming interface (API) that exposes data feeds as web services so that external web apps or other user applications can consume it. Exporting production data to participate in energy markets is one vital application here.

> "To the field data pouring in from tens of thousands of global feeds is added other external information such as detailed local weather forecasts and energy market pricing."

By combining that information with weather forecasts and spot market pricing data, it's possible to feed information to external or Engie's own internal market aggregators in order to predict output and so bid optimally when they commit to a volume of production.

"If you know exactly how much you are generating now, you have a much better idea of what you will generate in the next 15 minutes," explains Terrié. "By accessing the data in real time, they can lower their intra-day market risk and so the premium we pay is smaller."

Via a website, smartphone apps and a chatbot, it's possible for the public to see real-time information on generating facilities and their performance. That might be a factory owner whose site has Engie's wind turbines in the car park or solar panels on the roof, local residents near the wind farm or local authorities.

"The factory owner can know in real time how much he is contributing to the energy revolution and he can display that on his own website," says Terrié.

Darwin's business proposition contains the hard figures. A system investment of €13 million over two years has been balanced by extra income of €27 million over three years. Knowing how valuable that information is to the business, Engie is rapidly connecting the rest of its renewable assets to Darwin. Around two thirds have been linked so far, with the rest due by the end of 2018.

"We're going after the big fish first, connecting our largest assets then the smaller ones," says Terrié. "The readiness of the local team to use the Darwin information also has an influence."

The development work continues, with a February 2017 agreement between Engie and Schneider Electric to further develop remote supervision and control of its global renewable energy assets. Asset management, SCADA obsolescence management, remote monitoring, diagnostics and cybersecurity will all be investigated.

Further showing its confidence in the value of the data it generates, Engie recently made all the historical operational data from its small La Haute Borne wind farm fully public. Using this open data will showcase Darwin's capabilities to developers, manufacturers, operators, researchers and students.

"Five years ago, it was very difficult to look at your data like this," says Terrié. "Darwin really is a revolution." ■

## Collaborating on turbine reliability with SPARTA

Formed in 2013, the SPARTA joint industry project aims to help improve the availability, reliability and performance of the UK's offshore wind assets. Operational data is collected using agreed standard definitions at system level, from blade to onshore substation, with each participant submitting monthly metrics to a secure server for each of its wind farms. These are aggregated at project, portfolio and sector level, and shared between the eight contributing owner/operators. With all the market leaders involved, the high-level data so far released for the year to May 2016 covers a wide range of farm ages and locations as well as turbine types (3.55GW, 1,045 wind turbines).

Learnings include that younger, larger farms further from shore are currently achieving lower availabilities than older projects closer to shore. Other metrics suggest that as the wind farms mature, increased maintenance experience and improved work processes lead to higher availability.

However, far-shore sites' capacity factors are higher, which is generally attributed to increased wind speed at those locations and more modern turbines. As these assets mature and availability increases, higher production levels should result. The average monthly repair rate is 1.32 repairs per turbine per month, with the top three subcomponents requiring intervention being hydraulics, the blade adjustment system and rotor.

# Quality motors and drives

**Lafert Group** is a leading European motor company that has built a reputation for manufacturing quality customised motors and drives.

Focusing on the areas of industrial automation, energy saving and wind industry, Lafert is the preferred partner for many world leaders in the wind industry with motors installed in more than 20,000 nacelles on turbines worldwide.

The primary benefit of installing Lafert motors is a reduction in life cycle costs. Lafert has a strong focus on quality and reliability, which – combined with continuous improvements in motor efficiencies – puts Lafert in a strong position as the partner of choice.

The company has identified several applications where lifetime reliability, weight, size and efficiency can be key factors for a motor within the wind industry. These may include yaw and pitch drives, hydraulics, pumps, ventilation and lifts for service or personnel.

For pump and ventilation applications, Lafert has particular strengths in offering AC motor and PM motor designs alike. A strong AC motor range has the ability to meet the needs of specific applications through customisation. In general, PM motors are half the weight of AC motors of a similar power/size. If IEC dimension housings are required, PM motors for IE4 or IE5 are available.

In a wind turbine, there are numerous pump and ventilation applications. Pumps secure the energy-efficient flow of fluids, fans in ventilation systems cool equipment, and both are critical for quality and require robust motor designs adapted to the applications.

Lafert creates customised motors and drives that reduce life-cycle costs.

Lafert motors are designed for the harsh environments found in hubs or nacelles. It takes into consideration possible vibrations, temperature and environmental conditions, and provides corrosion protection, which is now required in offshore installations. ■

**Further information**
Lafert Group
www.lafert.com

# Home advantage

The Hywind project located 25km off the coast of Peterhead in Scotland is the world's first full-scale floating wind farm. Constructed by Norwegian multinational Statoil, the 30MW facility will provide electricity for 20,000 homes and could be a game-changer for the floating wind power industry. Rumayna Vakarelska reports.

Scotland has opened the world's first full-scale floating wind farm, the 30MW Hywind, comprising five 11,500t, 6MW turbines made by the Norwegian oil company Statoil in collaboration with Abu Dhabi's Future Energy Company, Masdar.

It will provide electricity for 20,000 homes from offshore wind turbines in much deeper water that is not suitable for conventional bottom-standing turbines. The wind farm officially opened on 18 October 2017, and demonstrates the huge strides taken in the field in terms of innovation and international collaboration by increasing turbine efficiency and blade sizes. Hywind has also placed the UK as number one, globally, for installed conventional wind farm capacity.

"This is a tech development project to ensure it is working in open sea conditions," said Leif Delp, project director for Hywind. "It is a game-changer for floating wind power, and we are sure it will help bring costs down. I think eventually that we will see floating wind farms compete without subsidy, but to do that we need to get building at scale."

## Groundbreaking design and technology

According to Statoil, floating windmill technology started with the Norwegian multinational's daring design 16 years ago, when the company tested a pilot floating turbine on the north-west coast of Norway. Hywind represented the first configuration of a floating wind farm anywhere in the world.

The turbines in Hywind have been upscaled from 2.3MW in the original pilot in Norway to 6.0MW each, so all elements of the windmill had to become much bigger. Statoil said that the most important part of the design is the float motion controller, but the biggest challenge was in the installation process when the turbine had to be placed on the top of the floating base, which is attached via three cables in a triangular configuration to the suction anchors on the seabed.

Although groundbreaking innovation defines Hywind throughout, Statoil

pointed out that the floating substructure itself made the biggest difference between conventional offshore and floating offshore turbines.

All onshore work was performed by the UK construction company Balfour Beatty Scotland, including the assembly of the underwater cables and the suction anchors, which weigh 110t each and were made by the Spanish company Nevantia.

Statoil says the blades software holds the tower upright by twisting the blades to dampen motions from wind, waves and currents. Without this customised software, the farms would not be able to operate in a deep-water environment, making it a crucial technology for Hywind as it offers the prospect of bringing down the overall price of wind power.

The turbine installation uses tug boats, heavy cables and remote-controlled submarines while the units tether. The turbines can be anchored in waters up to 120m deep and sustain the pressure of winds with average speeds of between 10–20mph, to a maximum of 40mph. Statoil assembled the turbines in Norway and then transported them by sea.

**Manage the onshore operations**

The onshore operations and maintenance base for Hywind Scotland is located in Peterhead, Aberdeenshire, while the operations centre is based in Great Yarmouth in England. This allowed a concentration of research and management functions, which is crucial for a project where a number of Scottish subcontractors were involved.

Statoil said that, overall, the biggest operational challenge was the project management of the subcontractors as well as building and moving the giant anchors.

The 30MW Hywind wind park will connect to the 1MW/h Batwind storage facility, which will optimise Hywind's electric production output by mitigating the intermittency of wind energy. Hywind Scotland will be connected to a 1MW/h lithium battery. Once installed, the Batwind storage will have the same battery capacity as two million smartphones.

Statoil is collaborating on the Batwind project with Scottish universities, the Scottish Government, the Offshore Renewable Energy Catapult and Scottish Enterprise. A senior Statoil representative claimed that the technology qualifying programme will guarantee a continuity of technology development in floating offshore farms in the UK and can be exported internationally.

"Our support for floating offshore wind is a testament to this government's commitment to the development of this technology and, coupled with Statoil's battery storage project, Batwind, puts us at the forefront of this global race and positions Scotland as a world centre for energy innovation," said Scottish First Minister Nicola Sturgeon at the inauguration of the project earlier in the autumn.

Sian Wilson of Crown Estate Scotland, the company leasing the Scottish seabed to renewables developers, said the organisation is committed to encouraging floating offshore wind projects, which will, in turn, drive down costs, benefitting the whole sector, the climate and consumers.

**Competitive pricing for offshore floating wind farms**

State-owned Statoil is funding 75% of the £210-million Hywind project, with the remaining 25% provided by Masdar.

Similar to other renewable energy projects, the new wind farm qualifies for financial support (for each unit it produces) only when it starts generating electricity – in this case, that support comes from the Renewables Obligation scheme funded by UK consumers through electricity bills.

Following its completion at the end of 2017, the Hywind farm is expected to encourage new orders for similar farms in the US and Japan, and is considered a trial showcase project that will allow Statoil to expand its floating turbine expertise. According to Statoil, the output from the giant floating turbines is expected to equal or surpass generation from existing conventional wind turbines.

"Hywind [turbines] can be used for water depths up to 800m, thus opening up areas that so far have been inaccessible for offshore wind," said Irene Rummelhoff, executive vice-president of the new energy solutions business area in Statoil. "The learnings from Hywind Scotland will pave the way for new global market opportunities for floating offshore wind energy".

The cost of floating wind power technology is largely expected to follow a similar downward trajectory to that of onshore and bottom-fixed offshore wind power. For example, in a recent contract for difference (CFD) auction for the construction of future offshore wind capacity, Dong Energy and Spain's EDP were awarded a strike price of £57.50 per MW/h for construction of the Hornsea 2 and Moray Offshore wind farms. The strike price is a future power price agreed between a generation asset owner and the UK Government to help fund new power generation construction. This contrasts with £92.50 per MW/h for the construction of Hinkley Point C's planned 3,200MW nuclear power station in western England.

If the price of power over a set contractual period (the CFD) falls below the agreed strike price, the UK Government will pay the difference to the generation asset owner. If the price

"Hywind [turbines] can be used for water depths up to 800m, thus opening up areas that so far have been inaccessible for offshore wind."

of power rises above the strike price during the period of the CFD, then the generation asset owner will pay the UK Government back the difference.

According to Statoil, the overall offshore wind sector has the potential to grow from a global capacity of 13GW in 2015 to more than 100GW by 2030, with floating wind technology accounting for a significant share of that expansion. Moreover, Statoil has the ambition to reduce energy costs from the Hywind floating wind farm to €40–60 per MW/h by 2030, according to Rummelhoff.

> “Conventional offshore wind turbines will power more than eight million homes in the UK by 2020, making offshore wind the lowest-cost option for large-scale, low-carbon power.”

“Knowing that up to 80% of the offshore wind resources are in deep waters (more than 60m) where traditional bottom-fixed installations are not suitable, floating offshore wind is expected to play a significant role in the growth of offshore wind going forward,” she said.

### Good prospects for floating off-shore farms

Currently, conventional offshore wind turbines power four million homes in the UK, and will power more than eight million by 2020, making offshore wind the lowest-cost option for large-scale, low-carbon power. The price of offshore wind is 32% lower than in 2012, and is getting cheaper more rapidly than initially predicted and four years ahead of the governmental predictions.

Moreover, the price of offshore wind power has dropped by 50% in the past five years and is cheaper than nuclear power, according to a National Audit Office (NAO) report.

“The phenomenal growth of the UK’s world-leading offshore wind industry is an industrial success story made possible by tens of thousands of tenacious innovators and game-changers all around this country working in renewable energy,” said Hugh McNeal, Renewable UK’s chief executive. “Offshore wind is a key technology in reducing carbon emissions by more than 7.5 million tons a year.”

Wind turbines have more than doubled their power capacity since 2007. The current generation of 8MW turbines have 260ft blades, spanning an area the size of the London Eye. With a single rotation, these blades generate enough energy to power a home for 24 hours. By the mid-2020s, turbine capacities are set to double again, reaching 15MW. These advances in turbine technology have played a big part in driving recent reductions in costs-per-megawatt-hour.

According to Statoil, the offshore wind power sector has the potential to grow from a global capacity of 13GW to more than 100GW by 2030

Moreover, offshore wind farms can be built in just two or three years, minimising the risk of cost overruns and ensuring that technological advances are adopted quickly.

“These ongoing cost reductions show that offshore wind is in pole position to be the foremost low-carbon power source, with the UK as the global market leader,” said Jonathan Cole, managing director for Offshore Wind at Scottish Power Renewables.

The offshore wind industry is one of the UK’s largest infrastructure programmes, according to HM Treasury, while job creation in the sector is focused in regions in need of regeneration, such as the north-east of England. This is the reason Siemens’ £310-million turbine blade factory is based in Hull, creating 1,000 new full-time jobs. According to Catapult, an innovation test-bed organisation, the UK will receive £27.5 billion in investment in UK offshore wind projects by 2021.

“Southern Electric (SSE) is currently investing in much needed energy infrastructure that contributes to UK growth with offshore wind becoming an affordable form of large-scale, low-carbon energy, we believe that the UK as a whole will benefit from these cost reductions,” said Paul Cooley, SSE’s director of generation development.

Vattenfall is also investing in UK offshore wind for the long term. Its Norfolk Vanguard, Norfolk Boreas and Thanet Extension projects will be even more competitive than today’s successful projects, according to Piers Guy, UK Country Manager.

Hywind is the second offshore wind partnership between Masdar and Statoil following the Dudgeon wind farm, a 402MW project also due to come on-stream in the end of the second half of 2017. ■

# Monopile foundations with flanged connections

Offshore wind turbines require solid, low-maintenance foundations. Experienced engineering company **Jörss Blunck Ordemann** is involved in design and certification work for offshore wind foundations. Dr Falk Lüddecke, managing director, and Walid Al Otaibi, head of offshore structural engineering, have validated the latest foundations layouts used in the offshore wind industry in view of reliability and maintenance.

The preferred foundation for offshore wind turbine generators (WTG) is a monopile (MP) foundation with a transition piece (TP). In this combination, the TP fulfills numerous functions, including:

- providing the load-transferring function between foundation and tower of the WTG
- housing for additional electrical equipment
- compensation of distance between the MP and tower
- fixation of external outfitting, such as boat landing or external working platform
- vertical adjustments to the entire foundation consisting of MP and TP.

### Connection types

The most common connection in European offshore wind farm foundations between MP and TP is a grouted connection with an ultra-high strength grout material.

Although grouted connections have been proved a successful technique, the industry has started using alternative connections methods, such as flanged connections, in which the MP and TP are bolted together – comparable to the flanged connection within the tower. The boat landing and the corrosion protection (anodes or ICCP) are directly connected to the TP in a typical grouted connection monopile foundation.

For monopile foundations with bolted connections, the boat landing and corrosion protection are either partially connected to an outer skirt or connected directly onto the monopile. The offshore industry is currently considering two options: one, backfilling the skirt with a special grout, or two, leaving the skirt unfilled.

The skirt is also becoming shorter in recent projects, and does not extend below water level, which means that boat landings and corrosion protections are being considered as part of the monopile (separate from offshore operation during installation).

The trend in the offshore foundations seems to go towards flanged connections between the MP and TP since installations can be faster and more cost-efficient. However, major risks are associated with this procedure, such as corrosion and pre-tension aspects, leading to an unexpected increase in maintenance costs over the lifetime of the WTG.

On the other hand, MPs with grouted connections have a proven track record, especially after the implementation of the new design guidelines. They overcome all problems associated with flanged connections, including corrosion, secondary steel and maintenance costs.

| Pros | Cons |
|---|---|
| **MP/TP foundations with grouted connections** | |
| ■ Proven technology<br>■ Hammering of MP into the seabed is not critical<br>■ Easy correction of verticality – levelling of piling tolerances<br>■ Diameter size of MP and TP allows WTGs of less than 10MW<br>■ Dampening effect of own-frequency with grout<br>■ No special corrosion measures required except traditional CP<br>■ Grout quality covered by TAC from DNV GL or Z.i.E. process (Germany) | ■ Grout installation process, mixing and pumping into cavity<br>■ Installation restricted by weather windows<br>■ Grouting in critical path of the installation vessel (grout dependent)<br>■ Grout is far more brittle than steel<br>■ Early age cycling measures needed |
| **MP/TP foundations with flanged connections – with skirt fill** | |
| ■ Classical steel connection, design and calculation is easier with steel components<br>■ Larger independence of weather windows<br>■ Installation period is shorter<br>■ Grouting does not interfere with the critical path of vessel<br>■ Grout provides additional protection against the corrosion of bolts<br>■ Skirt fill, such as grout, protects against the impact of boat landing on secondary steel | ■ Hammering directly on the flange of the MP, may result in possible physical damage and negative effect on the fatigue resistance<br>■ High accuracy (≤0.25°) during hammering required, as well as a possible need for foundation specific adapter ring<br>■ Angle of flange is difficult to manufacture<br>■ High corrosion risk; protection of bolts needs special attention<br>■ Limited MP diameter/flange size. Number of bolts/flange and size of bolts (> M72) limits the size of the WTGs to 8–10MW<br>■ Misalignment of bolt holes<br>■ Optimum torsion moments when torqueing the bolts leads to high maintenance and inspections costs<br>■ Flange prone to coating damage during hammering<br>■ If an adapter ring is used to correct verticality, the bolts need to be longer than the standard bolts, leading to higher costs and longer waiting periods |

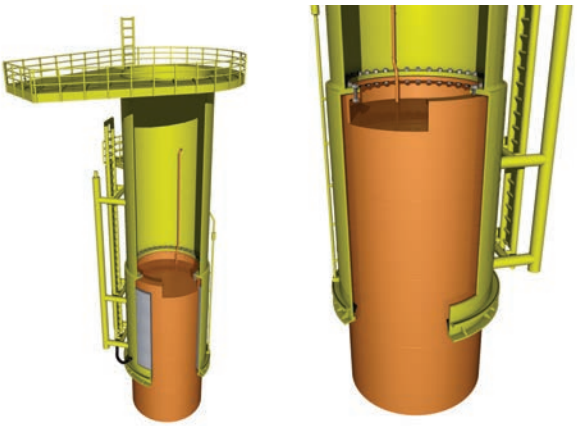
| Pros | Cons |
|---|---|
| **MP/TP foundations with flanged connections – no skirt fill** | |
| ■ Classic steel connection, design and calculation is easier with steel components<br>■ Larger independence of weather windows<br>■ Installation period is shorter<br>■ No grouting required | ■ Hammering directly on the flange of the MP, may lead to possible physical damage and negative effect on the fatigue resistance<br>■ High accuracy (≤0.25°) during hammering required, and possible need for foundation specific adapter ring<br>■ Angle of flange is difficult to manufacture<br>■ High corrosion risk; protection of bolts needs special attention<br>■ Limited MP diameter/flange size. Number of bolts/flange and size of bolts (> M72) limits the size of the WTG's to 8–10 MW<br>■ Misalignment of bolt holes<br>■ Optimum torsion moments when torqueing the bolts leads to high maintenance and inspections costs<br>■ Flange prone to coating damage during hammering<br>■ If an adapter ring is used to correct verticality, the bolts need to be longer than the standard bolts, leading to higher costs and longer waiting periods<br>■ Possible further hurdles in TP installation if no skirt is used<br>■ Possible additional offshore operations if short skirt is used, and BL or CP need to be attached directly to the MP |

Load transfer from the WTG to the foundation with the classic MP foundation is achieved by the grouted connection. Since the foundations are not only exposed to axial loads, but predominantly to bending and torsion moments, MP foundations with a grouted connection are typically designed with conical cross sections or cylindrical cross sections in combination with shear keys. Each layout has to overcome the earlier slipping problems with pure cylindrical MP/TP connections. The use of shear keys considerably increases the load-bearing capacity as the load transfer is the result of the struts effect between opposing shear keys.

Also with conical-shaped grouted connections, the bending moments and axial loads are effectively distributed and transferred to the foundation. Even minor angles of 1.5° considerably increase the load capacity of these foundation types.

Grouts and grouted connections are well covered by offshore standards. The guideline DNV-OS-C502 and the Z.i.E. (single case of approval) process in the German exclusive economic zone (AWZ) define requirements that have positively contributed to the quality of the grouted connections. Improved installation methods together with the possibility of applying the grout in shorter weather windows have strongly improved the durability and longevity of MP foundations with grouted connections.

Flanged connections are a well-known technique in steel construction, like onshore or offshore wind turbine towers. These connections, however, come with many hurdles and challenges when used near seawater conditions, especially if the MP-sided flange is impact driven during installation.



In order to work efficiently and safely, wind towers need reliable and low-maintenance foundations.

The bolted connections need special attention because the highly corrosive environment of the seawater causes steel corrosion of the normally galvanised components. Damages to the MP flange from impact driving need to be retrofitted, while imperfections in verticality need to be corrected using foundation-specific solutions, such as adapter rings. Due to the magnitude of current turbine generation, and corresponding loads acting on flanged connections, typically large bolts (M64–M72) are used at the monopile to transition piece connection.

## WTG developments

With a view on the future of the industry and the current development trends, it is safe to assume that the WTGs are getting bigger with larger loads, which would require bigger and more bolts in the flanged connection. Therefore, the flanged connections are likely to be used with 8–10 MW WTG generations if further bolt sizes will not be standardised.

In order to avoid corrosion, additional measures need to be taken. Such measures include installing seals within the skirt to protect the connection from water, or filling the skirt with a grout material. However, these protection measures have to be verified concerning their long-term durability. In this context, the constructive design and execution details of each are essential for the durability. Based on the number of projects with grouted connections in the splash zone, one can assume that the failure rates of a grout-material filled skirt should be less than the relatively recent versions of groutless protection concepts.

MP foundations with grouted connections, with their pros and cons, have proved successful with the advantages clearly outweighing the shortcomings. Flanged connections, however, have only been recently used, and need special attention and careful design to guarantee a durable and low-maintenance foundation. With such flanged connections, volume stable grouts with validated quality should be used to guarantee the high durability and longevity of monopile foundations. ■

**Further information**
Jörss Blunck Ordemann
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# The next global wind supplier

Wind energy is a global resource that needs global solutions – a demand that **Haizea Wind Group** fully understands and responds to with its products. The company's three integrated business units – Towers, Offshore Foundations and Metal Nacelle Structures – allow the company to deliver turnkey solutions with added value for its customers.

The wind market has seen a surge in growth explained, in part, by environmental concerns and a price drop in the cost of wind power generation.

The fast growth of the wind market can be explained by the declining cost of wind power generation and growing environmental concerns. This reduction comes partly from the need to be competitive against other technologies. In this sense, when an OEM signs a contract in a new wind market where there are no specific factories for wind towers, a need for a reliable and cost-competitive supplier becomes critical. It is this need that Haizea Wind Group (HWG) has based its growth strategy upon.

From a strategic standpoint, HWG is forging long-lasting relationships with the industry's global players, supporting them in approaching different markets, listening to their requests and trying to implement new facilities in the shortest possible time.

## Onshore towers

With the creation of its flagship onshore towers facility in Spain, HWG quickly discovered that the key to success was a fully dedicated onshore towers factory that included its own in-house cutting and bevelling service.

The Spanish factory has an output of 1,500 tower sections a year, and has been delivering onshore towers to all major OEM's since 2010. Based on the performance of the factory and the experience it gained, HWG improved factory layouts, which are now being applied to the new builds.

The company's first step towards globalisation will be an onshore factory in Argentina, a developing market where HWG intends to be a pioneer. The factory is being built under the umbrella of a joint-venture agreement with a local pressure-vessels manufacturer. The factory – named Haizea-Sica – is under construction, and will start operations in Q4 2017, delivering the first completed sections to its already established customers from February 2018. The output of the factory will be approximately 350

The Haizea Wind offshore facility, located in the port of Bilbao, Spain, has direct access to loading line.

tower sections, and will be able to manufacture actual and future sizes of onshore towers.

The second step towards globalisation is the signing of another joint-venture agreement in Saudi Arabia, with local company Al-Babtain, for the development of a fully dedicated wind towers facility. This will be located in King Abdullah Economic City on the western coast of the kingdom, nearby the cities of Jeddah, Meca and Medina. The plan for the Saudi Arabia factory is to start construction in Q1 2018 and conclude in Q4 2018, so the first tower sections can be produced and delivered to customers throughout Q1 2019. The output capabilities of the Saudi factory will match that of Haizea-Sica.

## Offshore towers and foundations

HWG is answering customer demand by constructing a new state-of-the-art facility for offshore towers and foundations at the port of Bilbao, Spain. The factory, which will start operation in Q1 2018, is a multifunctional facility with two separate bays that produce offshore towers, monopiles and transitions pieces. The total output will be a mix of over 500 offshore sections and 120 monopiles or transition pieces covering all dimensions of offshore structures in terms of wall thickness, length, diameter and weight.

An ideal location; the factory is placed on a dock with direct and priority access to the vessel-loading line. An improved and unique layout, the almost inexistence of inbound and outbound logistics together with experience in tower manufacturing, are the best ingredients to guarantee customers top-quality products.

## Metal nacelle structures

Another division within the HWG group is Haizea Metal Nacelle Structures, which produces steel metal structures mainly for wind nacelles as well as other segments, such as solar energy products and industrial appliances.

This division is delivering more than 10,000t of metal components to the wind energy market a year, covering the needs of major industry OEMs. Core business consists of creating structural components for the wind turbine nacelle as well as transport equipment for the storage and shipping of components. The facility is located in Zaragoza, Spain, and is comprised of three buildings under a roof area of 30,500m², and with a storage area of 16,000m².

## Promising future ahead

Driven by a group of experienced professionals, HWG is determined to become the next global tier-one supplier within the wind industry.

Today, the group has two factories in Europe, employing more than 350 employees with a turnover of €70 million, and two more factories under construction. By 2019, when the factories in Argentina, Bilbao and Saudi Arabia are fully operational, the group will have a total of five facilities located in Europe, the Americas and the Middle East with 1,000 employees and a €200-million turnover. The company's current strategic roadmap sets a goal of seven further factories, including locations in Asia, the employment of more than 1,500 workers and potential sales above €500 million.

HWG has set its goals, established a strategy and is providing the resources to achieve its objective of becoming the next global wind supplier. ■


Haizea produces towers, monopiles and TPs for the offshore market.

**Further information**
Haizea Wind Group
www.haizeawindgroup.com

# Boom time in the Baltic

Europe continues to blow away the competition when it comes to offshore wind development, with the Baltic region in particular enjoying a mini-boom, spurred on by WindEurope's Baltic Sea Task Force. However, challenges remain in terms of regulation, adoption and grid investment. James Lawson reports.

As a continent, Europe leads the world in offshore wind development. Farms have gone from demonstrator status to vast utility-scale deployments in little more than a decade.

The EU's goal of 20% renewable generation by 2020 has provided the main impetus, while a concerted effort by the wind industry to develop technology and deployment techniques has made that rapid progress possible.

WindEurope, the wind industry's public voice, is now pushing to maintain that momentum by lobbying for tougher 2030 thresholds – 253GW of onshore and 70GW of offshore wind are the targets, totalling 30% of generation by 2030. The North Sea remains the most attractive offshore development area with almost 48GW due to be produced there by 2030.

However, within Europe, adoption rates vary considerably. While the UK, Denmark, the Netherlands and Germany have pioneered offshore technology and driven down costs, others have yet to put a single turbine in the water. National wind trade bodies are now working hard to change that. Despite huge onshore capacity and ambitious offshore plans, France is still on the starting line as legal challenges stall its planned utility-scale deployments in the English Channel and Atlantic. Its first farm will be a floating one, with three 8MW turbines on tension-leg platforms at the Provence Grand Large pilot project.

Water depth, a cash-strapped economy and low wind resources make offshore a tough nut to crack for Spain and Italy too. The tiny 30MW Beleolico

project will be Italy's only offshore farm when it's commissioned in 2018.

### Spotlight on the Baltic

Instead, it's the Baltic that's commanding attention. With excellent wind speeds and shallow coastal waters, there's potential for almost 40GW. 9GW is the target by 2030 compared with just 1.5GW today. Signed on 28 September 2017 in Tallinn, Estonia, the Baltic Sea Declaration promotes 'regional cooperation in spatial planning, grid development, capacity planning and support schemes'. The Baltic Sea Offshore Forum (BaSOF) comprising of Denmark, Estonia, Finland, Latvia, Germany, Lithuania, Poland and Sweden has been working towards this for years.

"The Baltic Sea will become the second-largest market by 2030," says Andrew Canning, WindEurope's press and communications manager. "We are trying to mirror the North Sea Declaration. It's all about working together to unlock the potential that there is in the Baltic Sea."

The first step is for governments to draft national energy climate plans that specify the offshore wind volumes they want to deploy post-2020. A clear long-term outlook will help create confidence and an attractive market for project developers and investors. Now working under the banner of WindEurope's Baltic Sea Task Force, the eight aforementioned national trade associations are pushing politicians into action. For Germany and Denmark however, little pressure is needed.

Responsible for the largest share of today's installed Baltic wind farms, they run respectively second and fourth globally in installed offshore capacity. Denmark in particular is the offshore exemplar, building Baltic fields like Rødsand I and II, Anholt and the groundbreaking Middelgrunden in 2000.

"Denmark's offshore wind success is due to many factors such as the one-stop-shop approach that the Danish Energy Agency (DEA) developed and that other countries have since adopted," says Danish Wind Industry Association CEO Jan Hylleberg. "An early and far-sighted energy policy has led to many of today's leading offshore wind companies being based in Denmark. Focusing on developing competitive test sites has also helped this."

Already generating 40% of its electricity through wind, Denmark plans to meet all of its energy needs with renewable electricity by 2050. That contrasts with Estonia, the smallest Baltic state, which has zero installed offshore capacity today.

However, it has serious ambitions to lead the rest of the pack – WindEurope estimates the country could generate up to 60% of its electricity from wind by 2030. The Estonian Wind Power Association wants to see around 1,700MW up and running by 2020. But though Estonia is currently planning two large offshore projects – Liivi Laht (960MW) and Nelja Energia's Loode-Eesti Meretuulepark (700–1,100MW) – thus far there's been little political will to build offshore capacity because existing onshore wind, CHP and biomass helped Estonia hit its 2020 targets ahead of schedule. The EU's upcoming RED 2 directive will be critical in shaping its and other Baltic states' offshore ambitions.

"If they are not strict on reaching the 2020 targets then nothing will happen to reach the 2030 ones," says Tuuliki Kasonen, general manager at the Estonian Wind Power Association. "There needs to be sanctions for countries that don't make them."

Estonia did confirm its Energy Development Plan this October: 50% of domestic electricity and 80% of heat from renewables by 2030. However, there is scant money to spare for subsidies. The existing support scheme is capped at 600GW/h annually and swallowed up by current capacity.

Instead, EU cooperation mechanisms set up under the original Renewable Energy Directive (RED 1) will help it fund development. 'Statistical transfers' allow renewable energy to be deducted from one country's progress towards its target and added to another's. In late October, Estonia signed the first ever such agreement with Luxembourg, which is currently less than half way towards its 2020 target.

"By developing offshore wind, we can help other countries that are lagging behind with theirs," says Kasonen. "In return, we will get financing for more projects."

### Lithuania, Latvia and Poland

Estonia's progress looks scorchingly fast compared with its neighbours. Though it has long since hit its 2020 target and is also about to ink a power transfer deal with Luxembourg, Lithuania's already-permitted projects are mired in a constantly changing regulatory nightmare.

Lithuania's Association of Wind Energy Producers predicts nothing will happen until at least 2020, when legislation is finally amended. Political infighting and a focus on developing gas-fired generation are the reasons.

Latvia is in a similar situation. Its two existing projects are still undeveloped and

## The falling cost of offshore wind generation

It seems that with every new set of auction results, the levelised cost of energy (LCOE) for offshore wind achieves new record lows. In the results from the UK's latest CfD round, the winning bids were 50% less than those of just five years ago.

In November 2016, Vattenfall won the right to build and operate the 600MW Kriegers Flak farm with a record low bid of €50/MWh. The recent Danish subsidy agreement actually saw the industry asking for less support than it was finally awarded, while the first zero-subsidy contracts were awarded in Germany in early 2017.

## The economic benefits of European wind

Europe's wind power industry may attract €351 billion of investment by 2030 if countries adopt ambitious reforms and targets for their energy systems in the coming year, according to a September 2017 report by WindEurope.

In 2018, the EU will publish the exact form of the 'Clean Energy for All Europeans' package it will mandate under the second Renewable Energy Directive. By upping the overall 2030 renewable target to 35% instead of the current 27%, WindEurope predicts the wind industry could create 716,000 new jobs over the next 12 years.

there's little pressure to change. Latvia was already close to its 40% target by the end of 2015. Poland is also yet to see its first offshore farm running. However, it has two large projects – Polenergia's Baltic Srodkowy II and III at 600MW each – that already have environmental permits and grid connections. Other projects, totalling over 9GW, are at earlier stages but there's still much work to do to address permitting and tendering processes, which currently place a lot of risk on investors.

"The Polish Government is deciding on its future energy mix out to 2035," says Janusz Gajowiecki, president of the Polish Wind Energy Association (PWEA). "We need to withdraw a large number of coal power plants over the next decade, and the government has said offshore wind will play an important part."

The potential economic benefits are a big reason for that. Unlike most other Baltic countries, Poland is already seeing substantial income from wind-related supply chain investment. The country manufactures crew transfer vessels, generators, cabling, towers and jackets. KK Wind Solutions builds control systems in Szczecin, Euros has a blade factory in Zory-Warszowice and LM Wind produces large blades in Goleniów.

"We already produce the heart and brains of turbines, and many other parts," says Gajowiecki. "Next we need developers like DONG and EON to come here and help us with their knowledge."

### Finland and Sweden

Up in the north, Finland opened its first offshore wind farm in September: the 42MW Tahkoluoto project. The country has a well-developed regulatory structure supported by the Finnish feed-in-tariff (€83.5/MW/h for 12 years) as well as a €20-million demonstration subsidy. Using gravity base foundations, it's the first farm built to withstand Arctic weather and pack ice. The average temperature in the closest city of Pori is just 4.2°C and it's below freezing five months of the year.

In neighbouring Sweden, there was a burst of offshore activity up to 2013, but progress has stalled since then. Many current projects are permitted but they will all expire by the early 2020s due to lack of development.

"Onshore has been cheap in relation to offshore, so it couldn't compete," says Charlotte Unger Larson, CEO of Swedish Wind Energy Association (SWEA). "Real offshore development hasn't really started."

At 54% renewable power production, the country leads the way in Europe. This is laudable, but again there's little pressure to invest in new assets. However, a big decision taken this spring changes everything; namely, 100% renewable electricity production by 2040. Old nuclear power stations in the south of the country will be shut down and, already fully developed, new hydro can't begin to fill the gap. New offshore wind is therefore needed in the south, although free grid connections look like the extent of the subsidies on offer.

"We'll need to replace about 60TW/h of nuclear and the politicians are realising that offshore has to come to support that," says Larson. "But offshore prices are going down so rapidly, I don't think our government will advocate a new support scheme."

### 'Meshing' the European grid

Though there is some potential to reuse nuclear connections, coping with new offshore generation in the south will require grid investment – a common theme around the Baltic. With 80% of land-based power produced in the north, new lines are also needed to transmit it to the more densely populated south. The Baltic Declaration incorporates the goals of the EU's Baltic Energy Market Interconnection Plan (BEMIP), which aims to build a 'mesh' between allied countries. These interconnectors enable power sharing and common electricity markets. BEMIP has already inspired numerous links including LitPol (500MW) between Lithuania and Poland, the submarine HVDC Estlink (1GW) connections between Estonia and Finland, and the 700MW Nordbalt between Sweden and Lithuania.

"If you are installing cables for offshore wind, why not use them for a double function?" says Kasonen. "Then, they can transmit power to land and to other countries too."

A further ambition for countries like Poland and Estonia is to cut their networks' ties to Russia. Their grids were originally built in the time of the Soviet Union and power generation is still synchronised with the Russian network.

So, like offshore wind itself, there will be multiple benefits from a Baltic mesh, but it will take years more lobbying to push national governments to take action and invest. It won't be easy, but by working together with the EU, the wind industry associations should see 9GW – or more – flowing into Baltic grids by 2030. ■

# Firmer foundations

Gravity and suction bucket foundations are two technologies that promise a number of advantages – including the potential to reduce the cost of offshore wind projects – over the ubiquitous monopile for seabed-mounted installations.

At Vattenfall's European Offshore Wind Deployment Centre off Aberdeen Bay, Scotland, what have been described as 'game-changing' suction bucket jackets are to be used to provide the foundations for eleven large MHI Vestas V164-8.4 turbines (to be connected using 'next-generation' 66kV array cabling, instead of 33kV).

The suction buckets to be demonstrated at the European Offshore Wind Deployment Centre (EOWDC) are expected to enable faster offshore installation, while also keeping noise to a minimum and facilitating decommissioning.

Peterhead Port Authority has recently been awarded a contract to harbour the suction bucket jacket foundations for the 11-turbine scheme.

This contract will see the port moor one of the world's largest floating cranes with a maximum lifting capacity of 5,000t, and up to six barges that will transport the 11 foundations, the heaviest of which weighs around 1,800t and is about 77m high. Peterhead Port Authority

will also accommodate two supporting offshore construction vessels and a project site office will be established at the harbour for the EOWDC installation operations, which are due to start later this year.

The Peterhead Port Authority contract, including the foundations and cabling, was awarded by Boskalis, Vattenfall's key supplier for offshore construction and installation.

"Peterhead has been an integral part of the UK's energy industry for the past 50 years", said Ian Laidlaw, chief executive of Peterhead Port Authority, and "the EOWDC represents a new chapter".

Peterhead Port becomes the latest harbour in the north-east of Scotland to provide key support for the EOWDC. Last year, Vattenfall invested in leases totalling 24 years with Aberdeen Harbour Board to establish a base at Regent Centre for its construction team and a warehouse unit at Commercial Quay to support the lifetime operations of the project.

Seatower's gravity foundations can be installed without the use of cranes.

The first Seatower Cranefree Gravity foundation for offshore wind was installed in February 2015 at EDF's Fécamp offshore wind farm site about 15km off the French coast at a water depth of 30m.

> "The suction buckets to be demonstrated at the European Offshore Wind Deployment Centre (EOWDC) are expected to enable faster offshore installation, while also keeping noise to a minimum and facilitating decommissioning."

"Peterhead Port Authority's facilities provide a natural fit to support the foundation installation work for a number of reasons," Andre Andringa, project director at Boskalis says. "With more than 3km of deep-water berthing, it can comfortably accommodate a large heavy-lift vessel, while the harbour is also sheltered, which helps minimise the impact of weather conditions for loading."

The foundations will be transported to Peterhead for mooring via the six barge vessels, five of which will carry two foundations, while the sixth will transport the final one. 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.

## Gravity foundations without cranes

Development of 'float and submerge' gravity foundations is another area attracting interest. A pioneer in this field is Seatower, which is working on gravity foundations for offshore wind turbines and substations that can be installed without cranes, and was recently named winner of the 2017 Eurelectric Industry and Innovation Award. This was in recognition of its "unique technology", which is said to represent "a breakthrough in the offshore industry, because of a less risky process – as the installation involves fewer personnel in offshore operations – faster and much simpler installation procedure and larger weather conditions window".

Receiving the Eurelectric award, Seatower CEO Petter Karal said the foundation design was "perfect for larger turbines", with installation able to take place during winter time in harsh offshore conditions, "which is one of several advantages that reduce the total cost of an installed gravity-based foundation compared with the commonly used steel structures."

The Seatower foundation is said to "represent a rethinking of the entire value chain, from lean manufacturing methods to safe and cost-efficient installation."

The hollow foundations are "self-floating" before installation on the seabed, which is achieved by filling them with seawater. Only towing vessels are required for the transportation and installation of these foundations, which have also been described as "self-installing."

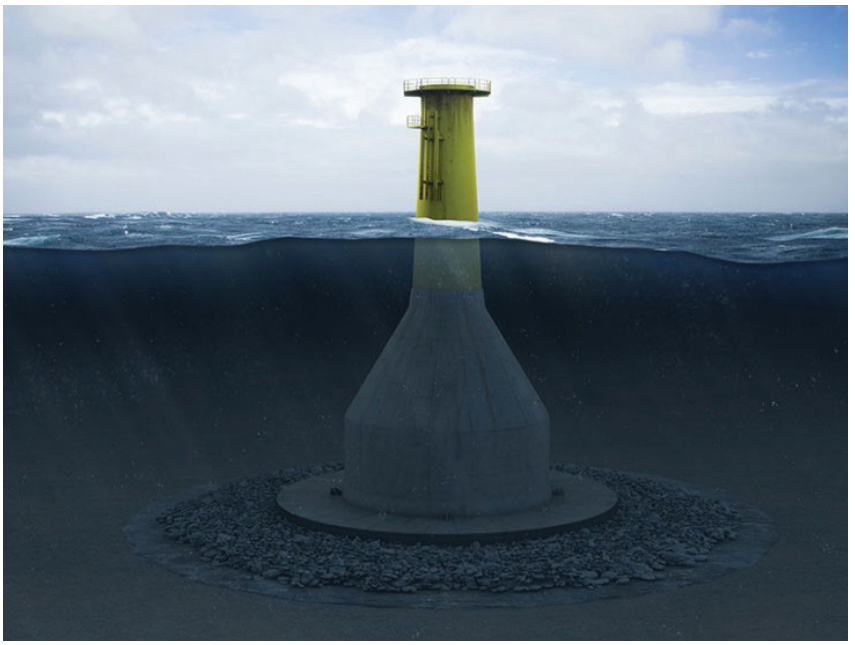
The foundations have been designed to employ mass manufacturing methods "using only standard, low-cost materials including regular concrete and steel."

There is no noise from pile hammering or drilling during the installation process, and at end-of-life, no steel or concrete is left on the seabed following decommissioning.

Another type of float and submerge gravity foundation, designed and manufactured by Royal BAM Group, is to be deployed at EDF's five-turbine 41.5MW Blyth Offshore Demonstrator wind farm in the UK. As reported in a previous issue of *World Wind Technology*, two of the five Blyth gravity foundations will be fitted with

a sensor system designed by the Offshore Renewable Energy (ORE) Catapult to analyse their performance, as part of the Demowind-funded FS Found project.

Each of the Blyth gravity-based foundations will weigh more than 15,000t when fully installed. Blyth will also employ 66kV array cables, the first offshore wind farm to do so.



An eco-friendly anti-corrosion coating can be used to protect steel foundations.


When the monopiles have been installed at the Arkona offshore wind farm, the transition pieces (above), towers and turbines will be mounted.

## Improving corrosion resistance

Meanwhile, work continues on steadily improving the incumbent technology, monopile foundations. For example, E.ON recently announced that it is protecting all 60 steel foundations of the Arkona offshore wind park in the German Baltic Sea with a special, environmentally friendly anti-corrosion coating, the first application to the monopiles of an offshore wind farm. Construction work on Arkona is now under way, with the first foundations successfully installed in the seabed.

Over the expected 25-year operating life of the wind farm, corrosion is significantly reduced and deposits into the sea are decreased by several hundred tons. E.ON says it has developed the Thermal Spray Aluminium (TSA) process for the coating of monopoles, with engineers Rambøll Germany collaborating with the relevant authorities. EEW and Krebs then developed innovative solutions on behalf of E.ON to implement the process industrially at their locations in Rostock. To this end, existing coating halls were also expanded and the world's first fully automated coating line for applying the process to offshore wind monopiles was developed.

"We will now analyse and further optimise the process in order to use it for future offshore wind projects," said Sven Utermöhlen, COO of E.ON climate and renewables.

During the coating process, a robot with two arc burners sprays a 350µm-thick layer of molten aluminium onto the foundations. The process is carried out under the most stringent safety and environmental protection standards, and is largely dust-free. The surface is then sealed with resin. The TSA process has hitherto mainly been used as corrosion protection for smaller steel components underwater or for larger components above water, such as in offshore substations. The process is being applied for the first time on an industrial scale for the foundations of the Arkona turbines. Because the process is automated, this alternative coating method can lead to significant cost savings compared with conventional corrosion protection.

All 60 foundations with the TSA coating for the Arkona offshore wind farm have now been produced. They have a maximum length of 81m and a diameter of up to approximately 8m. Once the monopiles have been installed, the transition pieces, towers and turbines will be mounted on them.

The 60×6MW (385MW) Arkona offshore wind farm, which is due to enter operation in 2019, is located 35km north-east of the island of Rügen, in water depths of 23–37m. It is a joint venture between E.ON and Statoil. ■

# Raising the standards

Andrew Tunnicliffe speaks with **Kate Harvey**, general manager of the G+ Global Offshore Wind Health and Safety Organisation, about the company's work to improve safety in the offshore wind farm environment, how the challenges have evolved and how they are being met.

Health and safety is a vital element at all stages in the life of an offshore wind farm. The Global Offshore Wind Health and Safety Organisation (the G+) was created in 2011 by leading offshore wind farm operators, who wanted to improve their cooperation and industry leadership on health and safety. Challenges workers face include working at height, and lifting and handling.

**Andrew Tunnicliffe: What are the most pressing matters for the offshore wind industry in relation to health and safety?**

**Kate Harvey:** The G+, supported by the Energy Institute, presents annual health and safety statistics reports. In June 2017, the G+ launched the global G+ 2016 incident data report, which gives a comprehensive insight into the health and safety performance of the G+ members. The data shows that a high number of lost workday incidents occurred due to manual handling. The G+ is currently looking further into the causes of manual handling with a view to developing guidance specific to the offshore wind industry. »

Working at height, and lifting and marine operations have the greatest number of high potential incidents reported. The G+ has good-practice guidelines on small service vessels, and has conducted workshops on lifting operations generally and davit cranes more specifically.

design on a particular topic/risk area and to investigate improvements in the design phase of an offshore wind farm project. This will lead to a reduction in the number of incidents, and to improvements and efficiencies in health and safety performance.

> "A key way to reduce health and safety incidents is to try and avoid using humans as much, through automated technologies and safer design."

### How have recent changes in the sector impacted its approach to health and safety regulation, and technological developments?

Offshore wind farm sites are growing in all dimensions in terms of capacity, area, distance from shore and the size of the technology being used. This leads to different types of vessels being used and a change to vessel strategies.

A key way to reduce health and safety incidents in the future is to try and avoid using humans as much, through automated technologies and safer design. The G+ has a Safe by Design programme; many workshops have been held and the purpose of each is to explore the current industry

With regard to automated technologies, the G+ is working with Cranfield University and the University of Oxford to assess the use of human-free offshore lifting solutions. Concepts for human-free offshore lifting operations in the categories of guidance and control, connections and assembly are studied in this work.

### Has regulation increased and is it now doing what it should, or is there more needed?

The G+ has been fortunate to work closely with the health and safety regulator in the UK, the Health and Safety Executive (HSE). This has led to the G+ publishing good practice standards, such as management of small vessels and working at height, as opposed to regulation being imposed on the industry by the HSE.

At the Offshore Wind Leaders event in Bootle in November 2015, it was widely acknowledged that the industry welcomed the G+ (or G9 as it was then), further consolidating its leadership role in driving the improvement of health and safety performance in the offshore wind industry. The HSE has now organised a second event for April 2018 to check the progress that has been made since November 2015.

The G+ is keen to extend relationships with regulators across the countries that members are currently working in, such as Germany, the US and Taiwan.

### Has there been a shift in focus towards health and safety by the industry, and if so, why?

Health and safety has always been at the forefront of the G+ members' operations. This hasn't changed. The safety agenda remains the top priority of all the G+ member companies. Members are very clear that to continue developing and operating offshore wind farm projects they need to maintain a high level of health and safety performance. Anything else is not tolerable to these large utilities. Statoil, for example, found that during the construction of Sheringham Shoal (2010–2012) it faced a number of safety related issues. The total recordable injury frequency peaked at 8.0 in 2010 and 3.8 in 2011.

In 2016, two executive vice-presidents working in New Energy Solutions and Projects at Statoil endorsed a new safety initiative for their offshore wind business. The proposal was to join forces with peer companies undertaking construction activities in parallel to Dudgeon (2016–18). Statoil was eager to find efficient and tangible ways of improving the safety performance in the offshore wind industry. The initiative was endorsed by peer companies, and the 'Safety Champions' met for the first time in April 2016 and continue to meet biannually. »

The G+Safe by Design workshops aim to improve health and safety by enhancing wind farm design.

The industry is becoming much more competitive and driving efficiencies in many areas, which is reflected in recent strike prices for new offshore wind farms. However, the safety agenda must remain at the forefront and not be relegated to the sidelines. Through the G+ work programme, those of other organisations, collaboration with key stakeholders and our partnership with the Energy Institute, the G+'s focus continues to be on improving the health and safety performance of our own companies, and of the industry as a whole.

### Are we getting any closer to formalised global standards, and if so what are the challenges still to be overcome?

The G+ currently has two good practice documents; working at height and small service vessels. Both guidance documents are currently being revised so that they can be used across the globe. The G+ is also developing global guidance on manual handling and ergonomics, and avoiding dropped objects, both of which will be published in 2018.

### How much more can the G+ do, and how important are your members and those they work with?

The G+'s focus over the past few years has been about engaging more with the supply chain and trade associations. The G+ has core members, but in 2017 it launched an associate membership concept. Membership is open to offshore wind farm developers with planning consent, non-lead wind farm operators, OEMs and transmission network owners. The aim is to further facilitate engagement with these stakeholders. The supply chain has also been more engaged in the good-practice guidance consultations, participating in the working groups and reviewing early draft documents. This has improved the content of the G+ guidance and will hopefully increase their uptake.

In response to the G+'s commitment to cooperation, and as an output of the HSE offshore wind leaders event, an Industry Collaboration Committee was formed. This is chaired by the G+ and meets on a regular basis to ensure that the various organisations' work programmes are consistent with current and emerging priority risks, that duplication is minimised and that efforts are undertaken by the most suitable organisation under a more collaborative framework. Members of the committee are IMCA, RUK, the G+, WindEurope and the GWO.

The G+ holds an annual stakeholder forum. The purpose of this event is for the G+ members to present work done and key deliverables, including the incident data work programme, the G+ Safe by Design initiative and implementation of the G+ good-practice guidelines. The stakeholder forums are attended by representatives from the G+ member companies and key offshore wind industry stakeholders. The event provides a platform for important discussions regarding health and safety in the offshore wind industry. In previous years, the forums have included panel sessions with senior industry representatives. The G+ has held stakeholder forums in 2013, 2014 and 2016, and is looking forward to hosting the next one in Hamburg in January 2018. ■

# The perfect all-weather platform for optimum turbine maintenance

A turbine maintenance platform is a major investment, so it makes sense for companies to look for a highly experienced manufacturer. We speak to Antti Suoniemi, sales manager at **Bronto Skylift**, and Joni Alasaari, chairman of the board at **Bladefence**, about their strategic partnership.

### What sets Bronto Skylift apart from its competitors?

**Antti Suoniemi:** In a single year, we deliver more 90m-plus units than all of our competitors combined. We are fortunate in that government bodies in countries such as China, Kuwait and Saudi Arabia have chosen us as their strategic partners. This enables us to have the infrastructure in place in Finland and abroad.

What sets us apart is the expertise and knowledge we have gained from delivering 100 units in our lifetime, versus the usual ten to 15. We've always had the biggest platforms in the market – for example, the units for wind turbine maintenance are mainly 90–100m. That's because we serve two areas: the fire sector, including fire departments, such as those in Shanghai, Beijing, Saudi Arabia and Kuwait, which use our units for rescue and firefighting operations, and the access sector, where we work with industrial customers such as our strategic partner, Bladefence, a Finnish company that provides high-quality repairs and maintenance for wind turbine blades.

### What can customers expect when they partner with you?

**AS:** We never take anything for granted. The most important thing is that we will never leave a customer stranded if problems arise with a unit. We will do everything in our power to give them the best customer support, service, maintenance and training possible. It doesn't matter if they have one unit, 15 or 50 – we will give them the best customer experience possible. We have a vast network with dealers and partners spread over 100 different countries globally, so we are ready to serve our customers no matter where in the world they are.

### What is your research and development process?

**AS:** We travel around the world to sit down with our customers and hear them out. In different parts of the world, different specifications might be required to fulfil the customer need. This is something that we realised early on and so we try to stay as flexible as possible. Recently, we hosted a research and development session where we invited some customers to attend to discuss their business and how they see working with Bronto Skylift. We want to involve our customers in the R&D as much as we can.

### What is in the pipeline for Bronto Skylift next year?

**AS:** At the beginning of 2018, we are putting more emphasis on the industrial side of Bronto. We are expanding our sales and R&D divisions, and it will include not only new units, but also a better service and sales network.

### So far, how has the experience of working with Bronto Skylift been for Bladefence?

**Joni Alasaari:** We see Bronto as one of our service partners. People at Bronto are knowledgeable and always willing to help. When it comes to product lines, Bronto can offer a best-in-class user experience, which is crucial in our business to offer top-quality services to our customers. Safety and reliability are two of our key factors when selecting equipment, and with Bronto's solid boom, we are able to work safely, even in challenging weather conditions.

In Finland, we are official service partners for Bronto and that way we're able to ensure that our fleet is always maintained and serviced, and that we have spare parts available. This is key when the focus is on safely lifting people.

### What were Bladefence's priorities when choosing a partner?

**JA:** Our aim is to provide the best possible service to our customers in a cost-effective way. This means that our partner needs to share our vision, and have the experience to analyse and execute challenging operations in a manner that adds value to our customers. For a successful venture, an honest and trustworthy partner is needed, but, more so, our partner needs to have the same passion that we have for continuously developing and improving techniques so that we are able to exceed the high standards our customers expect from us. ■

**Further information**

| | |
|---|---|
| Bronto Skylift | www.brontoskylift.com |
| Bladefence | www.bladefence.com |

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# Storage wars

Renewables have less inertia than the large turbines used by coal, gas and nuclear, meaning grid frequency changes faster when demand and supply are out of balance. Advancements in battery storage technology and increased competition could be the answer to the UK's increasingly inflexible and intermittent electricity supply, as James Lawson reports.

With more than 25% of UK generation capacity now coming from renewables, electricity supply is less flexible and more intermittent than ever before. That makes balancing the grid challenging, strains local distribution networks and, worse, impedes further renewable deployment. Batteries increasingly look like the solution to all these problems.

National Grid is the UK's transmission system operator (TSO), responsible for maintaining voltage and frequency within tightly defined limits. To do that, it needs to access flexible generation in near real time, contracting in advance for more than 20 different ancillary services, including short-term reserve and voltage control.

"The bulk of power is still traded in long-term contracts, but ancillary services that deal with power quality are becoming more meaningful and important," says Aris Karcanias, senior managing director at FTI Consulting.

Because solar and wind have far less inertia than the large turbines used by coal, gas and nuclear, grid frequency changes faster when demand and supply are out of balance. Too rapid, and that trips protection relays at the generation plant. Really fast frequency changes have the potential to uncontrollably disconnect large chunks of generation, causing parts of the grid to shut down.

## Enhanced frequency response

Balancing today's grid requires new services to cope. The first of these services to appear, enhanced frequency response (EFR), rapidly pumps large quantities of energy into the grid in order to maintain 50Hz.

"You want less than 500ms response time for EFR," says Karcanias. "Lithium ion (Li-ion) batteries can provide a 20ms response and can also participate in bilateral deals for capacity markets."

Published in mid-2016, the EFR tender's attractive rates have encouraged investors to sign up for storage projects in droves. From a standing start a few years ago, the UK's utility-scale storage now totals over 100MW, with gigawatts in the pipeline. Though hybrid flywheels, demand-side response and other innovative technologies were in evidence, 888MW of the 1,137MW that pre-qualified for the EFR tender was for Li-ion battery projects.

E.ON's 10MW battery located at Sheffield's Blackburn Meadows biomass plant became the first EFR project site to go live this October. Others include

the 20MW Broxburn and 35MW Port of Tyne batteries, both built by RES.

The latter system is currently the UK's largest, and these projects graphically demonstrate how the EFR tender has brought UK battery storage into the mainstream. RES brought its experience of US utility-scale deployments to the party, along with its proprietary Resolve control system.

"We've worked with National Grid since 2014," says Tim French, development director at RES Group. "We shared our expertise from the US and helped them figure out what the new EFR service was going to look like."

The UK's 14 distribution network operators (DNOs) are the other big potential infrastructure storage customers. Shifting use patterns means local networks designed decades ago no longer satisfy today's electricity generation and consumption requirements. Normally, DNOs are forced to put in extremely expensive new lines and equipment to cope.

"If you have a constraint locally, you can put in a battery instead, and avoid spending millions of pounds in network upgrades," says French.

The 33/11kV Leighton Buzzard primary substation is a good example, needing extra capacity to cope with peak winter demand. Instead of installing a third transformer and approximately 20km of underground cable, the Smarter Network Storage demonstration project installed a 6/10MWh grid battery that successfully provided peak shaving support for up to 1.5 hours at a time.

### Time-shifting electricity

Batteries are also today's default choice for behind-the-meter storage, where generation and consumption are co-located. Businesses large and small, as well as consumers, can time-shift electricity for their own use, sell it back to the grid and participate in energy markets as merchants, using techniques like arbitrage: storing cheap electricity and then selling it at higher prices during peak demand hours.

Time-shifting is what Cornwall's Olde House project was built to do. Storage vendor Red T worked with Centrica to attach a 1MWh flow device to an existing 350kW solar array. Solar generation and cheap electricity charges the battery, which then maintains power 24/7 to the houses on-site. Because they only import at off-peak times, it also lessens the load on Cornwall's weak grid.

"They can sell excess power to the grid too, but with today's low feed-in tariff, it's usually better value to store and use it themselves," says Joe Worthington, Red T's communications manager. "They save a third on imports from the grid, increased their solar utilisation by 1,800% and now get a 10% return on their asset investment."

Pairing legacy solar with battery storage is becoming common. Anesco's new 10MW Clayhill solar farm shares an existing grid connection and uses a 6MW battery to support grid services and arbitrage, making the project profitable without fresh subsidy. In contrast, there's little storage activity in UK wind as yet.

Where solar production has predictable nightly troughs, a turbine might generate for a week straight and then produce nothing for three days. That requires a larger, more expensive battery that then often goes unused."As wind is much more variable, it makes

## UK moves to low carbon power in 2017

From 21 June to 22 September 2017, almost 52% of UK electricity needs were met by low-carbon sources, including solar, wind and nuclear. In comparison, the same period in 2013 saw just 35% of energy needs coming from low-carbon generation.

"It's been an exciting year managing the many network firsts – from a day where we operated the system with zero coal power, to one where over half of the UK's energy demand was met by renewable generation," says Duncan Burt, director at National Grid.

Inside the Smarter Network Storage project in Leighton Buzzard.

sizing the storage quite challenging," explains Worthington. "That can make a project's economics difficult."

In 2016, Red T ran a trial on the Scottish island of Gigha with its 1.68MWh flow battery taking a feed from the three community-owned turbines. This stabilised the islanders' own supply and allowed export when the locally constrained grid could accept it. Vattenfall, another EFR winner, will complete its 22MW Pen y Cymoedd battery in February 2018. To lower capital costs, it again shares its grid connection with the 228MW wind farm next door but the battery is not tied to the farm's output.

The 2MW battery that Dong Energy is installing at its 90MW Burbo Bank wind farm is the only current example of UK wind storage. Delivering EFR services is its main purpose, but the battery and wind farm will work together in delivering those services, in addition to supplying better quality power to the grid.

### The capacity market

From peak shaving to black start and demand reduction, there are many markets and ancillary services that storage can cater for. That's just as well. With so much new battery capacity in the pipeline, the EFR market is getting crowded and rates look likely to fall.

UK developers will need to look elsewhere for income and the capacity market is the obvious one. The Port of Tyne battery is a good example, servicing a 12-year capacity market contract in addition to EFR.

"At the moment, most projects are frequency response but as you see more batteries being built, that market is finite," says French. "There's over 3GW in the planning system. They will want to participate in merchant services, ancillary services, and the balancing and peaking markets, using the battery for different services at different times of day."

To handle the differing demands of these multiple services, the batteries need to be versatile enough to cope. Control systems like Resolve are part of the answer – but what about the batteries themselves?

Stress events in the capacity market may last up to four hours, considerably longer than the 30 minutes to an hour discharge time that is all most UK batteries can handle. Because of this, the UK's Department for Business, Energy & Industrial Strategy (BEIS) is currently considering 'derating' smaller batteries.

The subsequent drop in revenue is worrying developers such as Anesco, which is reportedly investigating moving to flow battery technology to service the capacity market.

Redox flow batteries consist of two tanks of vanadium solution. When pumped into a reactor, the two solutions flow adjacent to each other past a membrane, and generate a current as electrons move back and forth during charging and discharging. They are more bulky than Li-ion: 250kW of storage approximates to one shipping container.

"Technologies like flywheels, capacitors and lithium are high power, they deliver energy very quickly," explains Worthington. "Flow machines store a lot of energy and you can discharge them all day. They are close to cost parity with lithium and, if you take lifetime into account, ours are significantly cheaper over 20 years."

### Li-ion technology

Li-ion's tendency to degrade when subjected to high cycles and repeated deep discharge was another concern for the BEIS. By contrast, vanadium flow batteries can be left completely discharged for long periods with no ill effects and have a 'semi-infinite' lifetime.

"Longer-duration batteries may be more effective for certain solutions," notes French. "It depends on the revenue model. But where you need black start capability or back-up, you need high energy density. That's what we've building in the US and Li-ion is very good for that."

Red T is currently developing a hybrid battery that combines lithium and flow technologies. Vanadium makes up 80% of the capacity while 20% lithium provides high power for short durations. "With occasional managed use, the lithium lasts a lot longer," says Worthington.

As renewable penetration continues to increase, more batteries to support the grid and smooth intermittency look likely. But although there have been recent encouraging moves, like continuing renewable subsidy support for batteries co-located with solar, the way ahead isn't entirely clear.

Many batteries are too small to participate economically in energy markets. DNOs will take years to connect the gigawatts of proposed storage across many distributed sites. Policy and regulation that would allow tactics like aggregation are still absent, while research funding is overly focused on vehicle batteries.

With that degree of market immaturity, it's hard to know which technologies will still be here in a decade's time. But with Li-ion batteries now so powerful, cheap and compact, don't bet against them still ruling the roost in 2027.

"Lithium is the main technology choice, because it's established and proven," says French. "Like PV, Li-ion will continually evolve to be faster, and have higher energy density and greater longevity." ■

## Tesla on track to build world's biggest battery

Tesla's "big battery" in South Australia was recently brought online. CEO Elon Musk committed to building the 100MW/129MW/h battery storage project next to the Hornsdale wind farm in 100 days earlier this year.

Part of the capacity will be contracted to the South Australian Government for grid security needs while developer Neoen will employ the rest – around 30MW/90MWh – as an arbitrage supplier for the wholesale electricity market.

"We expect this project to lay the groundwork for many similar projects, but at an even larger scale, in the years ahead," Musk said.

# The world's largest-ever reach stacker

**N.C. Nielsen** is Denmark's largest supplier of forklifts, terminal tractors and special-purpose machines with more than 225 employees and an annual turnover of more than Kr650 million (£77 million). Its product range stretches from small pallet loaders and mobile cranes to customer-specific solutions. The company's most recent endeavour is the creation of the world's largest reach stacker.

The world's largest, strongest and most powerful reach stacker is currently under construction by Danish company N.C. Nielsen. This heavy-duty machine – which boasts a lifting capacity of 152t from its hook – comes as a response to the many requests from shipping companies, supply bases, harbour terminals and wind turbine producers for a highly mobile machine that is capable of heavy lifting in a safe and efficient manner.

This is not the company's first foray into this area; it already has reach stackers with a lifting capacity of 100t for the wind turbine sector – an industry first at that time.

N.C. Nielsen is once again raising the engineering bar with an even more powerful machine that will offer companies more options, more capabilities and more power.

> "The new machine is based on a Konecranes 4545 reach stacker. It will have a net weight of 110t, a width of 4.9m, a length, with the boom down, of 15.0m and will lift 152t from its hook."

### Bigger is better

The new machine is based on a Konecranes 4545 reach stacker. It will have a net weight of 110t, a width of 4.9m, a length (with the boom down) of 15.0m, and will lift 152t from its hook.

The geometry of the product will be reconfigured, with a reinforced boom for 15.4m-high lifts, increased counterweight, larger lifting cylinders, 2m-high decks and a withdrawn undercarriage that allows easy access to the machine.


After a productive development process, engineers at N.C. Nielsen found the correct 'formula' for the creation of its new reach stacker.


N.C. Nielsen is building the world's largest reach stacker, which is capable of lifting 152t from its hook.

Most components of the new reach stacker have been enlarged. The process of its creation has taken numerous calculations, trial assemblies and tests in order to succeed. After a very promising development process, the engineers have now found the correct 'formula' for the machine, says technical manager for the company Per Nielsen.

Preparations at N.C. Nielsen are well under way, and the first reach stacker is expected to be ready for delivery by the end of this year. The bespoke reach stackers are being built at the factory in Balling, and N.C. Nielsen expects to put a minor series of the machines into production in 2018 to meet the increasing demand for heavy lifts. ■

**Further information**
N.C. Nielsen
www.nc-nielsen.dk



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