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Pit Boss

Subsea Power Distribution Systems Put to the Test

Offshore Wind
The Future is Floating

2021 & Beyond
More Remote, More Data & More Autonomy

Digitalization
The Digital Oilfield is Closer than you Think

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F E A T U R E S

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The Pit Stop

Ten years ago, a future where subsea fields and their power-hungry process equipment could be fully electrified, enabling long step-outs to tap remote reserves with lean new infrastructure architectures, lit the fuse for a spate of investment in subsea power distribution.

By Elaine Maslin

ON THE COVER: **Image Source: Siemens**

FEATURES

DEPARTMENTS

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BY THE NUMBERS

RIGS

Worldwide

Rig Type	Available	Contracted	Total	Utilization
Drillship	21	51	72	71%
Jackup	147	298	445	67%
Semisub	19	58	77	75%

Africa

Rig Type	Available	Contracted	Total	Utilization
Drillship	1	8	9	89%
Jackup	19	16	35	46%
Semisub		1	1	100%

Asia

Rig Type	Available	Contracted	Total	Utilization
Drillship	5	5	10	50%
Jackup	47	98	145	68%
Semisub	7	15	22	68%

Europe

Rig Type	Available	Contracted	Total	Utilization
Drillship	5	2	7	29%
Jackup	21	26	47	55%
Semisub	5	22	27	81%

Latin America & the Caribbean

Rig Type	Available	Contracted	Total	Utilization
Drillship	2	19	21	90%
Jackup	2	2	4	50%
Semisub	2	9	11	82%

Middle East

Rig Type	Available	Contracted	Total	Utilization
Jackup	28	116	144	81%
Drillship	1		1	0%

North America

Rig Type	Available	Contracted	Total	Utilization
Drillship	5	16	21	76%
Jackup	24	33	57	58%
Semisub	3	3	6	50%

Oceania

Rig Type	Available	Contracted	Total	Utilization
Drillship		1	1	100%
Jackup	1	1	2	50%
Semisub	1	4	5	80%

Russia & Caspian

Rig Type	Available	Contracted	Total	Utilization
Jackup	5	6	11	55%
Semisub	1	4	5	80%

This data focuses on the marketed rig fleet and excludes assets that are under construction, retired, destroyed, deemed noncompetitive or cold stacked.

Data as of November 2020.
Source: Wood Mackenzie Offshore Rig Tracker

DISCOVERIES & RESERVES

Offshore New Discoveries

Water Depth	2015	2016	2017	2018	2019	2020
Deepwater	26	12	16	16	19	11
Shallow water	85	66	74	51	81	24
Ultra-deepwater	19	16	12	17	17	5
Grand Total	**130**	**94**	**102**	**84**	**117**	**40**

Shallow water (1-399m)
Deepwater (400-1,499m)
Ultra-deepwater (1,500m+)

Offshore Undeveloped Recoverable Reserves

Water Depth	Number of fields	Recoverable reserves gas mboe	Recoverable reserves liquids mbl
Deepwater	555	41,951	21,184
Shallow water	3,223	418,326	143,499
Ultra-deepwater	327	41,723	26,419
Grand Total	**4,105**	**502,000**	**191,102**

Contingent, good technical, probable development.

The total proven and probably (2P) reserves which are deemed recoverable from the reservoir.

Offshore Onstream & Under Development Remaining Reserves

	Water Depth of fields	Remaining reserves gas mboe	Remaining reserves liquids mbl
Africa	614	19,633	11,988
Asia	863	16,074	7,574
Europe	770	12,071	13,377
Latin America and the Caribbean	198	5,941	37,364
Middle East	127	70,980	144,718
North America	557	3,034	13,909
Oceania	87	11,358	1,359
Russia and the Caspian	58	12,237	13,322
Grand Total	**3,274**	**151,328**	**243,612**

Onstream and under development.

The portion of commercially recoverable 2P reserves yet to be recovered from the reservoir.

Source: Wood Mackenzie Lens Direct

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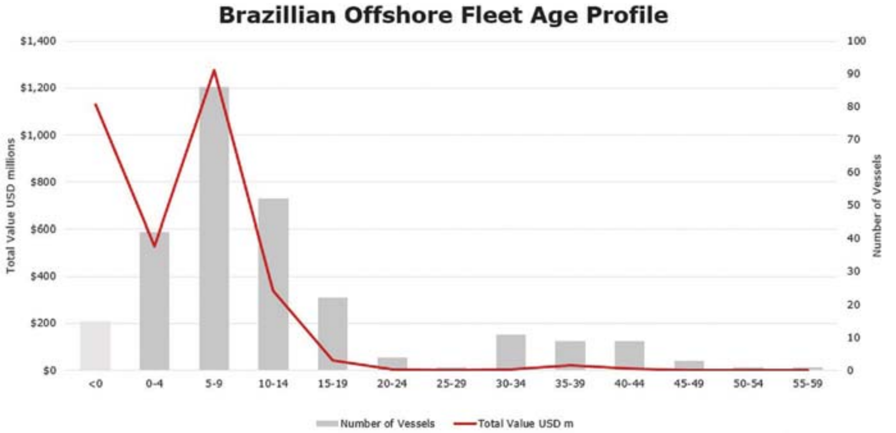

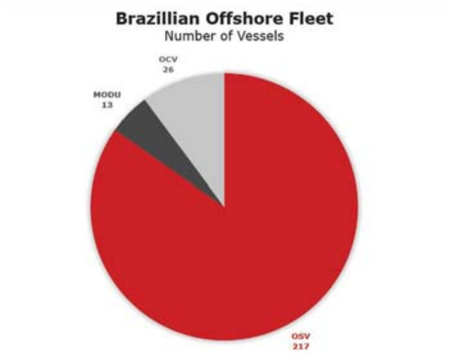

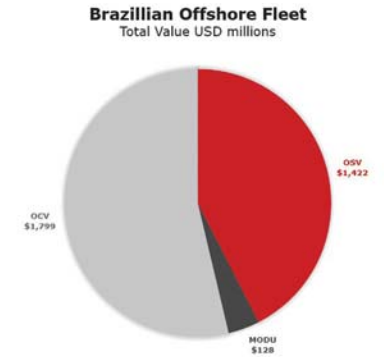

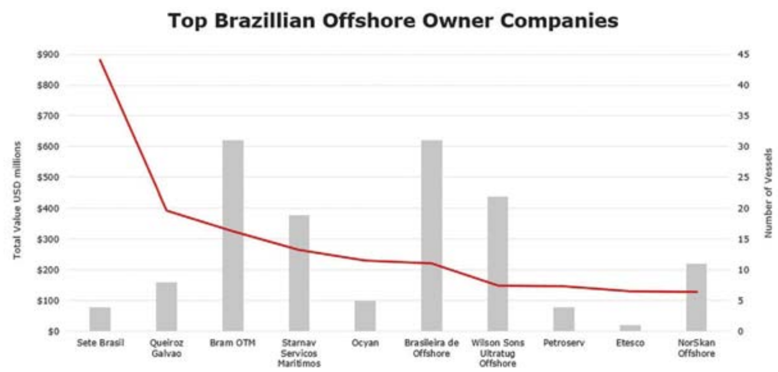

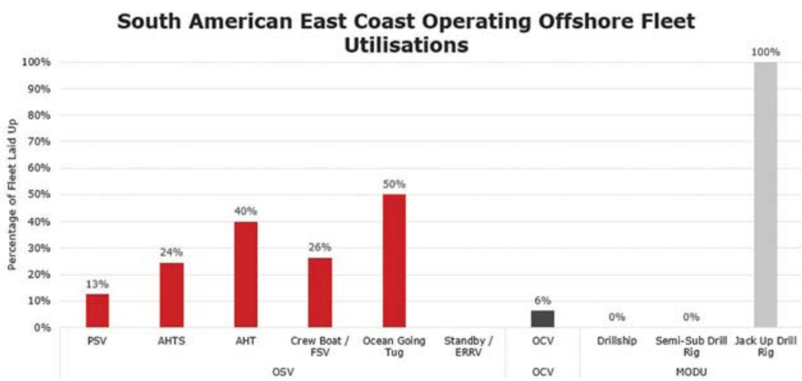

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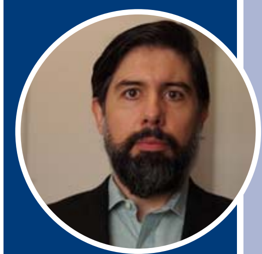
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Mulligan


Maslin


Olsen


Pallanich


Tomic

ON TO 2021

For most of us, the year 2020 will forever live in infamy, as it undoubtedly has been the longest, toughest and most mentally challenging 12 month period of my 54 years. The offshore oil and gas market, already mightily challenged by a prolonged half-decade plus slump, was punched in the face by the COVID-19 pandemic and its multitude of ripple effects. It yields little solace to realize that we are not alone, and the business and lifestyle changes from 2020 will echo for a generation.

The year 2021 starts with the seismic shift of U.S. presidential administration, and as most of you know that president-elect Joe Biden's party is not historically a favorite of the energy business. But these are not usual times, and there is a long laundry list of priorities for the incoming administration, including national security, energy security, jobs and the environment … all which sit directly in the wheelhouse of the *Offshore Engineer* community. NOIA President **Erik Milito** writes on NOIA's strategy to work with the Biden administration, with a recent study from Energy & Advisory Partners (EIAP) as its centerpiece. The study found that by 2040 Gulf of Mexico oil and gas production could support more than 367,000 jobs, provide $31.1B in GDP and $6.7B in government revenues. And that's not counting input from the burgeoning offshore wind energy industry. The U.S. is undergoing an energy transition, but it's not yet clear "how far, how fast." What is clear? For the coming generation, all forms of offshore energy – oil, natural gas, and renewables will have a role. Particularly exciting is the emergence of floating wind farms, as the floating wind industry will rely heavily on the expertise of the traditional offshore energy companies, and present big opportunities too for companies throughout the industrial, maritime, port and logistics supply chain. According to **Philip Lewis,** Director of Research, World Energy Reports (WER), "WER is tracking a pipeline of over 66GW of floating wind projects, which will create significant supply chain opportunities, from ship and offshore yards, to concrete pre-cast and in-situ contractors, ports, anchor manufacturers, mooring chain and rope suppliers and OSV companies."

Today's COVID-19 disaster will effectively fast-track a number of technological initiatives, too, as **Elaine Maslin** reports on the trends that will flourish in 2021 and beyond starting on page 20. The key word here is "more" … more remote, more data, and more autonomy.

The digital revolution will advance more rapidly, as organizations digest the pros and cons of the 'working remote' mantra. Working from home is certainly not a luxury for all, but efficiencies and cost savings associated with handling everything from routine inspections to emergency repairs efficiently, effectively, remotely, will not go away. This biggest change could come with the movement of production to the sea floor. As Elaine Maslin reports, "Ten years ago, a future where subsea fields and their power-hungry process equipment could be fully electrified, enabling long step-outs to tap remote reserves with lean new infrastructure architectures, lit the fuse for a spate of investment in subsea power distribution."

As we close 2020 and open 2021, I offer a sincere wish of a happy and healthy holiday season and New Year, and thank you, as always, for your interest and support.

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Source: Kongsberg Maritime

ISLAND CRUSADER

On the back of a deal struck by Norway's Kongsberg Maritime to supply turnkey hybrid battery solutions for 3 Island Offshore's platform supply vessels, Offshore Engineer *interviewed* **Geir Oscar Løseth**, *Kongsberg Maritime's General Manager Sales, Advanced Offerings, to learn more about the push to get more offshore vessels to go hybrid.*

OE: What is behind the Norwegian offshore support vessel sector's increasing drive to install batteries and go hybrid?

Løseth: Batteries and hybrid technologies are a key strategy for reducing fuel consumption and, consequently, emissions. Moving towards electric drive is also important in reducing maintenance costs and meeting charter requirements. Kongsberg Maritime is proud to offer vessels and technologies that are both more efficient and safer than previous standards, which is vital both for sustainability and safeguarding business in today's tough market.

OE: You've recently received an order to upgrade three Island Offshore's PSV's to run on hybrid power, including a lithium-ion battery solution. Kongsberg has said that Island Offshore has set "a clear precedent in the market" by contracting Kongsberg for the upgrade. How so?

Løseth: Kongsberg Maritime has cooperated closely with Island Offshore for many years and has developed a deep understanding of how their vessels are used. This has aided us in producing an ideal solution for the customer, which will adapt and scale for use on similar vessels.

OE: How expensive is such an investment for an OSV owner in Norway? What is the payback time? Is there government support?

Løseth: A typical turnkey solution costs NOK 18 million -23 million [$1.96 million - 2.51 million]. Without funding, the typical payback time is 4-6 years. However, in Norway, there are several government financial initiatives, ENOVA and NOX Fund being key enablers for several projects of this type.

OE: Can you talk about charging patterns, capacity, capabilities, battery lifetime? How much have things progressed in this space? If you can draw a comparison with smartphones, where charging times are going down, and battery capacity is increasing.

Løseth: We design our battery solutions to meet each vessel's requirements. Some need high charge rates; others may prioritize a long discharging period. All batteries have limits, and if they are used outside their design criteria, you will reduce their lifetime.

A typical battery installation of this type will be designed to function efficiently for its intended purpose for 10 years before degrading below its design specification. More demanding design criteria, of course, drive costs, so we always adapt our proposal to our customers' needs, budgets, and project frameworks.

OE: Apart from emissions reduction, what are the operational benefits of having such a solution onboard an offshore support vessel?

Løseth: Key benefits are redundancy and safety, but battery and hybrid solution also grant the possibility to run the vessel more efficiently in several operational modes. This leads to a reduction in engine running hours and maintenance costs. For some customers, the possibility for zero-emission operation in sensitive areas such as exposed harbors etc. is also important.

We have made our standard Containerized Energy Storage System with the option for charging via a shore connection too, meaning the vessel can be emission-free entering and departing port, and on the dock.

OE: When one says hybrid and/or battery in the offshore oil and gas space, one starts thinking green, environmentally friendly, safe. A casual reader will be familiar with lithium-ion batteries through, for example, usage in their smartphones. While it's not every day that one can hear about serious incidents, planes have been grounded in the past after batteries in phones, and hoverboards caught fire.
So, is it 100% safe to have Lithium-ion batteries aboard offshore vessels? Especially in the harsh offshore environment?

Løseth: We have addressed this by designing our marine battery solutions with a high focus on battery safety. Kongsberg Maritime uses a 'three barrier' safety system, which allows us to offer our battery system in the market with a high level of confidence in its safety.

Our SAVe batteries use both passive and active barriers to prevent thermal runaway, with passive isolation to inhibit heat propagation between cells and modules, and active water mist cooling between modules. In addition, the batteries are carefully managed during both charge and discharge, with cells monitored and logged for voltage, temperature, and current to ensure optimal storage, life, and safety. Battery modules are housed in sealed cabinets which give us complete control over their surrounding environment and enable management of any released gases.

OE: How many offshore vessels have you fitted with hybrid solutions so far?

Løseth: We have so far delivered 62 hybrid/battery solutions, 43 of which are now in operation. The first battery system was delivered in 2012, and our first collaboration on hybrid systems with Island Offshore entered service in 2015.

OE: Apart from OSVs, where else do you see battery usage as feasible in the offshore energy space?

Løseth: In general, all market segments and vessel types can make use of battery power, in various ways. We have deliveries to several different segments.

OE: While Norway is almost 100% powered by "green electricity" from hydropower, and charging batteries with such electricity can indeed be called green, not every country has that "luxury." Do you see this as an impediment to the rise of battery-powered/hybrid OSVs elsewhere? For example, in countries where electricity is produced by coal plants?

Løseth: We believe that the key savings are delivered through better engine performance and reduced parallel operation due to redundancy. We, therefore, do not expect the main growth area to be in fully battery operated vessels, but more in hybrid solutions with other fuels such as LNG, Ammonia, Hydrogen, Bio Diesel or similar.

For example, a hybrid power retrofit project on a Platform Supply Vessel yielded measured reductions of 20% in fuel consumption and 43% in engine running hours. This was achieved by utilizing a redundant battery solution connected to the main switchboard for Dynamic Positioning operations.

OE: Do you see a future where all the offshore support vessels are battery-powered or hybrid? What needs to happen for this scenario to unfold?

Løseth: On a global level, we need all major players to take action to reduce emissions. Hybrid operation with batteries is a part of such reduction. Kongsberg Maritime's solutions team emission reduction with significant other savings which is not the case for all suppliers' battery installations.

I believe that future OSV's will have more efficient power systems, whereby multiple power sources are used in combination. Batteries will be a part of the solution, but not all of it. If we look to the aviation industry, none of the airlines own their engines any more: the have a 'Power by the Hour' solution where they pay for use of the machinery, which remains the property of the manufacturer. I think this type of business model can be applicable for the marine industry, especially as power systems become more complex to maintain. Kongsberg Maritime is leading the market by already offering this kind of solution, and I think this will be a growth area for our business going forward.

BIDEN ADMINISTRATION CAN ALIGN WITH OFFSHORE ENERGY

By NOIA President Erik Milito

Economic recovery. Climate change. Racial equity. COVID-19. These four issues are at the core of President-elect Joe Biden's Day 1 priorities. Separately, each issue seems like a monumental challenge with no easy solution. But there is a path forward for each priority offered by America's offshore energy industry.

The continued success of U.S. offshore oil, natural gas and wind development and production paves the way towards energy security, high-paying and accessible jobs, and capital investment and spending in every state, while our nation produces vast quantities of energy with a much smaller physical environmental footprint, lower air emissions, and more efficient water use and management.

The Gulf of Mexico has long been a domestic energy anchor. Prior to the unprecedented drop in energy demand due to COVID-19, the U.S. Gulf of Mexico was producing close to 2 million barrels of oil per day. In 2019, they symphony of U.S. offshore production involved more than 345,000 men and women across all 50 states, had a GDP impact of $28.6 billion and provided more than $5.4 billion in government revenues.

The industry provides opportunity throughout every corner of the U.S. From the oil and gas companies that make up the fabric of countless Gulf Coast communities to buoy experts in Maine to software companies in Florida to concrete specialists in Hawaii, every U.S. state has businesses and employees linked to the offshore industry.

Every barrel of oil that these men and women help produce is a barrel that our nation does not have to import from countries such as Russia or China. Not only does outsourcing our energy needs to Russia and China send jobs and economic growth overseas, but it also outsources energy production to regions of the world that do not share our level of safety and environmental performance and oversight.

Once offshore oil and natural gas reach American refineries, it provides the plastic components that is used in the medical equipment at the front lines of the COVID-19 response, among many other products. These benefits are nonpartisan and touch every American.

One of the strengths of the U.S. Gulf of Mexico is how it produces energy. On average, Gulf of Mexico oil and gas production has a carbon-intensity one-half of other producing regions. Deepwater oil and gas production has the lowest greenhouse gas emissions of all sources of oil and gas production. The Gulf of Mexico is also one of the best performing regions when it comes to the venting and flaring of gases, including methane. This incredibly small environmental footprint also occurs miles and miles away from onshore populations areas, completely avoiding the traditional adverse fenceline issues related to environmental justice.

Revenues from offshore oil and gas fund virtually the entire Land & Water Conservation Fund. Since 1965, the Land and Water Conservation Fund has provided more than $4 billion in funding that has gone towards more 40,000 conservation and environmental programs in every county in every U.S. state, territory and in the District of Columbia.

Along with providing recreational opportunities and preserving ecosystem benefits for local communities, the LWCF also enables public access to outdoors areas, including in our urban areas. One program – the Outdoor Recreation Legacy Partnership Program - allocates funds to build new parks or improve existing ones in economically-disadvantaged urban areas throughout the country. More than $28 million has been distributed to approximately 50 disadvantaged communities since its creation by Congress just six years ago. Offshore oil and gas production thus promotes positive environmental justice benefits by helping to make parks and recreation more readily available to underprivileged neighborhoods.

The importance of environmental stewardship and access is a consistent point of bipartisan cooperation, which was shown through the recent signing of the Great American Outdoors Act. The recently signed law permanently funds the LWCF and boosts maintenance funding for our treasured national parks through offshore revenues.

Americans can be able to count on these benefits for decades to come. Oil and natural gas, and lots of it, are going to be needed for the foreseeable future. The firm Energy & Advisory Partners (EIAP) released a study finding that by 2040 Gulf of Mexico oil and gas production could support more than 367,000 jobs, provide $31.1 billion in GDP and $6.7 billion in government revenues.

But economic and energy devastation would be unleashed if the offshore drilling or leasing bans floated by some political circles are enacted. EIAP predicts that an offshore leasing ban would reduce the economic and employment outlook by 50 percent to 60 percent, while a drilling ban would cut them by 75 percent to 85 percent.

The health of the Gulf of Mexico oil and gas industry is inextricably linked to our rising offshore wind industry. Offshore oil and gas innovation is helping to build the offshore wind sector. Hundreds of companies, many of which have their roots in oil and gas, are helping to build out the offshore sector.

Wood Mackenzie found the near-term wind lease sales in just four offshore areas - New York, North and South Carolina, Maine and California – could provide 37 gigawatts of new, clean energy, support 80,000 annual jobs, and drive more than $166 billion in new investment by 2035. This is just the tip of what offshore wind can deliver the U.S.

Offshore wind jobs and investment will have a significant economic impact throughout the nation. Whether it is turbine safety equipment providers in Georgia, steel fabricators and heavy lift vessel operators in Louisiana or blade manufacturers in Colorado, the widespread impacts of offshore wind will drive jobs and economic opportunities throughout the U.S.

The U.S. is undergoing an energy transition, but one that is going to need all forms of offshore energy – oil, natural gas, and wind. The offshore energy industry has a track record of innovation and technological advancement that is solving energy challenges, increasing efficiency, and reducing emissions. Not only can we solve energy and climate problems, but we can also scale and deploy real-world solutions.

As President-elect Biden begins building his agenda that coalesces around economic, social and environmental opportunities, he should not forget the opportunity the offshore energy industry can provide. Alignment with the offshore opportunity would be a win for every American.

THE DIGITAL OILFIELD IS ARRIVING SOONER THAN WE THINK

The Coronavirus and a surge of available connectivity means take up of new E&P technologies is stronger than ever, writes ***Tore Morten Olsen,*** *President, Maritime, Marlink.*

The oilfield of the future is a concept that was emerging before the Coronavirus overwhelmed the global economy and sent shockwaves through the energy markets. In fact, the disruption of 2020 is the continuation by other means of a trend that was already gathering pace.

When Norwegian energy major Equinor first announced a tender for the 'Rig of The Future' it aimed to lower its cost of operations with fewer humans onboard, greater automation and digitalization, driving higher efficiency and lower carbon emissions. The company targeted 50% lower operating costs than its current rigs, achieved through a combination of fuel savings and reduced headcount.

Some skepticism surrounds the project's status and while evaluation of the project is continuing, it is becoming clear that Equinor identified technology gaps in areas including fully unmanned operations on the drill floor and solutions for achieve zero carbon dioxide emissions.

Whatever the short-term impacts, it seems clear that digital technology will be key to realizing similar projects and helping the wider industry meet both its environmental and financial targets.

For new technology to be more widely adopted also requires cultural and organization change. The offshore industry has used surveillance and some elements of remote control for many years but the acceleration of this process towards remote and virtual operations marks a critical step forward on the journey.

The energy market has traditionally positioned itself on the conservative end of the adoption curve and the inherent disadvantages of both operational size and legacy systems have led to uncertainty about how to safely adopt and integrate new technology.

The combination of 'new technology plus people' has been seen as risky while simply applying enough people power gives a level of confidence. This stems in part from the fact that company senior decision-makers have field experience but are not 'digital natives' who have grown up with technology.

THE NEW NORMAL

Current market conditions, compounded by the imposition of social distancing measures have led to a unique crossroads that all offshore operators must face. Less capacity for available staff, increased costs and the difficulty of transporting people to and from remote sites are forcing them to quickly adapt.

When the potential of remote operations was proposed in the past, there tended to be push back: a combination of regulation and corporate culture meant there was always a reason to have people on site. It's possible that with the shore office also changed by Covid-19, and the remote work revolution the idea of a hybrid approach has become more acceptable.

Out at sea there is a need to develop a transformational vision, while keeping the focus on the asset itself. While modern platforms are likely be well equipped, but depending on the age, configuration and condition of their assets, the extent of digitalization effort and the investment required will vary.

This new normal allows for previously sacrosanct subjects to be approached and different solutions to be considered. The last few months have seen the advancement in technological acceptance

> *"Remote operations in the offshore market provide multiple benefits. These include risk mitigation because more personnel are removed from the offshore environment, certainty of program delivery thanks to expedited data delivery, client cost reductions and more flexible and scalable operations and finally sustainability because operational carbon footprint can be dramatically reduced.*
>
> **– Tore Morten Olsen, President, Maritime, Marlink**

pushed forward by months or even decades. In February 2020, a major operator reported that remote operations had increased from less than 10% to approaching 30% six months later.

Applications such as video and low latency two-way data transfer share the same drivers which are catalyzing the adoption of more remote operations. In fact, the kind of remote visual inspections we have seen done increasingly by drone or over video might even be possible by direct satellite inspection as more and more low earth satellites join the fleet.

Such working practices have proven their value during months of lockdown and the technology is reliable enough to support increasingly complex applications.

Remote operations in the offshore market provide multiple benefits. These include risk mitigation because more personnel are removed from the offshore environment, certainty of program delivery thanks to expedited data delivery, client cost reductions and more flexible and scalable operations and finally sustainability because operational carbon footprint can be dramatically reduced.

A designer of remote operations centers mentioned that pre-Covid-19, his company faced a long cycle of justification, approval and funding before he got to a sale. Now he's dealing with engaged executives that know they need to adapt and who see remote as a conduit to do this.

This serves as a catalyst allowing for the remapping workflows and reshaping management structures enabling a transformational vison to emerge with a focus on digitalization.

A DIGITAL EVOLUTION

The connectivity component of the digital oilfield was already changing prior to the pandemic. Just a few years ago the focus was mainly on crew welfare and how to monetize bits and bytes with new applications.

An OSV that might have been on a 256kbps plan five years ago would have at least quadrupled its bandwidth to 1MB using a combination of remote monitoring and other operational data. Upgrades to communications platform mean that the same OSV might be able to use its existing antenna and onboard equipment to get much greater capability without increasing its sunk costs.

At the more technology-driven end of the market seismic survey vessels are performing edge processing of data and connecting to the cloud rather than share raw data for analysis ashore. A subsea vessel can work faster and with greater control over its actions thanks to improvements in network technology.

Marlink supports this kind of innovation using a distributed teleport infrastructure with 'handover' and landing to the local teleport which reduces latency.

In both onshore and offshore fields, whether moving or static these remote facilities face the same challenges. The problem of reliably and robustly connecting systems and workers in the field to control centers and the cloud requires expertise in mobile and fixed communications.

It is still a case of selecting appropriate bandwidth capability to match the application as a different speed of response is needed for remote drone piloting compared to pipeline inspection. A tendency we have noticed is for operators to ask for higher and higher bandwidth without necessarily having the demand to support it. It is better to start lower and upgrade as they move from low level data into real time applications.

INTO THE FUTURE

What seems clear is that with fewer people onboard, the size of assets whether fixed or mobile can be smaller and more tailored to specific roles. They will be more tightly connected to shore but will also have more systems onboard for processing data gathered from any phase of the exploration and production process.

We have grown accustomed to an industry with assets and vessels specialized towards specific and particular tasks. The future could see fewer larger motherships controlling smaller and potentially autonomous vessels which perform specific tasks but without crew onboard.

Operators are already looking into a new generation of multipurpose vessels for the inspection, repair and maintenance market, which provide a platform to launch autonomous and remote-controlled vessels. These will perform tasks such as mapping of the seabed and other geophysical survey applications for pre-seismic and pipe-laying survey and windfarm development.

Marlink is providing a "smart" network solution to the Remotely Operated Service at Sea (ROSS) OSV project developed by offshore services operator SeaOwl, which demonstrated the concept to strategic partners including French energy major Total in early September. The ROSS project aims to bring down the cost of operations by remotely controlling a vessel from shore, initially in the offshore sector with potential application to other civilian and military craft.

The rig of the future has already been conceived as a smaller asset, designed for more flexible operations with a higher degree of automation and control systems that enable the operator to reduce numbers and still satisfy regulatory requirements.

Such designs would embrace technical flexibility in a way we have not seen in place in the energy market with smaller multi-purpose vessels having capabilities beyond the larger vessels in service today.

The key message is this: the oilfield of the future is not a distant dream but already a work in progress. It needs to happen here and now as we adapt to the Covid-19 environment; cultural resistance to positive technological change cannot be an excuse for lower safety standards or higher costs. Despite the tragedy of the virus, operators can take advantage of a once in a lifetime opportunity, leverage the digital transformation towards a smarter and safer industry.

CONNECTIVITY & CYBER SECURITY WALK HAND-IN-HAND

PATRICK DECOOL, Director Innovations, Marlink

While connectivity is the circulatory system to digitalization, cyber security is the immune system. We recently spoke with Patrick Decool, Marlink's Director Innovations, to discuss the increasing prevalence of cyber-attacks on maritime and offshore assets and strategies to protect those assets.

While 'Cyber Attack' is the buzzword, attack in this regard can be somewhat of a misnomer as the majority of 'attacks' are actually facilitated accidentally from within a company.

According to Decool, Marlink sees that there are many IT breaches made by the crew; 'cybersecurity is not just about attacks, it's also about managing properly your network and making sure the crew are not bypassing the rules that you've defined within your own IT policy,' said Decool. 'We've seen that 68% (of) these threats are coming from the crew.'

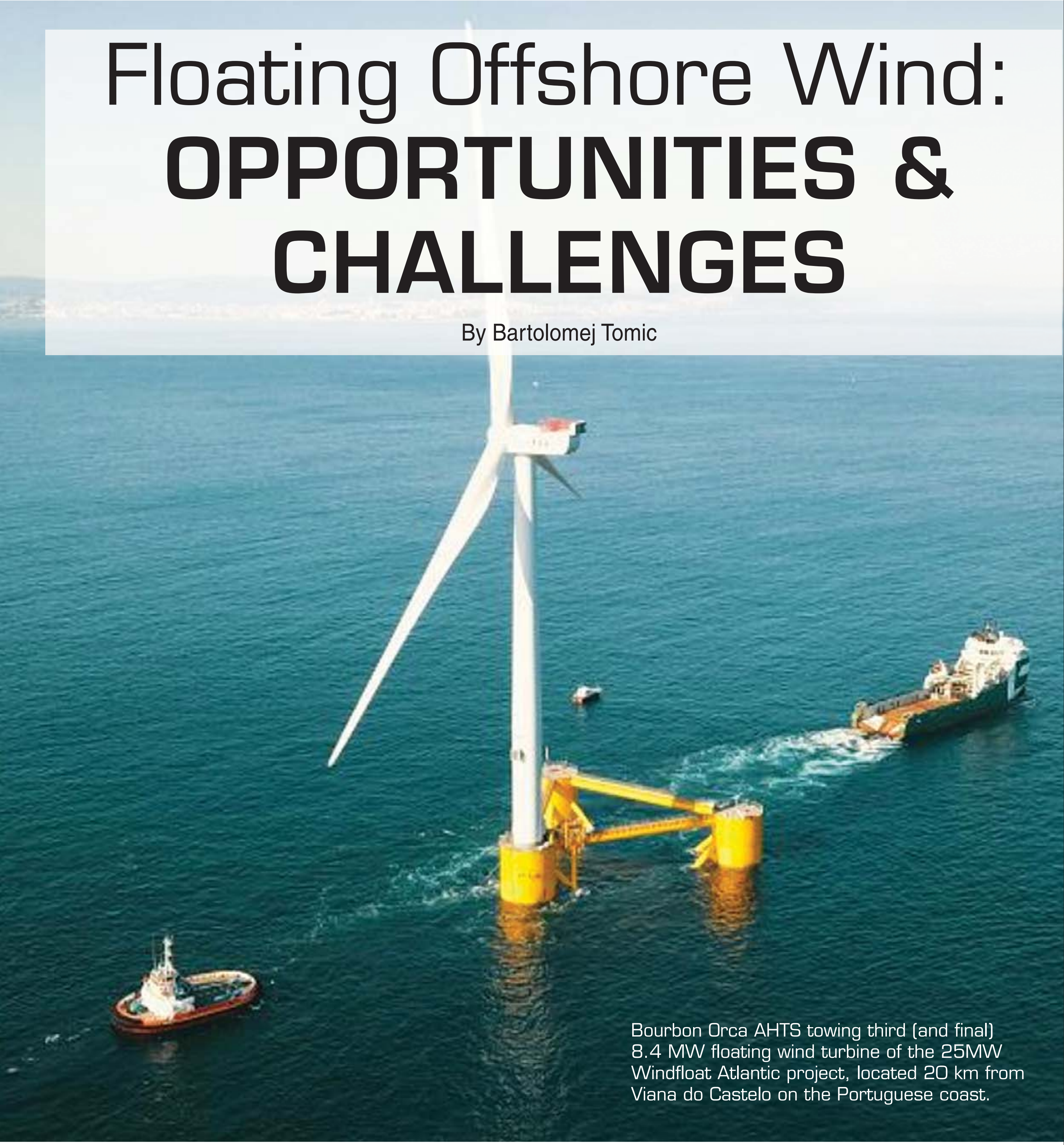
Marlink's study further found that 22% of the threats are coming from the admin network, with 10% coming from the IoT or OT network. '10% compared to the rest might be not so much, but 10% of something that could affect an engine or an automation is dramatic from a safety perspective of the vessel.'

Decool believes the discussion will start to move from IoT to OT as OT gets more and more connected. 'Then the interest from attackers may grow because the impact will be much larger. Once I have an access to the OT environments, then I have a real pressure on the company moving forward.'

According to Decool, vigilance is the keyword in keeping your networks safe – 'Be pragmatic, follow the 'plan-do-check-act' principle, and don't worry you'll do that next year and the year after' – as cyber security is a race without a finish.

Floating Offshore Wind: OPPORTUNITIES & CHALLENGES

By Bartolomej Tomic



Bourbon Orca AHTS towing third (and final) 8.4 MW floating wind turbine of the 25MW Windfloat Atlantic project, located 20 km from Viana do Castelo on the Portuguese coast.

Source: Bourbon Offshore

The floating offshore wind industry, still considered nascent – and minuscule compared to the installed capacity of its "older brother, "– that is the conventional, fixed bottom offshore wind industry (29GW at 2019 end) – is showing promise and is expected to take off big time by the end of the decade.

While the current installed capacity – less than 100MW - is small and focused on pilot and demonstration projects, the potential is there for the floating wind farms to reach and, theoretically, even surpass the installed capacity of the traditional offshore wind turbines, and not by a little, given that there are no water depth limitations for installation.

Offshore Engineer's Greg Trauthwein interviewed Philip Lewis, Director of Research, World Energy Reports, and author of *OUTLOOK FOR OFFSHORE WIND POWER, THE FRONTIER OF FUTURE ENERGY,* to learn more about the opportunities and challenges in the industry that could rise to prominence sooner that one might think.

Lewis first provided some context on the traditional offshore wind industry, which uses fixed-bottom turbines, installed at water depths of up to 60 meters.

"…bottom-fixed offshore wind farms have been in operation since 1991, and so this is not a new industry. We saw the true industrialization of the sector over the last decade and the adoption by more and more European and East Asian countries of this increasingly cost-competitive technology," he said.

80% OF WIND RESOURCE FOUND IN DEEPER WATERS

However, Lewis says the reason World Energy Reports is so interested in floating offshore wind is the sheer amount of resource available beyond the 60-meter water depth, the general threshold considered for floating solutions.

"Some 80% of the world's wind resource is found in deeper waters suited to floating wind foundations. These resources are generally able to access higher quality wind resource. Further, floating structures can deploy larger turbines which support higher capacity factors, which means they produce more electricity," Lewis says.

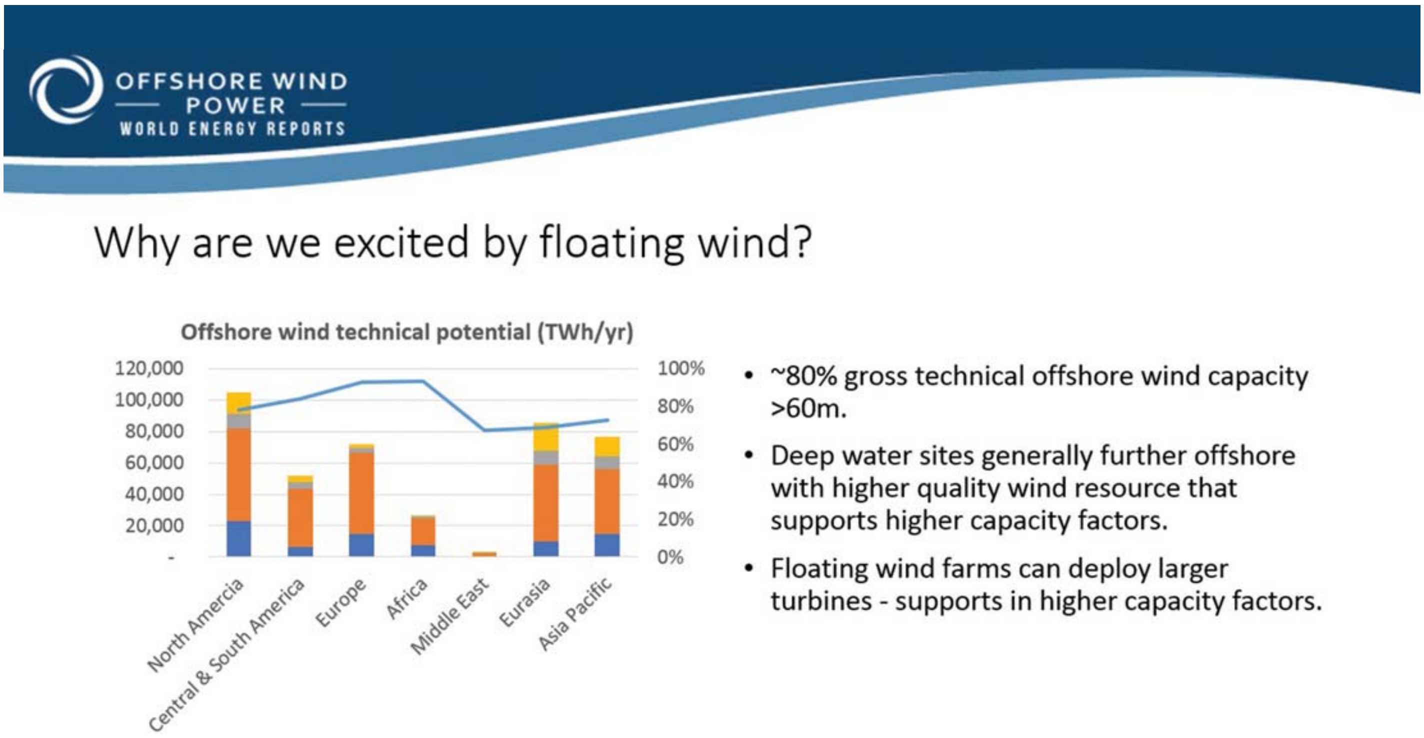
So, where are we now? We are passing from the prototype and demonstration project phase towards industrial-scale floating wind farms, Lewis says.

According to World Energy Reports, the floating wind installed capacity will reach between 8 to 10 GW by the end of this decade, and next decade WER expects to see more than 60GW of floating wind farms commissioned.

Worth reminding, DNV GL recently said that floating wind could grow 2000-fold, by 2050 (DNV-GL), from 100 MW today to 250 GW in 2050.

BIG OPPORTUNITY FOR OFFSHORE O&G SUPPLY CHAIN FIRMS

Lewis says that the expected growth in the floating wind



industry also represents a significant opportunity to those in the supply chain, and the companies that have traditionally served the offshore oil and gas industry. Concrete contractors will benefit, as well.

According to WER's offshore wind report, floating offshore projects differ from bottom fixed in that offshore construction and installation calls on methods very familiar to oil & gas offshore yards and offshore support vessel (OSV) owners and operators.

"At World Energy Reports, we see the opportunities for traditional offshore and marine companies that support the oil and gas sector like offshore yards, mooring system chain and anchor manufacturing and OSV operators. We also see exciting opportunities for those not traditionally involved in the offshore oil and gas market, such a pre-cast concrete and in-situ concrete contractors and manufacturers of synthetic ropes," Lewis says, however warning that WER does not feel that the supply chain has fully embraced the scope and scale of the opportunities that exist in this sector.

60 CONCEPTS

World Energy Reports is tracking some 60 floating wind substructure concepts. Of these 60, 38 have been tank tested and 20 scale tested in the field and 3 concepts have been demonstrated at full scale.

"Only 2 concepts have reached the stage of pilot array to date, although several more concepts will reach this stage over the next couple of years. We expect to see the first pre-commercial arrays - that's under 100MW by 2022 - and the first commercial arrays over 100MW by the middle of the decade," Lewis says.

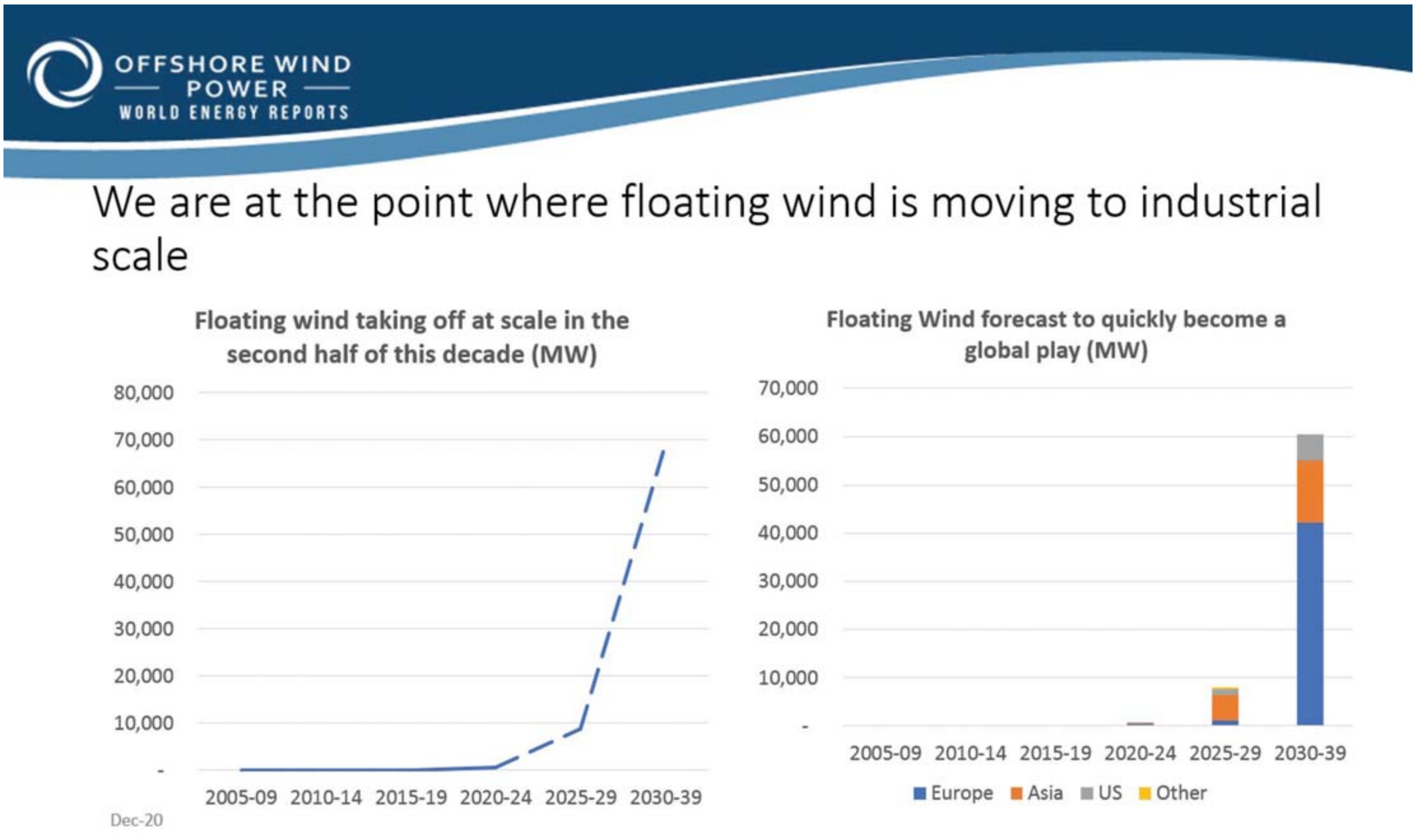
CHALLENGES

With any opportunities, invariably, there are challenges. What has been touted as a benefit earlier in the article – bigger size – can also pose a challenge.

"Firstly, I think most people would struggle to picture how big these units can be. If we take an industrial-scale floating wind farm, you could easily expect to see 50 to 100 steel or concrete or substructures to meet a 200-300 day installation weather window.

Taking the example of a steel floater, Lewis explains, that could be 150,000 to 350,000 tonnes of steel to be produced in two to three years, with each 2500-3500 tonnes structure requiring some 6,000+sqm of area.

"The structures are physically large and will be required in large quantities," Lewis says.



Furthermore, in addition to waterside laydown areas, there will be a need for assembly berths and wet storage, where turbine diameters exceed 200 meters.

Lewis' World Energy Reports also sees a major opportunity, as well as a constraint, in the quantity and capacity of anchor handlers and construction vessels to tow wind turbines, pre-lay moorings, and hook-up systems.

"There is a specific challenge to adapt offshore oil & gas mooring solutions to floating wind – addressing weight, quantity, and footprint of the anchors and mooring lines," Lewis explains.

Dynamic array and high voltage export cable manufacturing and installation capacity is another challenge to address, especially the manufacture of above 66kV dynamic export cables, he says.

And finally, Lewis says, the inspection of large numbers of in-water components and where the question of in-situ (floating-to-floating) versus tow-to-port repair and maintenance programs is to be addressed.

"SOME 80% OF THE WORLD'S WIND RESOURCE IS FOUND IN DEEPER WATERS SUITED TO FLOATING WIND FOUNDATIONS. THESE RESOURCES ARE GENERALLY ABLE TO ACCESS HIGHER QUALITY WIND RESOURCE. FURTHER, FLOATING STRUCTURES CAN DEPLOY LARGER TURBINES WHICH SUPPORT HIGHER CAPACITY FACTORS, WHICH MEANS THEY PRODUCE MORE ELECTRICITY."

PHILIP LEWIS
DIRECTOR OF RESEARCH,
WORLD ENERGY REPORTS

MORE remote, MORE data, MORE autonomy

By Elaine Maslin

Late 2018, before net-zero targets had been agreed to by most western energy giants and nations, BP came out with a goal to reach 100% of subsea inspection by marine autonomous systems by 2025.

It was a tangible goal then, and it's one that might now be reached faster as remote and more "digitally" oriented operations take hold with greater opportunities for new nimble players in the market. It's a goal being chased in the offshore wind sector too.

Some of it is about emissions targets. Starting in 2019, the growing mass of pledges to net-zero targets by nations, upstream companies, and even suppliers has accelerated moves to do more remotely – lowering emissions (and, it's hoped also, costs).

In offshore wind, it's also about the growing mass of turbines out there that present a significant operation and maintenance challenge.

A global pandemic restricting travel has now accelerated some of that innovation. Remote operations a reality rather than a road map.

Refocus, reform – greener visions

Taking a step back, it's a tough, rapidly evolving environment for many, with depressed oil prices having impacted the oil and gas industry specifically, resulting in a wave of company restructuring.

"Companies are busier than ever working out what to prepare for the future," says Bjørn Søgård, Segment Director for Subsea, DNV GL.

Tier 1 contractors created through mergers just a few years ago are starting to be unravelled into more renewable versus traditional business (e.g. Aker Solutions spinning off its offshore wind and carbon capture segments) or demerging to distinguish upstream from midstream-downstream (e.g. TechnipFMC and its spinout Technip Energies), points out Søgård, as CO2 starts to emerge as a balance sheet item and companies need a visible green profile.

Operator strategies are focusing on emissions reduction, production and use of renewables alongside and oil and gas, but also power from shore, says Chris Pearson, the UK's National Subsea Center director.

Expect more sensors, data, analytics

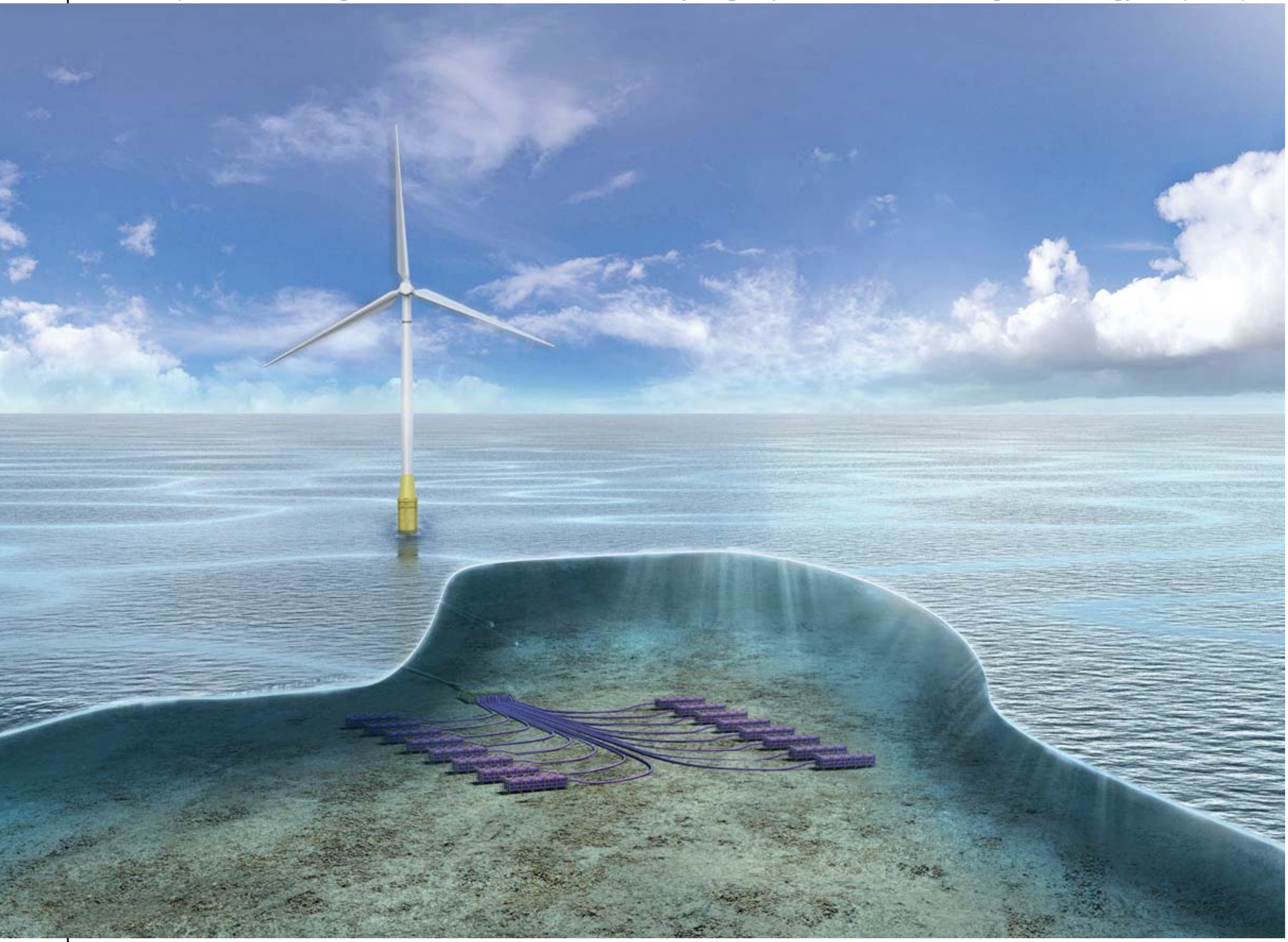
In the technology domain, the world is potentially equally as agile. Lee Wilson, who co-founded new company Honuworx at the start of 2020, says we now need to learn from the likes of Apple and Amazon and behave more like software companies, instead of sticking rigidly to a four-year technology roadmap and finding the world has changed at the end of it.

So what does that involve? Expect there to be more sensors, data, and data analytics that will feed subsea robotics, automation, and remote hubs and cyber-physical systems, says Pearson.

Some of that is already coming, not least around the use of unmanned systems (UxV). In 2019-2020, unmanned surface vessels (USVs), such as those from XOCEAN, were used for survey and data harvesting type operations. In 2021, USVs that can deploy ROVs and AUVs will enter the market, including the first of the 21m and 36m-long Armada fleet, being built by Ocean Infinity, and Fugro's SEA-KIT USVs; both of which will increase the scope of what can be done remotely.

After the first vessels come out, more that can also deploy aerial drones will come – something which will be of use in the offshore wind industry for blade inspection – but also bigger and more capable ROVs, including work class, for inspection,

TechnipFMC is working with a consortium on subsea hydrogen production and storage technology Deep Purple.



Source: TechnipFMC

repair and maintenance and even geotechnical work, says Karl Daly, director, IRM services Europe, at Fugro, speaking at the recent joint IMCA, SUT, Hydrographic Society in Scotland seminar. Instead of contracting a DP vessel, operators will be contracting for delivery of data, he says.

While initially there will have to be a human in the loop for all operations, from the growing number of remote operations centers popping up, the future will move to one person overseeing two or even three vessels, says Mike King, business development manager at Ocean Infinity, also speaking at the online event.

The vessels and what they do will also become more and more autonomous, says Daly, although this will have to be done in tandem with the development of regulatory policy around uncrewed marine operations.

Subsea residency

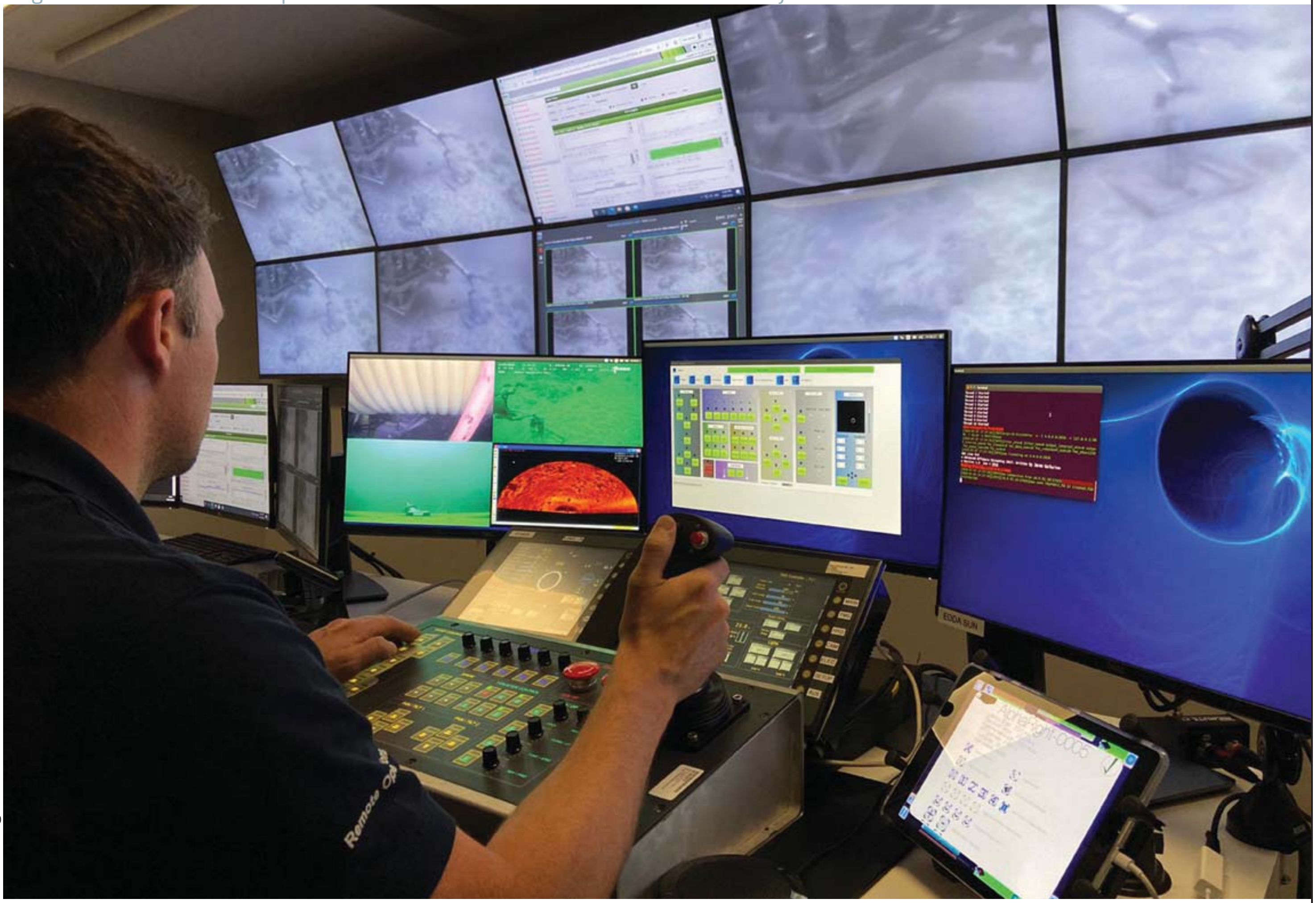
Deploying an ROV with batteries and communications buoy (i.e. Oceaneering's E-ROV system) will continue, enabling un-vessel supervised campaigns, while moves towards subsea residency continue to creep forward.

Saipem's Hydrone-R is set to be deployed at Equinor's Njord field offshore Norway some time in 2021.

Saipem says Hydrone-R can spend up to 12 months underwater, without being brought back to surface.

Hydrone-W, it's work class cousin, is due to go through testing in 2021. Eelume, the snake robot, is also due to be trialed at Åsgard, also in the Norwegian sector, while Oceaneering's Freedom vehicle is also set to be let loose in the wild, likely on pipeline inspection operations.

"Whether the systems are hosted subsea or on the surface, Fugro has four remote operations centers around the world currently.



Source: Fugro

having 'eyes, 'ears' and even 'hands' on site remotely will help to increase asset uptime and potentially reduce the number of incidents through early identification," thinks Damian Ling, Geomatics Advisor at Chevron's Energy Technology Company (ETC), while USVs will increase how much shallow water inspection or host an AUV for deep water, without using crewed vessels, he says.

"I see both methods or services as complementary to achieving the same goal," he adds.

Increasing use of survey techniques adopted from terrestrial industries, such as photogrammetry, LiDAR, fiducial landmark navigation and automatic target recognition, will also help increase the efficiency of surveillance data collection and "enable autonomous inspection methods and provide data products from which we can have additional uses," says Ling (his views, not Chevron). Companies like Cathx Ocean, 2G Robotics (photogrammetry), 3D at Depth (LiDAR), and Forsea (landmark navigation) are examples here.

But rather than coming back to base with a flood of data, edge processing, data analytics, and miniaturized sensors will also help.

The same technologies and systems are set to benefit the offshore renewables industry, as it looks for ways to provide inspection and maintenance scope across its growing fleet of wind farms. "We are seeing residency systems for subsea becoming viable," says Dan Summer, Project Development Manager at the UK's Offshore Renewable Energy (ORE) Catapult. "IoT and continuous monitoring technologies enable more predictive maintenance, meaning less trips to site while remote technologies mean less people offshore."

Electrification

Some of the underlying technologies that enable remote operations and autonomy have become increasingly available over recent years, from terrestrial communications, including satellite and marine 4G networks, to underwater communications, including free-space optics, acoustics radio, and hybrid systems, says Ling.

Emerging low earth orbit satellites will further expand what's possible.

But another enabler may also finally come to market: subsea electrification. Subsea electrification could enable increased use of subsea processing, from pumping through to compression, enabling longer subsea tiebacks without the need for new topsides or significant modification to existing topsides, and also deeper water projects.

It's been a long time coming. Subsea power distribution systems have been qualified by ABB and GE Oil & Gas, with Siemens following and TechnipFMC also developing a lower cost system for sub 6MW users, initially. Others are offering local power generation with options ranging from power generated on site using wave or tidal technology (Ocean Power Technologies, Mocean Energy), to fuel cells, such as Teledyne's subsea supercharger, battery storage systems, including EC-OG's Halo energy storage system, and a combination of both, such as one being created by Columbia Power Technologies (C-Power).

"We see a clear trend towards a greater degree of electrification as the CAPEX/OPEX benefits have been demonstrated and the industry seeks to lower emissions," says Christina Johansen, Senior Vice President, Product Management, TechnipFMC, which has been developing its own subsea power distribution system and sees digitalization and industrialization as key directions of travel for the subsea industry.

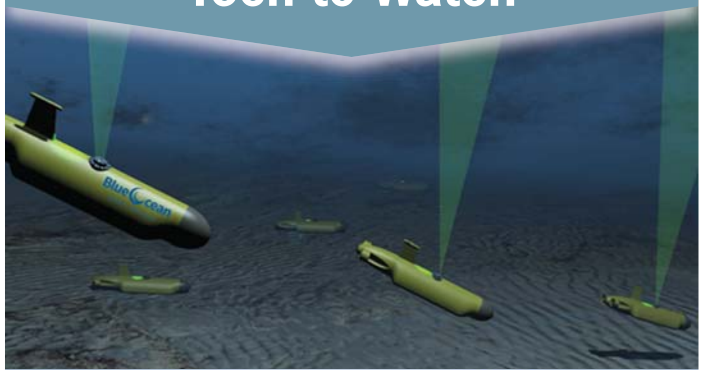
The future is fluid

There's a lot going on – the future is fluid, says Ling. Incumbents are being forced to compete with new entrants. University spinouts and new start-ups have or are entering the market, think Seebyte and Hydromea). There's also room for players from other industries (e.g. Kawasaki) to disrupt the market with innovative technology.

Honuworx is one of those. It's developing solutions for the launch, recovery, and remote operation of underwater vehicles that removes the requirement for large support vessels and complex lifting equipment.

It's co-founder Lee Wilson says the industry and market dynamics have changed structurally in the last year, with tiebacks more likely than big new greenfield projects (such as those that might attract a field resident system), and companies will need to be more agile. If they are, there's a lot to go after in the wide subsea ocean economy, he says, from food and energy production to mineral mining. There's just little certainty how that's going to look.

Tech to Watch



Source: BOSS

SWARM ROBOTICS: Blue Ocean Seismic Services (BOSS) is developing autonomous underwater vehicles that will operate as a self-repositioning autonomous underwater node to carry out seismic surveys. It's effectively a fleet of AUVs that will be able to take themselves, en-mass to pre-programmed sites on the seabed, stay there while a source vessel sails over, then move to the next site – saving the time it currently takes to manually place nodes using ROVs or via the node on a rope method. They could also identify and monitor carbon storage sites, says BOSS.

SUBSEA HYDROGEN: Hydrogen has shot up the energy agenda in the past 12 months and it's likely to be there for some time. TechnipFMC hasn't missed this and, as part of a consortium with Sintef, Energy Valley, and the Ocean Hyway Cluster in Norway, it's developed Deep Purple, a wind-powered subsea hydrogen production and storage technology, complete with fuel cells to provide power when required. This could be used at offshore platforms, but also remote islands, for ship refueling offshore, and simply for hydrogen export.

UNDERWATER CO2 TRUCKS: More of a mid-long-term vision is Equinor's vision to use a "large subsea drone" to transport CO2 to subsea injection sites, where it could also recharge, while offloading its cargo. The 135m-long "Subsea Shuttle" could also be used to transport gas and water, for reservoir injection, and offload oil, presumably meaning storage subsea can be skipped, instead pumping it directly into these huge vehicles, serviced by resident vehicles.

Edging towards a SUBSEA POWERHOUSE

Ten years ago, a future where subsea fields and their power-hungry process equipment could be fully electrified, enabling long step-outs to tap remote reserves with lean new infrastructure architectures, lit the fuse for a spate of investment in subsea power distribution.

By Elaine Maslin

The result, following at least two major joint industry projects (JIP) and tens of millions of dollars of investment, is that subsea power distribution is now a ready technology, waiting for its first application.

GE Oil & Gas (as was) qualified a subsea power distribution system back in 2016, including variable speed drives (VSDs), switchgear, and power protection, based on existing components marinized in pressure tolerant housings. The system was developed to provide power over a 120 km distance to the Ormen Lange subsea compression project in Norway, only for Shell to decide against the project.

This year, ABB qualified its subsea power distribution system – complete with transformer, VSD, switchgear, and controls, and Siemens is moving closer to qualifying its system.

Others are moving in on the patch with smaller, less complex systems, including TechnipFMC, while Baker Hughes' Modular Compact Pump aims to come with integrated VSDs, mitigating the need for full-on 'type-3' (i.e. supply, transmission, and distribution).

The goal is to provide power, ranging from 750 kW to more than 11MW, to subsea systems, from pumps to compressors.

This includes the power equipment and electronics required, to avoid having to make brownfield modifications on existing topsides and/or enable entirely subsea developments to shore. The benefits are touted as a more scalable and flexible architecture.

However, the much longer step-outs that have been targeted have bigger challenges, in terms of flow assurance, points out Bjørn Søgård, Segment Director, Subsea, at DNV GL. Potential candidate projects like Chevron's Janz-Io subsea compression project, in 1300m water depth 200km offshore Australia, are targeting topside power and controls.

Source: Siemens

Meanwhile, there's also a growing move towards less simpler systems, which could provide a quicker win for less power-hungry near-term tiebacks and brownfield projects, such as the one TechnipFMC is working on with Brazilian electrical and automation firm WEG.

The floating offshore wind market could also offer an alternative market for these technologies – helping to bring power back to shore, instead of sending it out.

ABB trials with OneSubsea

The vendors are looking at options. ABB's system would be suitable for 4-12MW applications, says Asmund Mæland, Global Head of Subsea, ABB Energy Industries, such as a OneSubsea wet gas compressor (WGC).

In fact, earlier this year, ABB joined forces with OneSubsea and performed a full-scale string test using ABB's VSD (which varies the power to meet the needs of the pump/compressor) on OneSubsea's multiphase WGC6000 compressor.

The VSD and compressor operated submerged in a shallow water test pit on a hydrocarbon loop at OneSubsea's Horsøy facility, near Bergen. The test demonstrated 8MW shaft power capability and took both systems to TRL5 (Technology readiness level 5) – meaning they're ready to be deployed commercially, says ABB.

The test, supported by the JIP partners (although the JIP is officially complete), was mostly carried out remotely, due to covid restrictions, with 100 client witnesses watching on.

"It's scalable," ABB's Mæland says, and opens the path for longer distance oil tiebacks, but these hinge on solving flow assurance challenges, which others are working on, he says.

Longer gas tiebacks could also come, but these hinge on solving flow assurance challenges, which others are working on, he says.

Subsea pumping and gas compression are likely the first users for this technology, says Mæland, but also pipeline heating systems, for flow assurance.

Subsea to shore projects, which are enabled by this technology, are also being looked at by the energy companies, says Svein Vatland, Head of Subsea Technology Programs ABB Energy Industries.

Other ideas are also being assessed, such as using a subsea transformer and maybe also switchgear subsea to support brownfield platform electrification where lack of topside space or the economics of modifications would preclude such options, says Mæland. This is an area gaining interest in the UK, where platform electrification is seen as a way to reduce emissions. ABB is working with Aker Solutions and Kellas Midstream in this space, and it's something BP has been exploring.

Beyond these ideas, the technology could also help integrate offshore wind power and even hydrogen into the offshore energy mix.

Subsea transformers could be used as gathering stations for offshore wind power, reducing platform maintenance, says Mæland. Having subsea power distribution could also support seabed mining operations and the increasing move to autonomous marine systems, which would need power. Integrating batteries and offshore wind would need subsea control systems, and this is something ABB is also working on.

Siemens testing its subsea power distribution system.

Siemens close to qualified

Another JIP was run by Siemens Energy to deliver 6 MVA of power over 200km and distribute it locally, is ongoing. Supported by Chevron, Exxon, Equinor, and Eni Norge (now Vår Energi), Siemens Energy is adding a VSD (now at TRL4), switchgear and controls to its already qualified transformer, all for 3,000 m water depth.

Siemens' entire subsea power distribution grid, including VSDs, transformer, switchgear, and control, all in oil-filled pressure compensated enclosures or 1-atmosphere control canisters, was put through a full shallow water test in a dock in Trondheim in 2018-2019.

Since then, the company has been working through lessons learned, says Eduardo Pimentel Silvestrow, product life cycle manager for the Subsea Power Grid at Siemens Energy.

It's reached TRL 4 on the VSD, making it ready for commercial use, alongside the already qualified transformer. The switchgear has been through an optimization project with a new version currently going through testing and is expected to be ready for commercial use in 2021. The power grid would work alongside Siemens' DigiGRID, which is an open architecture infrastructure and communication platform facilitating all-electric control systems.

Source: ABB

Source: ABB

"We have proven what we wanted to prove," Silvestrow says, "testing the underwater cooling capacity and we're confident the cooling is as expected and matches all the simulations we have done." Silvestrow says the company is seeing potential applications for multi-megawatt large compressors and single load as well as dual or mixed load applications.

While the prototype is 6 MVA, the system is modular, he says, and can be easily downrated or uprated as needed. In service, the VSDs could be put in parallel to provide higher power. Additionally, low voltage local distribution could be done using some of the subsea power grid elements.

TechnipFMC works with WEG

TechnipFMC has been developing a subsea power distribution station since 2015, working with Brazilian firm WEG, but it's been assessing the market since 2013, says Eduardo Cardoso, director of Subsea Processing Technologies at TechnipFMC. The company thinks there's a gap in the market for less complex systems.

"We concluded there was an unmet market for subsea power distribution, as long as we successfully address the system cost and complexity," he says. "Those were the main problems preventing customers from using subsea process-

Selection from ABB showing their VSD being lowered into a test pit for a test with OneSubsea's WGC600 and the control room during the test.

Source: ABB

Source: TechnipFMC

"WITH THE SUBSEA POWER DISTRIBUTION STATION, YOU HAVE A LOWER OVERALL SYSTEM COST AS YOU HAVE REMOVED ALL THE REAL ESTATE MODIFICATION CONSTRAINTS," *HIGHLIGHTING THAT A POWER CONTROL MODULE TOPSIDE WOULD MEAN ADDING 70-100 TONNES AND MECHANICAL STRUCTURE ADJUSTMENTS.*

Eduardo Cardoso,
Director of Subsea Processing Technologies at TechnipFMC

ing more frequently."

TechnipFMC's solution, based on existing components that have been marinized, is modular, based on 1.5MW subsea VSDs that can be combined, in parallel, to create 1-6MW power stations.

Initially, TechnipFMC is looking at 6MW and lower projects, which will mean it's mostly targeted to pumping projects down to 700kW. It's a good fit for single pump applications that need something lower cost where the topside is constrained, but it can be scaled up, says Cardoso.

It's also a good fit for all-electric fields, including electric Xmas trees, he says, as that means you no longer need hydraulic cables and would have a more flexible power distribution architecture.

"With the Subsea Power Distribution Station, you have a lower overall system cost as you have removed all the real estate modification constraints," he says, highlighting that a power control module topside would mean adding 70-100 tonnes and the mechanical structure adjustments that comes with it.

When that's all subsea, you just need to hook up a power umbilical. "With that, we can start entertaining tiebacks in ways we haven't seen before. Now wells that are sitting far from a host can ignore the distance issue and just add pumping."

TechnipFMC has run an extensive qualification program on the technology, including a full load test on the subsea VSD to make sure it can manage the heat efficiently. A 3000-hour test is ongoing.

Baker Hughes integrates its VSDs

In 2016, GE Oil & Gas qualified a subsea power distribution system based on existing components marinized in pressure tolerant housings to provide power over a 120km distance to the Ormen Lange subsea compression project, which then, as mentioned above, didn't materialize. The project included variable speed drives (VSDs), switchgear, and power protection.

Since then, Baker Hughes (which was bought by GE, but is now an independent company again) has been working on its Modular Compact Pump which, with its own integrated VSD, will not need a complex subsea power distribution system, says Alisdair MacDonald, business leader, subsea power and processing, Baker Hughes.

The MCP is a barrier fluid-less system for multiphase boosting with an integrated VSD in one-atmosphere containers, based on topside VSD technology from Calnetix in California. It's due to be qualified in shallow water test at Sintef flow loop in 2022 MCP 1MW will be qualified at the same time, taking it to TRL 4-5.

"Because we have the MCP, we don't need a conventional type-3 (supply, transmission, and distribution) for either multiphase boosting or water injection," says MacDonald. As already pointed out, more conventional subsea pump systems could benefit from a type-3 system, particularly for longer step-outs, but then you have some flow assurance issues to overcome, he says.

For subsea compression, a type-3 would still be needed, yet potential projects that could have used this solution have favored power equipment topside on a spar or floating structure near to the compression station. Others are considering power from shore, with the VSDs onshore.

Time will tell. The march of electrified systems is ongoing. The all-electric subsea production system is the next step. Once that's adopted, the industry could move faster and also start thinking about autonomous power systems, power buoys, and tidal power – see page 30.

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REMOTE POWER, ON DEMAND

By Elaine Maslin

Taking the power to where you want it is another option – perhaps not for compression or pumping system, but potentially for monitoring, inspection, and even intervention systems, such as resident robotics concepts.

It's an idea some have been looking at, such as Ocean Power Technologies, which recently won a DeepStar project award to study the deployment and operational requirements of using its PB3 PowerBuoy to provide remotely controllable power for deepwater subsea oil production applications.

The project, supported by Total, will explore using the PowerBuoy and a subsea battery in 1,000, 2,000, and 3,000m water depth. Read more here (https://bit.ly/37rw1d8).

OPT's Power Buoy system has already been demonstrating local electricity supply from wave energy production offshore Italy.

Now Virginia, US-based Columbia Power Technologies (C-Power) has come up with what it's calling an autonomous offshore power systems (AOPS) to support anything from a resident ROV to, potentially, even uncrewed surface vessel (USV) recharging.

Later this year, the SeaRAY system, which includes power, data, and communications, and could support short term (i.e. for a specific campaign) or longer term subsea power requirements, is set to be deployed on a six-month trial in 80m deep water at a US Navy Wave Energy Testing Site near the Marine Corps Base offshore Hawaii.

Next year, the firm hopes to deploy the system at a 500m deep site in the UK North Sea through a SMART: Scotland grant, before going even deeper. It's also looking at campaign-based asset inspections for offshore wind, which could also be in UK waters.

SeaRAY AOPS combines a wave-energy converter, with single combined mooring that includes power and communications from Wood Hole spin-out EOM Offshore, a seabed unit containing Aberdeen-based EC-OG's 100-kWh Halo lithium-ion battery energy storage system and a tie-up with satellite communications firm RigNet for when 4/5G LTE isn't available.

It's fully capable of supporting vehicles such as trials partner Saab Seaeye's Sabretooth doing 24/7 inspection and light intervention operations, says Reenst Lesemann, C-Power's CEO.

C-Power was set up in 2005 to produce utility-scale wave power. It's still an aim, but the company became aware that discreet power systems could benefit other applications after taking part in a DARPA project to provide power to a subsea power network, says Lesemann.

Last year, it then worked on a US Department of Energy project, and the result was the SeaRAY AOPS, which can provide <1 kW to 20 kW. It also has DataRAY, providing <20 watts, and is working on StingRAY, to provide megawatt power needs.

Key requirements were that it could easy to transport (it fits in two containers), deployable with a small vessel and depth agnostic, says Lesemann.

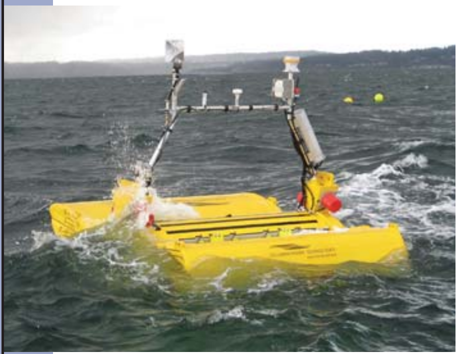
Other potential uses include supporting leak or environmental monitoring, says Lesemann, or even replacing umbilicals in projects. Interestingly, Lesemann suggests this ethos, using small vessels to deploy a local subsea power, inspection, and or intervention provision could then change what types of vessels are used, by shifting what does what. Mix that in the USVs and the options open up even more.

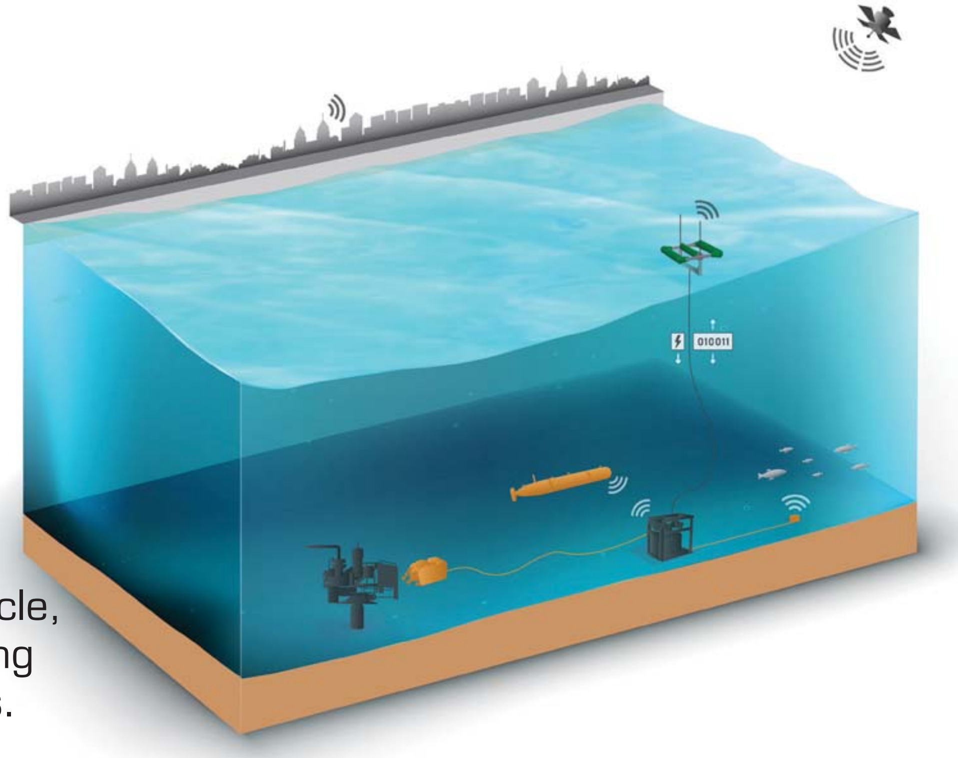
Over in the UK, Edinburgh-based Mocean Energy is also looking to fuel subsea vehicles. The firm has designed a wave energy converter that it wants to offer to supply power to oil and gas facilities, including tie-backs and fleets of AUVs.

Earlier this year Mocean Energy announced a pilot project with the Oil and Gas Technology Centre (OGTC), oil major Chrysaor and subsea specialists EC-OG and Modus to study the potential to use their Blue Star prototype to power a subsea battery and a remote underwater vehicle.

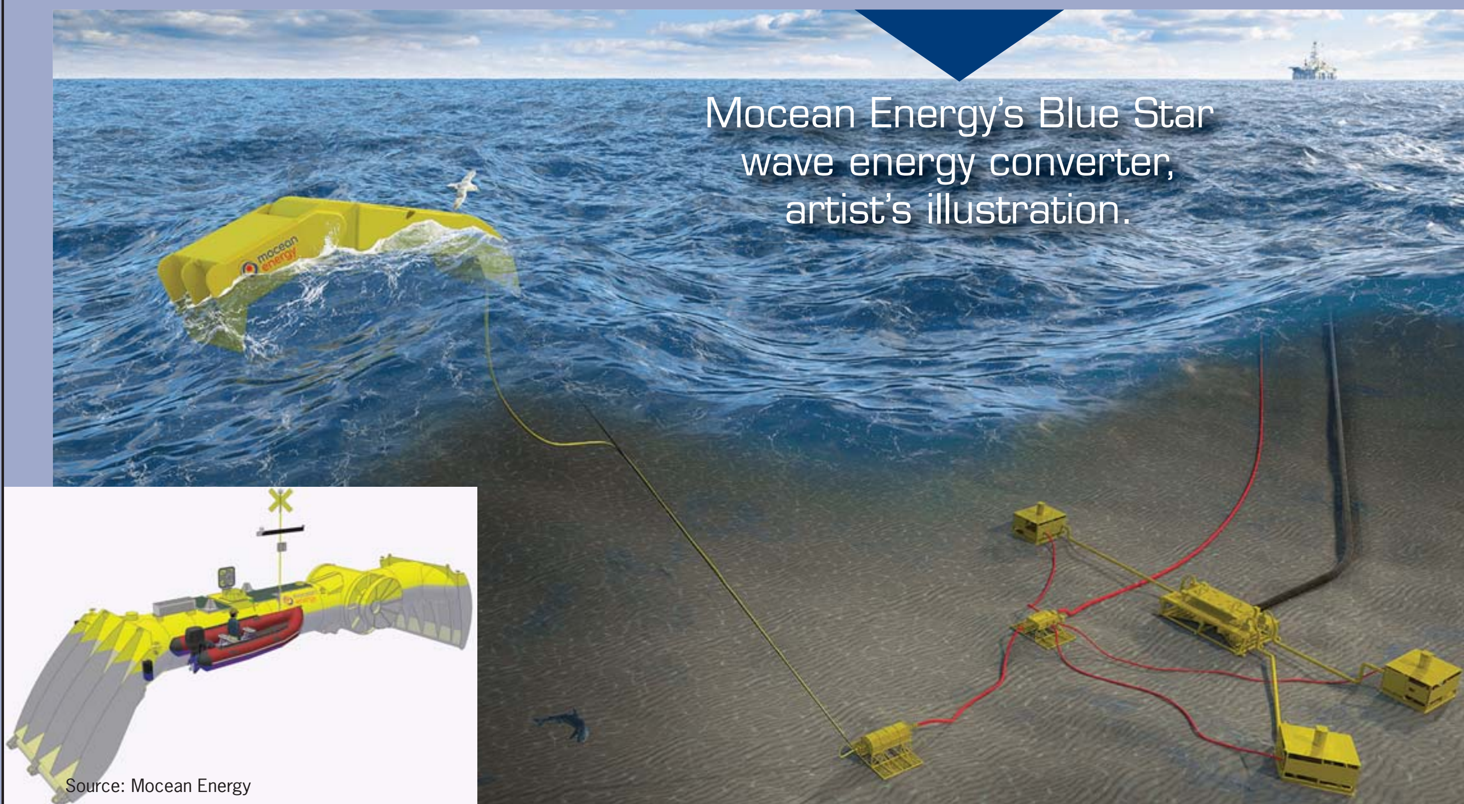
Last year, Mocean Energy secured £3.3 million from Wave Energy Scotland to build and test a half-scale version of their technology at sea. The device is currently being completed at AJS Fabrication at Cowdenbeath in Fife.

Source: C-Power



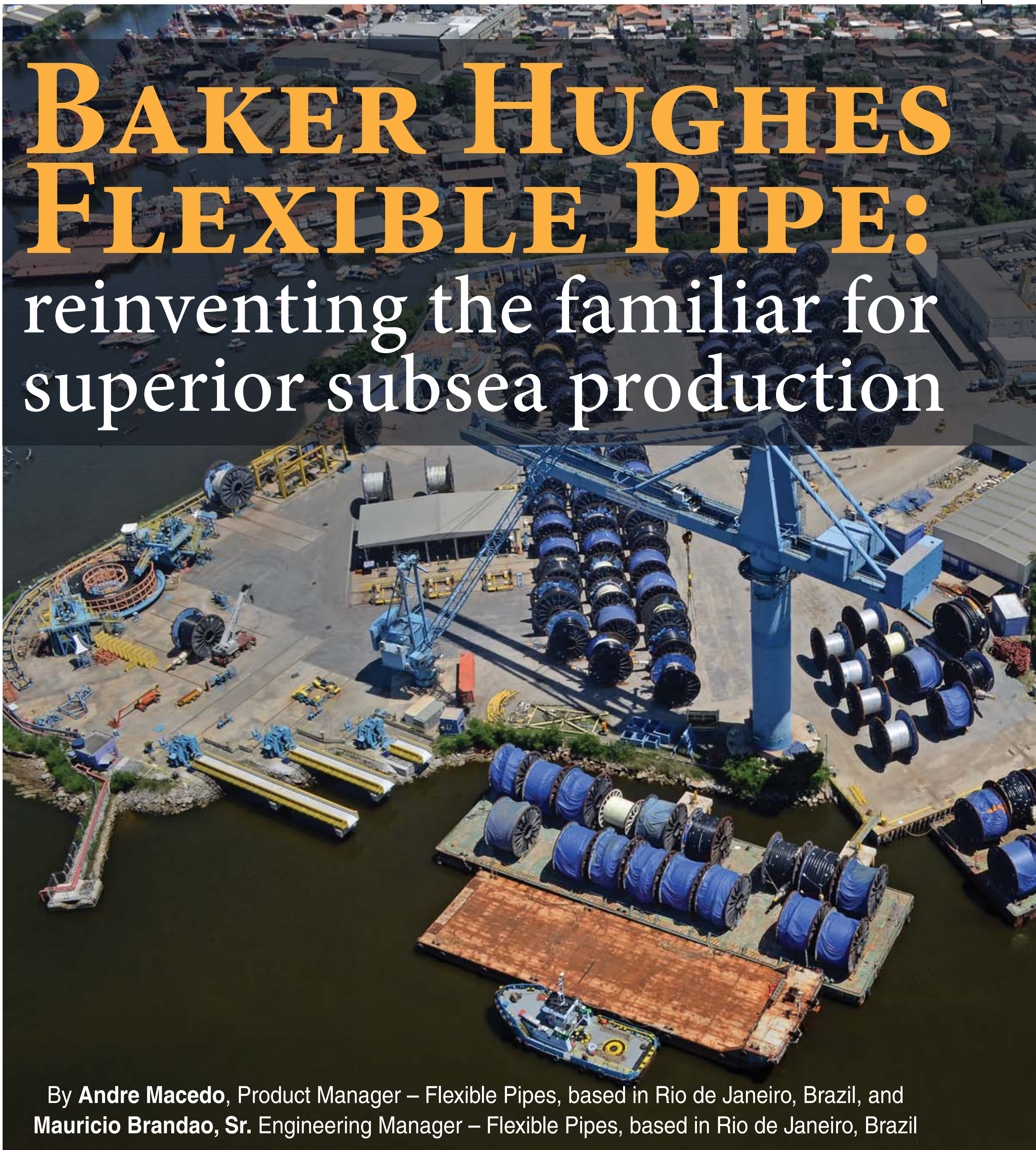


The AOPS with vehicle, sensor and operating equipment payloads.



Mocean Energy's Blue Star wave energy converter, artist's illustration.

Source: Mocean Energy



Baker Hughes Flexible Pipe: reinventing the familiar for superior subsea production

By **Andre Macedo**, Product Manager – Flexible Pipes, based in Rio de Janeiro, Brazil, and **Mauricio Brandao, Sr.** Engineering Manager – Flexible Pipes, based in Rio de Janeiro, Brazil

In 2017, the Brazil National Petroleum Agency (ANP) issued a failure mode alert: stress corrosion cracking (SCC-CO_2) triggered by the presence of CO_2 in high-pressure pre-salt conditions had been identified as the cause of broken tensile armor wires on a certain flexible pipe installation. Relatively common in other applications where carbon steel is subject to high CO_2 concentrations, this failure mode was unknown in flexible pipe – and it presented a major challenge for operators in Brazil's extensive pre-salt fields.

Flexible pipes have played an important role in Brazil's history of oil production.

No other oil province in the world has applied flexible pipes so intensively as the Campos Basin, for example, where approximately 2,223 km of risers and flowlines have been installed to connect giant fields including Marlim, Albacora and Roncador, in water depths that range from 1,500m to 2,000m. It's no exaggeration to say that flexible piping has been crucial to the development of Campos and other basins as viable production sites.

FLEXIBLE ADVANTAGES

Of course, flexible piping is not exclusive to Brazil. Its widespread deployment is down to the many advantages it offers to so many operators. With concentric and unbonded layers, each of which contributes to the mechanical strength and chemical resistance needed to withstand deep-water conditions, flexible pipes were designed to ensure collapse resistance, internal pressure capacity, bending stiffness and axial-load capacity – among numerous other advantages to deep-water operations.

In addition, this unique design gave operators several logistical advantages. Flexible pipes can be transported on smaller, nimbler, and more cost-effective vessels. Manufacture does not require quality-sensitive offshore processes such as welding or field-joint coatings – both of which have, historically, raised concerns about operational integrity.

As the name suggests, they also give operators the luxury of flexibility and enable them to make subtle but important changes at later stages of a project without incurring severe cost penalties.

Once in production, flexible piping gave operators the option of moving subsea lines and re-positioning pipes in response to production needs, or to postpone the exact location of production-well placement decision. As operators started production and built knowledge of reservoir behavior, that flexibility allowed them to optimize both output and field life.

That ability to be easily recovered, inspected, repaired, re-laid and connected at new sites was key: flexibles proved themselves to be the best way of reducing time to first oil by enabling feasible production in short timeframes, even before reservoir de-limitation and subsea layout consolidation. They reduced the risks of drilling campaigns and delivered associated advantages in terms of time and cost.

The ANP's announcement about SCC-CO2 in 2017 therefore had implications for the entire industry.

ADDRESSING SCC-CO2

One short-term option was for operators to reduce their perceived risks by moving away from flexible pipe solutions and adopting rigid pipes instead. But by doing so, all the flexibility that had allowed Brazil to develop offshore fields efficiently would be lost.

Operational complexity, such as the water depth, bore size, temperatures, pressures and contaminants found in the Santos Basin, requires constant review and development of the technology – in this case, the optimization of subsea hardware, as well as installation and operational procedures.

For this reason, Baker Hughes directed its considerable research and development efforts to the exploration of alternative mitigation measures for its clients in Brazil. In the aftermath of the problem identified in 2017, and while not experienced on its own manufactured pipes, Baker Hughes began work on an extensive program to improve the resilience of the installed fleet and to deliver the next generation of SCC-CO2-resistant pipes.

UNDERSTANDING THE PROBLEM

As the ANP report noted, SCC-CO2 is a condition that can induce cracking and even failure in a pipe's steel wires. However, three conditions need to be present simultaneously for such cracking to take place: environment (water and concentrated CO2); high tensile stress exceeding a critical level; and very high-strength materials that are consequently crack-susceptible. If one of these three elements are designed out, cracking cannot happen. Since environmental conditions and high levels of tensile stress were unavoidable, the improvement had to come from the materials used in pipe manufacture.

Also, critical to developing an improved pipe solution is the knowledge that the SCC-CO2 phenomenon is defined by two stages – nucleation and propagation – and that managing them requires different, but complementary approaches.

In the case of propagation of an existing crack, fracture mechanics can be used to define the remaining life of the asset and mitigation work needed. However, a completely different approach is needed when considering the susceptibility of a pipe to crack nucleation.

In this case, multiple small-scale tests using armor wires taken from commercial products can be run for six months to simulate severe environmental conditions. When Baker Hughes ran these kinds of tests, wires were exposed to various combinations of contaminants while loaded at stresses close to the yield point.

COLLABORATION AND COMPOSITES

The lab results showed that it is feasible to design and manufacture a flexible pipe to operate in a SCC-CO2 envelope without incurring any damage. In fact, the tests showed that, in pipes proposed, designed and developed by Baker Hughes, the initiation of cracking would only occur if the loading on the wires and associated stress was raised to double that experienced in the field.

With the results of extensive testing and lab-work as a foundation, Baker Hughes began to develop solutions for its customers. One of the most important steps was to build alliances and partnerships with key material suppliers, test houses, installers and external experts such as the National Composite Centre (NCC) in the UK. This has brought experiences, insights and lessons from other industries to the manufacturing of flexible pipe, adding robustness to the qualification and validation programs.

The outcomes of this work are a new hybrid composite material for pipe manufacturing. The new material offers superior gas permeation performance, but without the traditional metallic layer that is most susceptible to CO2 damage. Not only does the composite pipe reduce the concentration of CO2 at the tensile armors, and is not susceptible to SCC-

CO2, it is also lighter than standard flexible piping. This reduces installation costs even further and allows operators to deploy risers in a free-hanging catenary, removing buoyancies, accelerating installation time and improving safety.

Recent pipe designs have also included reinforced outer layers to protect against perforation or damage during installation, while all end-fitting ports and seals can be tested against external pressure to prove their capacity in deep water. A machined area that allows ultrasonic testing inspection for detecting flooding and a visor rated to 2,500m water depth are added to end fittings.

SENSORS AND MODELS

Recognizing that pipes in service were also a concern for operators, new ways of carrying out dissections to define initial cracks (the starting point for fracture mechanics) and calculating the service life of installed fleets was also needed. This required some means of testing to identify whether a given pipe was flooded or not.

Naturally, this is a key challenge for integrity management teams: the pipes are not designed to have this kind of verification performed once they have been installed and bringing a riser or flowline to the surface for verification is incredibly disruptive.

However, it is an area where sensor technology can deliver exceptional results. Baker Hughes' proprietary sensor technology is now embedded into current risers for pre-salt and work continues developing methods for retrofitting sensors to installed pipe.

Such a system can detect any ingress of water from the topside into the riser annulus along its full length. It provides continuous monitoring, rather than one-off inspections, without extra vessels or ROVs. It can also cover up to five separate pipes and monitor all riser sections from the FPSO up to a 3,600m range. A database of Baker Hughes' SCC-CO2 program outcomes also enables quick identification of products that are not susceptible to this damage mode.

CONTINUING DEVELOPMENT

A team of engineers is now developing comprehensive sets of modeling tools that will be further calibrated by the test results, as well as undertaking a wide range of manufacturing trials in an automatic fiber-tape placement module. This work will enable the behavior of any pipe structures to be predicted without repeating full qualification testing.

These kinds of testing campaigns will continue in order to confirm that all variables – and any combination of variables – that may influence or trigger the SCC-CO2 damage mechanism – are fully explored, mapped and documented to ensure the industry can develop the mitigation strategies for their particular circumstances.

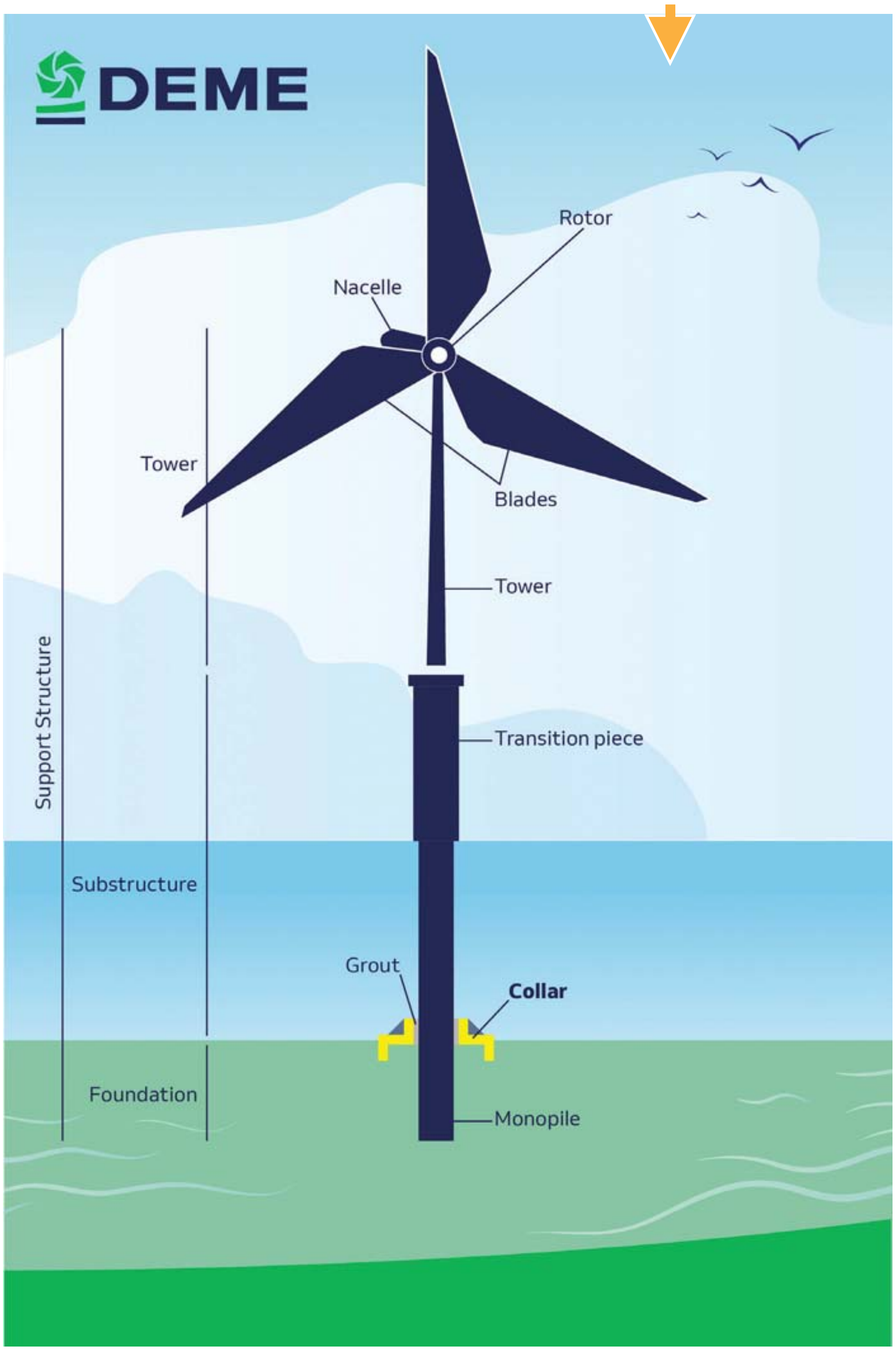
However, the work in Brazil is part of an even bigger picture. The world's oil and gas sector faces unprecedented challenges to meet social and political demands for greater environmental responsibility and emission reduction in the face of extraordinary price pressures and capital constraints. There is, as a result, no shortage of speculation about what the new normal will look like: from autonomous operations to extremely efficient, carbon-neutral developments.

What is perhaps less widely discussed is the idea that 'normal' of any kind will be an increasingly rare phenomenon within the oil and gas sector – or indeed within any industrial sector. Constant innovation, continual development, permanent evolution, and a relentless re-assessment of what works and what can be done better, will be the defining features of successful operators and their service companies. Whether it's the use of advanced sensors, data and analytics, or the modification of manufacturing materials, almost every aspect of the business is open to re-evaluation.

The reality is composite flexibles combined with advanced sensors, and conventional pipe design and manufacturing offer a viable way to continue to use flexible pipes in pre-salt without concern for SCC-CO2.

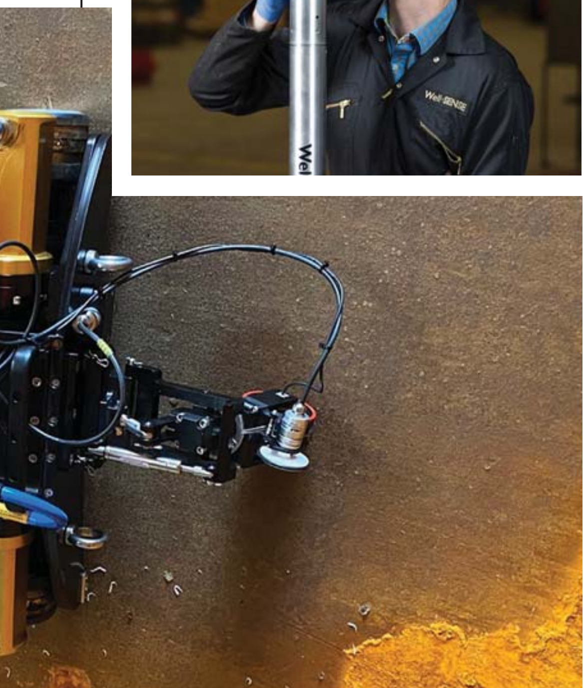
The ability to work on the seabed has always been a challenge. These innovators aim to de-risk subsea ops, helping to make them more seamless, efficient and safe.

Deme



ORE Catapult

WellSense



Baker Hughes

Collared Monopiles

RWE will deploy special collars around the monopile foundations at the seabed level at its Kaskasi offshore wind farm, in what has been described as "the first time ever in the renewables industry."

The 'collared monopile' technology will provide additional support for lateral loading, increase the bearing capacity and improve the structural integrity of the entire foundation – especially in difficult ground.

DEME Offshore will transport and install the new foundation technology at the Kaskasi wind farm in the German North Sea. Also, Kaskasi will be the first commercial offshore wind farm in the world to use an improved installation method to drive all monopile foundations to target penetration. The vibro pile driving technique will reduce both installation time as well as noise emissions for marine life."

iFROG

An amphibious robot called iFROG capable of working in teams to clean and inspect monopiles above water level and up to 60 meters below (~6 bar), has recently completed trials at the Offshore Renewable Energy (ORE) Catapult's National Renewable Energy Centre in Blyth.

Teams of iFROG robots will be able to clean corrosion and biofouling from monopiles, before inspecting the surfaces and conducting pre-emptive checks of weld integrity.

During the final trials, two robots demonstrated how they can work together in a team above and below the waterline. The first robot performed corrosion mapping and water-jet cleaning of the monopile. The second robot inspected weld lines to assess integrity and flag potential defects, ORE Catapult added.

By increasing the frequency and quality of subsea inspections, iFROG can save up to £150,000 (around $200,000) per offshore wind turbine per year, ORE Catapult said.

Floating buoy for subsea power

Ocean energy technology developer Ocean Power Technologies (OPT) has received a DeepStar project award to study the use of its PB3 PowerBuoy to provide remotely controllable zero-carbon power for deepwater subsea oil production applications.

OPT's moored floating buoys - such as OPT PB3 PowerBuoy - harvest wave energy and convert it to electricity.

The project will explore using OPT's PB3 PowerBuoy and a subsea battery to reduce the cost and carbon emissions associated with conventional means of powering and controlling subsea oil and gas production equipment. The study will consider water depths of 1000, 2000, and 3000 meters.

The wave-energy buoy, i.e., power source, can be placed closer to the production site reducing the cost of a subsea umbilical. Coupled with a modular subsea battery (energy storage in the 100-500 kWh range) it provides sufficient power to operate electric trees, SCMs, and HPUs. This enables decarbonization and autonomous, remotely controlled, all-electric subsea production.

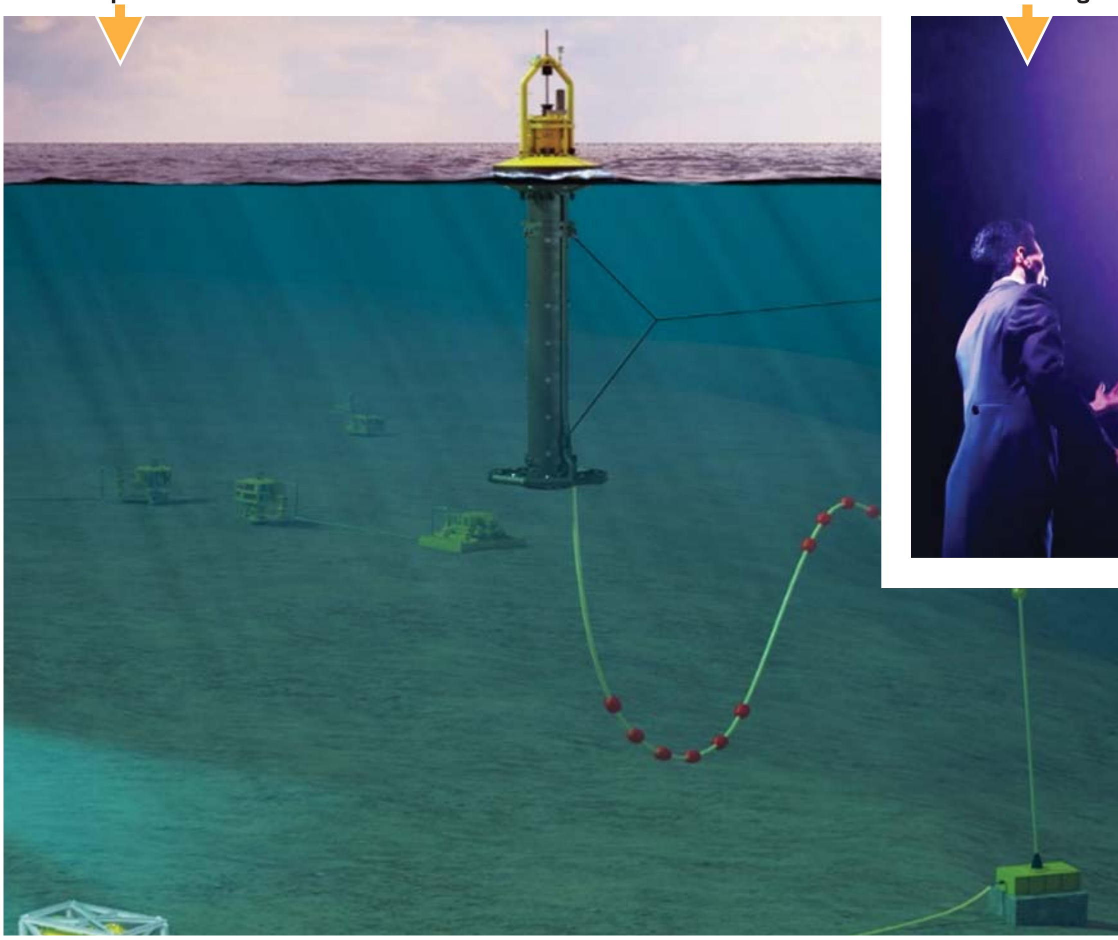
Terminator

Baker Hughes has recently launched its vessel-deployed subsea wellhead cutting system Terminator.

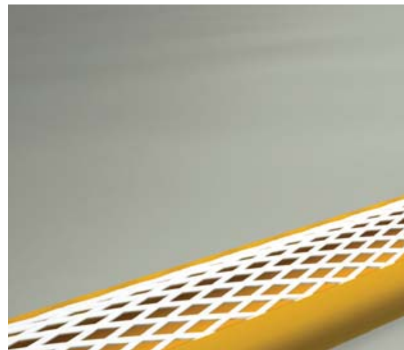
Using a first-of-its-kind mechanical wellhead removal method, the Terminator system cut a subsea wellhead from an abandoned exploration well owned by Wintershall DEA in Norway.

Baker Hughes worked with Wintershall DEA to cut the subsea wellhead from an abandoned exploration well in 360-meter water depth in only 35 min-

Deepstar



Schlumberger



utes. By comparison, alternative abrasive cutting methods could take as long as five or six hours for the cut alone.

The Terminator system can be deployed from a vessel and uses a mechanical cutter, rather than water jet cutting methods of conventional systems, to eliminate associated risks with high pressures. Also, the system can reduce offshore personnel by two-thirds compared to conventional systems, requiring just two people instead of the typical six for water cutters.

The Terminator system can reduce fuel consumption with its 100-horsepower motor and is also smaller and lighter compared to the original 1000-horsepower abrasive water cutting system typically used on similar types of vessel-based operations.

The total operation with Wintershall DEA, from deck deployment to laying down the Terminator system, took just two and a half hours – saving the operator up to 12 hours compared to conventional systems.

FiberLine Intervention

Aberdeen-based downhole sensing technology specialist, Well-SENSE recently won an award for its FiberLine Intervention and its contribution to the offshore well intervention industry

FiberLine Intervention is a new approach to gathering well data, employing single-use, bare fiber-optics for distributed temperature and acoustic sensing. The fiber delivers immediate data as soon as it enters the well, demonstrating changing conditions as it is installed from surface to total depth. FLI then provides a dynamic picture of the entire wellbore, from every point simultaneously, for the duration of the well survey.

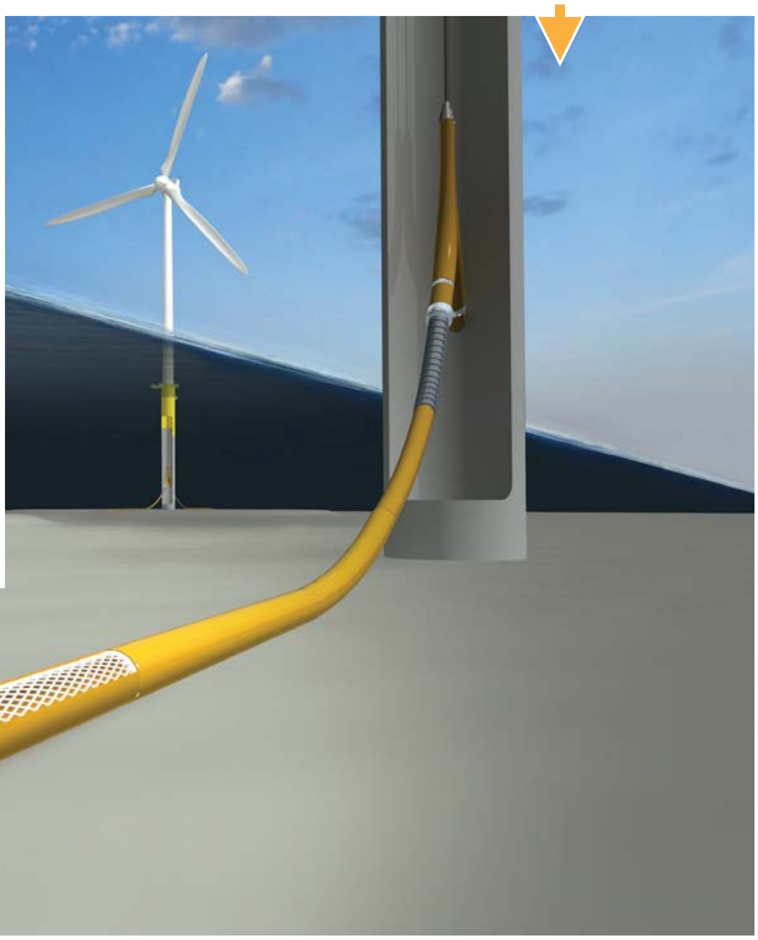
FLI is suitable for a variety of applications from integrity monitoring to seismic surveys. Its rapid, lightweight, rigless intervention system delivers significant cost and efficiency savings, with just one engineer at the wellsite and no requirement for wireline support, according to WellSense.

ReLineWL Coretrax

UK-based well integrity and production optimization firm Coretrax recently deployed its ReLineWL expandable straddle in the Gulf of Mexico, helping an operator to troubleshoot an inoperable safety valve, passing through a restriction that conventional straddles could not pass through.

According to Coretrax, the one-trip

Balmoral



Coretrax

rigless system developed to address common well integrity issues, delivers a 700% greater flow area when compared to traditional straddles, "allowing operators to install a patch without creating a restriction and to unlock greater commercial value from existing wells."

"Unlike conventional straddles, the ReLineWL's slim outer diameter meant it could bypass various ID restrictions to reach the flapper valve. Once in position at 8,675 ft, the patch was expanded to permanently open the valve. This resulted in full well access so upper completion removal could be facilitated. This saved significant rig-time when compared to costly and time-consuming traditional milling operations," Coretrax explained.

FibreFlexx

Balmoral, a UK-based engineering company, specializing in offshore buoyancy, insulation and protection solutions for the offshore energy industry, has developed Balmoral FibreFlexx - a cable protection solution for offshore wind.

According to Balmoral, its fiber-reinforced cable protection system mechanically locks to the end connectors removing the need to rely on unpredictable PU bonding.

Balmoral says FibreFlex's long-term creep performance is a substantial improvement on traditional cable protection while bending and axial stiffness is optimized without having to qualify alternative PU materials.

Symphony

Schlumberger has recently launched Symphony live downhole reservoir testing, a technology platform that enables operational control of the downhole testing toolstring to deliver real-time downhole measurements.

According to the company, Symphony testing reduces operational time and improves safety and efficiency while enabling informed decision making for better reservoir understanding and reduced field development planning uncertainty.

Symphony testing unites Schlumberger's Muzic wireless telemetry with the downhole string, creating a digital solution that enables real-time control of the dynamic range of conditions during well testing operations. The digitally enabled toolstring is customized for the test objectives to position, isolate, connect, measure, control, sample, select and profile the reservoir.

WOODSIDE	PETROFAC	ØRSTED	ULSTEIN	NEPTUNE ENERGY	SIEMENS GAMESA	GLOBAL ENERGY
						
Coleman	**Asfari**	**Hardy**	**Marti**	**Shahat**	**Becker**	**Sinclair**

Woodside's CEO **Peter Coleman** has informed the Australian oil and gas giant of his intention to retire in the second half of 2021. By the time he retires, he will have served more than ten years in the role. Coleman has been CEO since May 2011. Woodside has started an internal and external search for the company's next CEO.

Ayman Asfari, CEO of oilfield and renewables services giant Petrofac, will retire as Group Chief Executive at the end of the year. Petrofac said Asfari would focus on his family, health, and charitable interests.

Sami Iskander, former EVP Upstream Joint Ventures at Shell, has joined as Deputy Chief Executive on November 1, 2020 and, following a short transition period, will assume the role of Group Chief Executive from January 1, 2021, at which time he will also be appointed as an Executive Director to Petrofac's Board of Directors.

Ayman Asfari joined Petrofac in 1991 and became Group Chief Executive in 2002. He will, on January 1, 2021, be appointed as a Non-executive Director to Petrofac's Board of Directors, to provide stability and continuity, Petrofac said.

Denmark-based offshore wind giant Ørsted appointed **David Hardy** as new CEO of its U.S. subsidiary Ørsted Offshore North America.

Hardy, who becomes CEO after previously serving as COO, replaced Thomas Brostrøm who has led Ørsted Offshore North America since the summer of 2015.

As CEO, Hardy will oversee all North American offshore wind activities, including development and operations for Ørsted's current and future portfolio of U.S. projects. Hardy will be based out of Ørsted's Boston office.

Norwegian shipbuilder and vessel design group Ulstein in November promoted its CFO **Cathrine Kristiseter Marti** to the CEO position. Marti was promoted to replace long-serving CEO **Gunvor Ulstein**, who decided to step down. Marti took over as CEO after six years as Ulstein Group's CFO.

Oil and gas firm Neptune Energy appointed **Mohamed Mounes Shahat** to the role of Egypt Managing Director, based in Cairo.

Mounes joins Neptune from Egypt's Ministry of Petroleum, having most recently held the position of Minister's Advisor for Gas Affairs.

Spanish-German wind turbine maker Siemens Gamesa Renewable Energy said in November that **Marc Becker** would return to the company as CEO of its Offshore business.

He served as Managing Director for Germany and Head of Offshore Sales and Projects at Siemens Gamesa before leaving the company in early 2020.

Becker will be the permanent replacement for **Andreas Nauen** who was promoted to CEO of the company in June.

Inverness-based offshore energy construction and services firm Global Energy Group named **Iain Sinclair** to the newly created role of Executive Director of Renewables and Energy Transition. Sinclair is a former professional rugby player, with over 18 years' experience in senior energy and infrastructure roles, having previously held man-

TEKMAR

MacDonald

INTERMOOR

Johnston

CAIRN

Giadrossi

ENHANCED DRILLING

Lunde

CHEVRON

Hewson

WINDEUROPE

Nauen

HARVEY GULF SUBSEA

Lounsbury

aging director positions at Forth Steel and Murray Plate Group.

Tekmar Group, a provider of offshore energy equipment and services, has appointed **Alasdair MacDonald** as Chief Executive Officer. He was Chairman of Tekmar Energy for five years, before the company's flotation in June 2018, when he became Non-Executive Chairman of the new entity, Tekmar Group plc. **James Ritchie**, founder and long-term CEO of the business, announced that he was stepping down from the role in August 2020.

Offshore services group Acteon said in November that Chris Johnston would be joining its moorings and anchors business InterMoor as group managing director.

In his most recent role as a vice president at Valaris plc, Johnston was responsible for overseeing and leading the North and South Americas team managing a fleet of 29 offshore drilling rigs.

Oil and gas company Cairn Energy will appoint **Nicoletta Giadrossi** as Chair of the Company with effect from January 1, 2021.

She will succeed **Ian Tyler** who, after seven years on the Cairn Board including six as Chairman, announced in May this year that he would retire from the Board on the appointment of a successor.

Nicoletta Giadrossi is one of the Company's existing non-executive directors and was first appointed to the Board in January 2017.

Norwegian offshore drilling equipment provider Enhanced Drilling appointed **Kjetil Lunde** as Chief Executive Officer.

Enhanced Drilling said that Lunde had been a key member of the senior management team since 2016 as VP of Finance and Business Support.

Prior to joining Enhanced Drilling, he held the position as VP Finance and Business Control for the Plattform Drilling division with Odfjell Drilling.

Marillyn A. Hewson, until recently CEO of aerospace and defense firm Lockheed Martin, has been elected to Chevron's board of directors, effective on January 1, 2021. She will serve on the Audit Committee of the Board.

Hewson, 66, is executive chairman of Lockheed Martin Corporation. She served as Lockheed Martin's chairman, president, and chief executive officer from January 2014 to June 2020 and held the positions of president and a chief executive officer from January 2013 to December 2013.

Andreas Nauen, CEO of wind turbine manufacturer Siemens Gamesa Renewable Energy (SGRE), has been elected Chair of WindEurope for the next 18 months.

Nauen will lead the association together with Nicolas Couderc, EDF Renewables Executive Vice-President, who serves as Vice Chair.

Harvey Gulf Subsea Solutions has appointed **LaDawn Lounsbury** to its Business Development Team. During her twelve year career, Lounsbury worked for Helix, Ranger Offshore, Oceaneering International and, most recently, Bayou Companies Deepwater Flow Assurance and Coating and Insulation Business.

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JANUARY - FEBRUARY

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