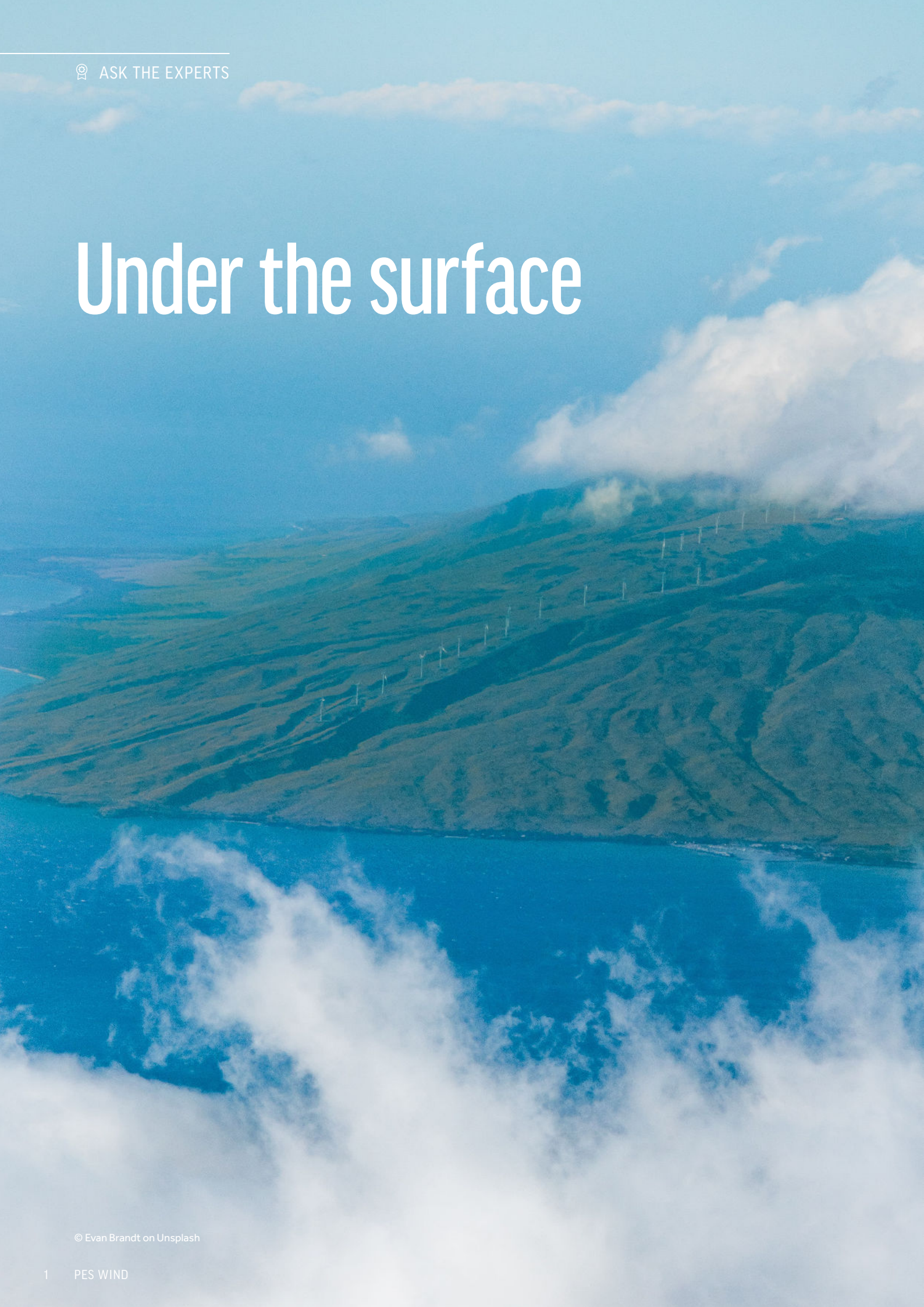
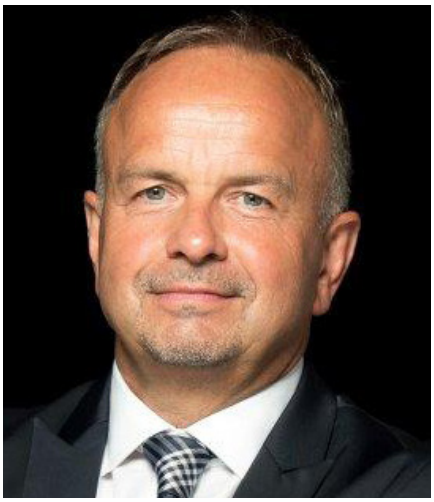
Under the surface



Scott Gardiner and Stefan Bill represent REWITEC, a company whose technology aims to promote the longevity and efficiency of systems, machinery and gearboxes. Founded in Germany in 2003, REWITEC was acquired by Croda in 2019, forming part of their Performance Technologies sector. This was then itself acquired by Cargill in July 2022. PES took the opportunity to speak to them about the acquisition and the company's plans for the future of turbine repair and restoration.

Scott Gardiner



Stefan Bill

PES: It is lovely to speak to you both. Perhaps it would be useful for our readers if we began with a little bit of background to Cargill and the Croda takeover. It's the smart materials and energy technology sectors that are now under Cargill, is that right?

Scott Gardiner: That's right. As of July 1 2022, both of those sectors formally became part of Cargill Inc.

PES: How did the acquisition come about?

Stefan Bill: During 2021, Croda International Plc announced a strategic review of its Performance Technologies and Industrial Chemicals businesses (PTIC). The core objective was to establish what ownership structure best served this part of Croda's business going forward, and to create a stronger platform for its future growth.

The acquisition of 77% PTIC by Cargill Inc was announced in December 2021, and by July 2022, transfer of the business to Cargill was complete. By combining the Performance Technologies team's capabilities with Cargill's track record of innovation and global reach, tremendous growth opportunities for the Cargill Bioindustrial customers can be realized.

PES: What does it mean for Croda and Cargill customers in terms of service levels and also product solutions that may be coming through?

SG: There will be no change to our service levels. We anticipate that through joining Cargill and combining our product portfolios, we will be able to accelerate our sustainable product solutions offer to our customers.

SB: Absolutely. With our strong combined global talent and customer-driven culture, we see innovative product solutions ramping up in number as time progresses.

PES: Scott, you are based in the US, is that right? While Stefan you are based in Europe. How does this work in terms of the company's international reach, presumably there is a global outlook for the business?

SB: I founded the REWITEC company in Germany in 2003, working in industrial, marine and automotive areas. We entered the wind space in 2008 and steadily we gained business in all EU countries. In 2017 Scott joined us and we started our business in the North American market. We have partners in Japan and Brazil, and of course our global network of sales offices as part of the Croda PTIC business.

SG: I'm based in the US and responsible for North America for REWITEC technology.

We are looking forward to understanding how being part of Cargill Bioindustrial allows us to further develop our sales network.

PES: How do the two markets, US and Europe differ in terms of the wind industry and its evolution?

SG: The structure of the North American market is very different from that of Europe. The US market comprises roughly 30 large utilities and power producers who own and operate 85% of all wind turbines. The companies act as huge corporate powerhouses, particularly in terms of how they make decisions. They have engineering staff with in-house asset management personnel and operational strategies.

Smaller owners/operators rely on turbine OEM service companies for their maintenance. When they buy a turbine from an OEM like GE or Vestas, it is common to include service contracts for five to ten years.

Another difference is that turbine drivetrains, bearings and gearboxes are all designed and manufactured in Europe and shipped to the US. Most of the major turbine OEMs are based in Europe, where they have large technical centers driving research, product development and innovation.

SB: The European market is very different to North America. It's a very diversified market and there are a much smaller number of turbines per customer. We work with both small scale and major owners and operators, OEMs and independent service providers. Approaches to servicing and maintenance vary significantly across Europe, as turbine warranties differ from country to country. In Scandinavia, for example, there will be new turbines sold with 30 year service contracts, so there are very few independent O&M companies operating in this region.

The market is still changing rapidly, especially in Europe and Asia. Offshore wind is growing quickly, particularly within the United Kingdom, and there are a number of new owners, operators and service companies emerging within this space. However, we anticipate this will change over time. There will be a smaller number of big owner/operators doing their own in-house servicing and maintenance after the OEM warranty period.

SG: Looking to Asia, we see Japan as being an up-and-coming market, particularly in offshore wind. China is a unique market heavily supplied by Chinese turbine and component OEMs. We anticipate that it will grow to double that of the rest of the world in a very short space of time.

SB: We should also expect to see the emergence of Chinese wind turbine OEMs within Europe. Margins of the Western wind turbine OEMs are tight within the US and Europe, so lower-cost manufacturing would allow Chinese OEMs to gain more market share.

PES: As a specialist in surface repair, what are some of the common challenges you are presented with, particularly when it comes to older wind turbines?

SG: Back in 2008, we were asked by a major insurance company if we could help solve the problem of wear issues they were encountering in older wind turbine gears and bearings. Such issues included micropitting and adhesive wear on gear tooth and bearing surfaces; these have continued to be troublesome for owners and operators today.

Main bearing problems such as spalling and white etching cracks, are also common, particularly in the US. We have also observed corrosion problems due to water ingress into the gearbox lubricant and bearing grease. Choice of appropriate lubrication for wind turbines is a very important topic and can drastically impact asset performance and longevity.

Today, there is much focus on lifetime extension, so moving towards preventing problems occurring in newer turbines, is just as important as treating damage in older turbines.

SB: In the US, although the nominal average price residential electric customers paid in 2021 was the highest on record, retail electricity prices adjusted for inflation have been slowly declining.

The real price of electricity last year was at the lowest level since just before 2006. This disadvantages older turbines as profitability is lower and the operational budget for repairs and maintenance will be much reduced. If I have an older turbine that may have five years of useful life left, how much do I want to invest in it? Is it worth repairing it or replacing costly parts?

Knowing exactly when to treat a turbine with REWITEC is also a challenge for operators and owners. If the damage is too severe it can be too late to apply a surface repair treatment.

PES: How can the damage you just mentioned be avoided or treated, and the longevity of turbines be extended?

SG: Surface finish improvements are key here, especially for the gearbox and main bearing manufacturers. The smoother the surfaces within the componentry, the less wear will occur because contact fatigue is reduced. This is a concept that is well understood within the gearing and bearing industries.

REWITEC is a technology that can remedy contact fatigue failures. Adding REWITEC as soon as possible into the gearbox or main bearing has the most impact on the longevity of the system.

SB: Everything within a tribological system relates to surface roughness and oil film thickness. If we can decrease the surface roughness, we are able to improve the protective oil film thickness. When a surface roughness is too high there is potential for metal-metal contact, which causes increased friction and leads to damage and surface wear.

REWITEC technology is centered around reducing surface roughness and optimizing the surface structure of metal components.

Turbines that have been in operation for more than ten years are ideal candidates for treatment with REWITEC as they can already have very rough surfaces, lots of micropitting and damage. However, this technology could potentially be used as a first fill application.

Surfaces in gearboxes and bearings are not always perfect, so the technology could act as a preventative from the outset. Component manufacturers try to optimize surfaces in the very beginning for example by shot peening, DLC coating and superfinishing.

PES: Is it possible to repair parts like gears and bearings?

SB: I think it's important that we first clarify what we mean by repair, as the severity of damage that needs to be repaired is critical. If we have a broken gear tooth, for example, that is beyond the scope of the REWITEC technology. If there is mild wear at the surface, so a surface roughness of 30 microns or less, repair is possible. We discuss the appropriate course of action based on inspection reports before recommending a REWITEC application to our customers. In certain cases, we recommend surface analysis before and after the application that gives a visual demonstration of how successful a treatment has been.

PES: Are there cost-savings to be had from repairing rather than replacing parts?

SG: It costs around 5,000 to 6,000 USD to treat a damaged gearbox with REWITEC, and it can be applied to the tower during routine maintenance. If we treat a gearbox every two years, starting in Year 5 this roughly equates to ten treatments over the course of the turbine lifetime. This means that 40,000 USD would be invested in reparative technology over the lifetime of the gearbox.

In contrast, it costs around 300,000 USD to replace the gearbox, excluding downtime and associated loss of income. It is common for gearbox replacement to result in a change to the main bearing as well simply because the crane is already in position. A cost benefit analysis shows significant savings.

PES: Are there any other benefits to the technology and what it can provide a wind turbine owner?

SG: REWITEC can potentially help generate more electricity per kilowatt hour as a result of efficiency gains in the drivetrain.

SB: We have performed scientific tests at universities and in our UK laboratory which show a reduced surface friction of up to 50%, in the mixed lubrication regime. Reducing friction will result in greater efficiency of gearboxes and bearings. Megawatt gearboxes and bearings under normal load typically have an efficiency of around 97%. However, as the components age you would expect that efficiency level to drop, especially for older turbines.

We are now working with a German wind turbine owner operator, a major lubricant formulator and a large test institute in Germany to measure the impact of REWITEC on efficiency. This involves equipping a wind turbine with all the necessary sensors to measure the potential efficiency gain when the gearbox and main bearing are treated with REWITEC technology. We hope to start the test in September, anticipating results will be back in 6 months.

A 1-2 % efficiency gain would be incredibly valuable, driving a significant amount of revenue for the owner over the remaining lifetime of the turbine's lifetime.

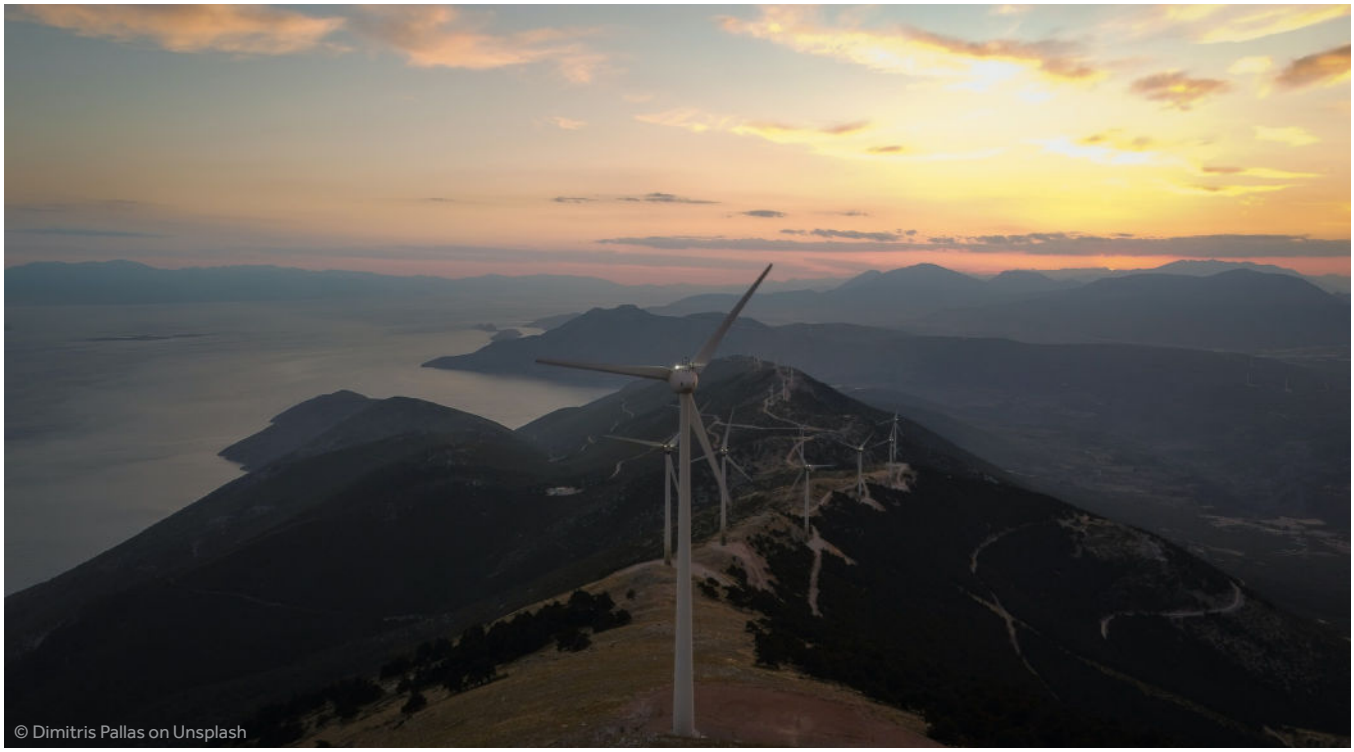
PES: How simple a job is it though, particularly considering turbines that are offshore and therefore not easily accessible?

SB: If we are treating a turbine for the first time, it is vital that we have the last service report with oil analysis, endoscopic images or other surface images, before agreeing on a treatment plan. Our technicians can travel to the wind turbines to perform surface analysis before treatment, during application, and afterwards if required.

SG: The actual treatment itself, to simply add REWITEC to a main bearing or gearbox, takes between 1 to 4 hours. It is administered in-situ, directly from the bottle/grease tube. It takes half a day or less and there is minimal downtime.

SB: This is straightforward on shore. Offshore is a new challenge, and requires special training, licenses etc. We have just started working with a large offshore company who will perform a first application themselves whilst we observe. It is something we are looking at for the very near future.

SG: If you have a general, regular maintenance routine, application can be managed whilst the technician is climbing to carry out this. Application is very quick and simple and can be done with minimal training.



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PES: Are there benefits in terms of being able to avoid decommissioning and repowering too? That must save time and therefore costs too?

SG: The primary reason for decommissioning a turbine is that it's no longer profitable and repairs are just too costly. This is like having a very old car and deciding whether to replace the timing belt/chain, transmission, and other expensive parts, or simply scrapping it. REWITEC technology can be beneficial for very old turbines because it can prolong the life of some key drivetrain components with minimal investment. Ultimately this is a financially driven decision, as the condition of other parts of the turbine must also be considered.

Repowering is a similar situation to decommissioning. When faced with a repair decision on a turbine set for repowering, an owner will want to invest as little money as possible since the turbine will most likely be completely replaced. REWITEC can allow operators to keep those turbines running for as long as possible, generating revenue before they are taken offline. Again, it is an overall business decision based on budgets and agreements.

SB: In Germany, turbine lifetime is expected to be around 20 years. In the past there was a strong focus on repowering, but this comes with challenges due to their locations, they are often too close to residential areas, and permission would not be granted to replace them with larger, more powerful turbines.

Feed in tariffs are also lower today, so it makes sense to maximize the existing wind turbine life. Two per cent of Germany should be used for wind energy generation but availability of land and regulatory requirements are so challenging that it will take at least four or five years to obtain permission to build new wind farms. This is also driving a desire to extend the lifetime of existing turbines from 20 years to 30 years.

SG: This goes back to the market differences and what is happening in the EU. The war in Ukraine and subsequent political situation have made many countries fire up old coal plants for electricity. Electrical demand and profitability are going to be higher in the EU in the next few years, compared to the US.

PES: How is the market developing and how do you see that changing further over the coming months and years?

SG: Wind turbines are getting bigger and bigger. At some wind sites, we now have 10 turbines able to perform the work of 100 older smaller turbines. They are becoming more like traditional fossil fuel power plants in that they are fully instrumented, well maintained and built to last. Consider the loss of one turbine which now reduces output by 10% instead of 1%. There will be a much heavier focus on reliability and maintenance.

Direct drive turbines, which eliminates the need for a gearbox system, are also becoming more prominent, particularly offshore. However, direct drives still retain a very large main bearing, which will need protecting and repairing.

SB: The biggest growth I would expect in Europe is in the offshore segment. Offshore means bigger turbines, bigger dimensions and capacities, whether they be attached to the ocean bed or floating.

China is also going to be a market to really watch. I heard a speech from the Chinese minister of their Energy department at the WWEC conference in Italy, who promised China would reach a 500GB capacity in wind energy by 2024. They have a lot of space for onshore but are looking at offshore as well.

SG: The US has an abundance of natural gas and utilizes this in electrical generation, which is causing the tight margins in the electric industry. This margin squeeze is forcing turbine OEMs to change their strategy and focusing on service contracts built into the sale of the turbine.

PES: And for Cargill? Are there more plans for expansion in the pipeline?

SB: We are still very much exploring our integration into Cargill in terms of ways of working and currently learning how to unlock our huge potential together.

We know that Cargill has a huge focus on sustainability and wind energy, enabling the shift towards cleaner energy and improving the lifetime of wind turbines fits nicely with sustainability strategies.

SG: If we talk about sustainability, think about global emissions: 2% are driven by marine engines. Engine tests with REWITEC show a significant reduction in GHG and increased fuel economy. Since Cargill is a world leader in shipping large commodities utilizing marine and rail the potential here is fantastic. Watch this space.

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