OE OFFSHORE ENGINEER

THE FUTURE OF OFFSHORE ENERGY & TECHNOLOGY

MARCH/APRIL 2022 OEDIGITAL.COM

Blade Runner

Robots Help Rationalize Lifecycle Costs of Offshore Wind

Edward Heerema
Dutch Courage – with Single-minded Focus

MOWU
Odfjell Oceanwind Drives to Decarbonize Offshore Drilling

HKZ
Vattenfall's Hollandse Kust Zuid Offshore Wind Farm

VOL. 47 / NO. 2

IGP

INTELATUS

GLOBAL PARTNERS

OFFSHORE WIND MARKET INTELLIGENCE PACKAGE

2022 U.S. Offshore Wind Outlook and Market Forecast

The monthly report and database contains all of the latest developments and information on the projects that will lead the U.S. to deploy 30 GW of offshore wind by 2030 and 110 GW by 2050. The report contains insights to support component manufacturers, shipyards, vessel owners and operators, service providers, ports and terminal operators, public agencies and financial institutions amongst others to better understand the opportunities and challenges presented by this growing segment.

Get all the information you need to access this growing multi-billion dollar market today!

VISIT US

WWW.INTELATUS.COM

تحت رعاية صاحب السمو الشيخ خليفة بن زايد آل نهيان رئيس دولة الإمارات العربية المتحدة
UNDER THE PATRONAGE OF H.H. SHEIKH KHALIFA BIN ZAYED AL NAHYAN, PRESIDENT OF THE UNITED ARAB EMIRATES

أديبك ADIPEC | Host أدنوك ADNOC

31 October - 3 November 2022

Abu Dhabi, United Arab Emirates

Supported By

وزارة الطاقة والبنية التحتية MINISTRY OF ENERGY & INFRASTRUCTURE
وزارة الصناعة والتكنولوجيا المتقدمة MINISTRY OF INDUSTRY & ADVANCED TECHNOLOGY
دائرة البلديات والنقل DEPARTMENT OF MUNICIPALITIES AND TRANSPORT
غرفة أبوظبي ABU DHABI CHAMBER
مصدر Masdar A MUBADALA COMPANY
دائرة الثقافة والسياحة DEPARTMENT OF CULTURE AND TOURISM
دائرة التعليم والمعرفة DEPARTMENT OF EDUCATION AND KNOWLEDGE

2022 TECHNICAL CONFERENCE CALL FOR PAPERS NOW OPEN

WHY SUBMIT ABSTRACTS FOR THE TECHNICAL CONFERENCE?

1. ADIPEC hosts one of the world's biggest and most important technical conferences, attracting 12,000 delegates
2. Extend your influence as part of an exceptional Technical Programme
3. Present your technical knowledge and experience globally to industry colleagues
4. Raise your company's technical profile at a prestigious industry event

SUBMIT YOUR ABSTRACT ONLINE:

www.adipec.com/cfp

#ADIPEC #ADNOC @ADIPECOFFICIAL

2022 TECHNICAL CONFERENCE CATEGORIES:

- AI and Digital Transformation
- Drilling
- Energy Transition and Decarbonisation
- Field Development
- Geoscience
- Health and Safety
- Operational Excellence
- People Development
- Project Management
- Unconventional Resources Development

FINAL SUBMISSION DEADLINE: FRIDAY 15 APRIL 2022

Partners: ExxonMobil, INPEX Group, JODCO

Gold Sponsors: 振华石油 ZhenHua Oil, Weatherford®

Host City: Abu Dhabi
Venue Partner: ADNEC
Knowledge Partner: IHS Markit
Strategic Insights Partner: BCG
Technical Conference Organised By: SPE Society of Petroleum Engineers
ADIPEC Brought To You By: dmg::events

MARCH/APRIL 2022
WWW.OEDIGITAL.COM
VOL. 47 / NO. 2

FEATURES

Photos from ORE Catapult

Winds of Robotic Change

Robotics continue to evolve and take on the dirty and dangerous jobs, particularly in the offshore wind maintenance sector. For floating wind farms, the opex savings could to be more, at up to 18.8% by the end of 2040, and up to 25.8% once all robotic innovations have been realized, says a recent report. To put that in context, operations and maintenance activities typically contribute between 15% and 35% of the lifetime cost of an offshore wind farm.

By Elaine Maslin

ON THE COVER: BladeBUG during trials at the 7 MW Levenmouth Demonstration Turbine.

Photo from ORE Catapult.

FEATURES

Image courtesy Allseas

Image courtesy Odfjell Oceanwind.

DEPARTMENTS

OE OFFSHORE ENGINEER
THE FUTURE OF OFFSHORE ENERGY & TECHNOLOGY.

www.OEDigital.com
Vol. 47 *No. 2*
ISSN 0305-876x
USPS# 017-058

118 East 25th Street,
New York, NY 10010
tel: (212) 477-6700
fax: (212) 254-6271

OFFSHORE ENGINEER (ISSN 0305-876X) is published bi-monthly (6 times per year) by AtComedia, Inc. 118 East 25th St., 2nd Floor, New York, NY 10010-1062. Periodicals postage paid at New York, NY and additional mailing offices.

POSTMASTER: Send All UAA to CFS. NON-POSTAL AND MILITARY FACILITIES send address corrections to Offshore Engineer 850 Montauk Hwy, #867 Bayport, NY 11705

SUBSCRIPTION
To subscribe please visit:
www.OEDigital.com

Email:
oecirc@offshore-engineer.com

Web:
www.OEDigital.com
t: (212) 477-6700
f: (212) 254-6271

BY THE NUMBERS

RIGS

Worldwide

Rig Type	Available	Contracted	Total	Utilization
Drillship	7	67	74	91%
Jackup	146	294	440	67%
Semisub	34	48	82	59%

Africa

Rig Type	Available	Contracted	Total	Utilization
Drillship	1	12	13	92%
Jackup	17	18	36	50%
Semisub	1	2	3	67%

Asia

Rig Type	Available	Contracted	Total	Utilization
Drillship	4	5	9	56%
Jackup	60	87	147	59%
Semisub	14	11	25	44%

Europe

Rig Type	Available	Contracted	Total	Utilization
Drillship	2	5	7	71%
Jackup	12	35	47	74%
Semisub	9	19	28	68%

Latin America & the Caribbean

Rig Type	Available	Contracted	Total	Utilization
Drillship		24	24	100%
Jackup	4	2	6	33%
Semisub	4	8	12	67%

Middle East

Rig Type	Available	Contracted	Total	Utilization
Jackup	23	111	134	83%
Drillship		1	1	100%

North America

Rig Type	Available	Contracted	Total	Utilization
Drillship		20	20	100%
Jackup	25	31	56	55%
Semisub	1	5	6	83%

Oceania

Rig Type	Available	Contracted	Total	Utilization
Drillship				
Jackup		3	3	100%
Semisub	1	3	4	75%

Russia & Caspian

Rig Type	Available	Contracted	Total	Utilization
Jackup	6	5	11	45%
Semisub	4		4	0%

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 April 2022.
Source: Wood Mackenzie Offshore Rig Tracker

DISCOVERIES & RESERVES

Offshore New Discoveries

Water Depth	2017	2018	2019	2020	2021	2022
Deepwater	15	16	20	13	14	3
Shallow water	76	55	85	41	40	6
Ultra-deepwater	12	18	18	8	5	4
Grand Total	**103**	**89**	**123**	**62**	**59**	**13**

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	572	46,965	22,739
Shallow water	3,250	423,392	142,416
Ultra-deepwater	329	41,087	27,833
Grand Total	**4,151**	**511,444**	**192,988**

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

Region	Number of fields	Remaining reserves gas mboe	Remaining reserves liquids mbl
Africa	605	19,690	12,296
Asia	866	15,950	7,576
Europe	766	12,258	12,601
Latin America and the Caribbean	196	6,190	41,381
Middle East	132	75,524	145,261
North America	517	3,138	14,286
Oceania	92	12,206	1,242
Russia and the Caspian	61	17,239	13,992
Grand Total	**3,235**	**162,195**	**248,633**

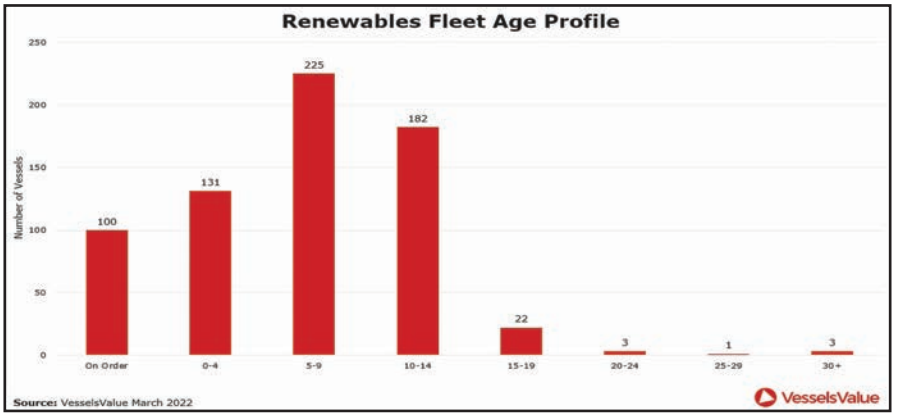
Onstream and under development.

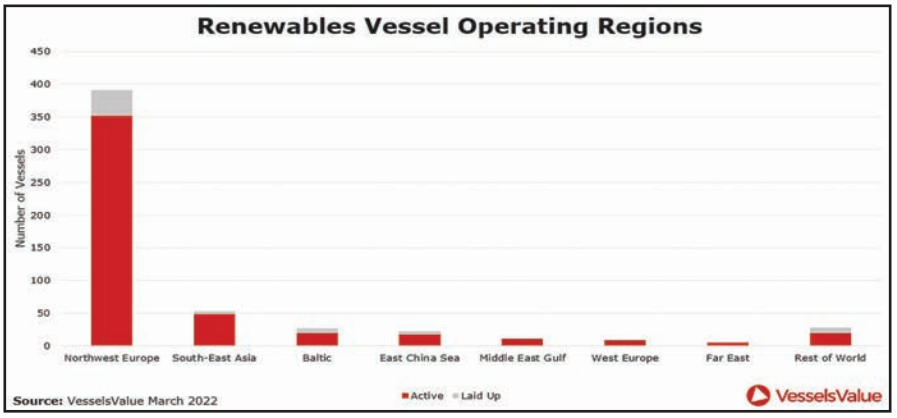
The portion of commercially recoverable 2P reserves yet to be recovered from the reservoir.

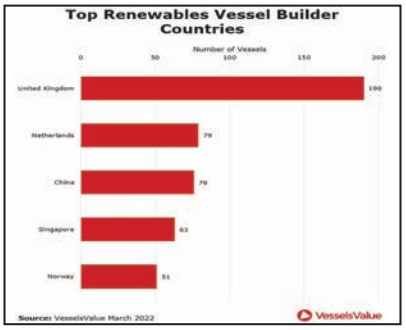
Source: Wood Mackenzie Lens Direct

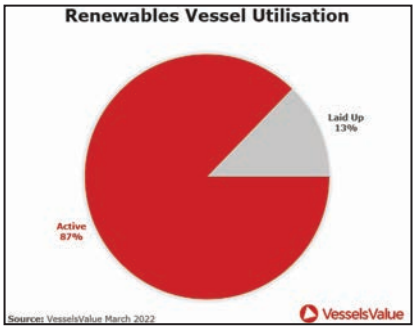
SECTOR IN FOCUS
OFFSHORE WIND VESSELS

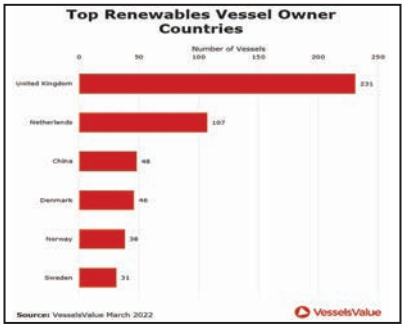
Data & Statistics powered by VesselsValue

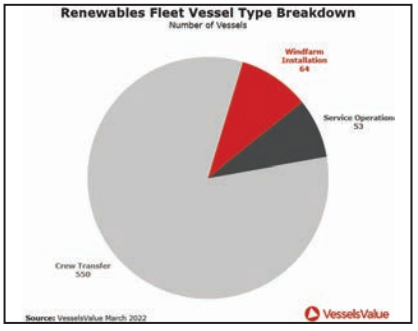












New York: 118 E. 25th St., New York, NY 10010
tel: (212) 477-6700; fax: (212) 254-6271

PUBLISHER
JOHN O'MALLEY
jomalley@marinelink.com

EDITORIAL
GREG TRAUTHWEIN
Associate Publisher & Editorial Director
trauthwein@offshore-engineer.com

BARTOLOMEJ TOMIC
Managing Editor
tomic@offshore-engineer.com

ERIC HAUN
haun@offshore-engineer.com

ELAINE MASLIN, Aberdeen
maslin@offshore-engineer.com

WILLIAM STOICHEVSKI, Oslo
ws@offshore-engineer.com

PRODUCTION & GRAPHIC DESIGN
IRINA VASILETS
vasilets@marinelink.com

NICOLE VENTIMIGLIA
nicole@marinelink.com

ADVERTISING & SALES
TERRY BREESE, VP Sales
+1 (561) 732-1185 • breese@marinelink.com

GARY LEWIS, Panama
(516) 441-7258 • lewis@offshore-engineer.com

ARTHUR SCHAVEMAKER, The Netherlands/Germany
+31 547 27 50 05 • arthur@kenter.nl

TONY STEIN, UK, France & Spain
+44 (0)1892 512777 • tony.r.stein@btinternet.com

CORPORATE STAFF
VLADIMIR BIBIK, **IT**

MARK O'MALLEY, **PUBLIC RELATIONS**
momalley@marinelink.com

ESTHER ROTHENBERGER, **ACCOUNTING**
rothenberger@marinelink.com

KATHLEEN HICKEY, **CIRCULATION**
k.hickey@marinelink.com

MARCH/APRIL 2022
WWW.OEDIGITAL.COM
VOL. 47 / NO. 2

OE WRITERS


Farrell

Oliver Farrell is Systems & Technology - Structuring & Competitiveness Leader at Baker Hughes.


Haun

Eric Haun, former managing editor of *Offshore Engineer*, is the editor of *Marine News*. He has covered the global maritime, offshore and subsea sectors since 2013.

Paul Kerr is a registered professional engineer with over 30 years of practical experience in ship systems. His company, KOSL, specializes in technical services supporting DP.

Philip Lewis is Director of Research, Intelatus Global Partners.


Kerr

Elaine Maslin is *Offshore Engineer's* Aberdeen correspondent and an offshore upstream and renewables focused journalist, covering technologies, from well intervention and asset integrity to subsea robotics and wave energy.


Lewis

Dril-Quip Director of Energy Transition **John Mossop** joined the company in 2020 and has more than 20 years' experience in engineering/management.

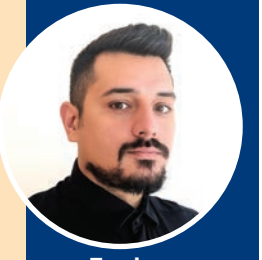
Jim McCaul is Managing Director and founder of International Maritime Associates. He has extensive market analysis and strategic planning experience in the maritime and offshore oil and gas sectors, and has managed more than 400 consulting assignments in over 40 countries.

Bartolomej Tomic is managing editor of *Offshore Engineer*. He has, since 2010, written hundreds of articles covering the international offshore industry. The coverage includes E&P, Drilling, Seismic, interviews with oil and gas professionals, and reporting from industry events.


Maslin


Mossop


McCaul


Tomic

PIONEERING SPIRIT

Just when life and business seemingly started to get back on track in the wake of a global pandemic, Russia invades Ukraine – breaking a rules-based order in place since the end of the Second World War, putting the European continent, and in fact the world, on edge – and setting off a near immediate and mass exodus of Western energy companies from Russia; a dizzying chain of events in the span of a few weeks that promises to effectively rewrite the handbook on global energy exploration, production and supply for the coming generation.

Through it all, through oil's per-barrel wild price ride over the last six plus years – from one point at the outset of the pandemic when futures pricing briefly went sub-zero, rebounding to around $100 per as of this writing – time and again it is the innovators, the deep thinkers and the long-range planner that will ultimately help to shape the industry's present and future.

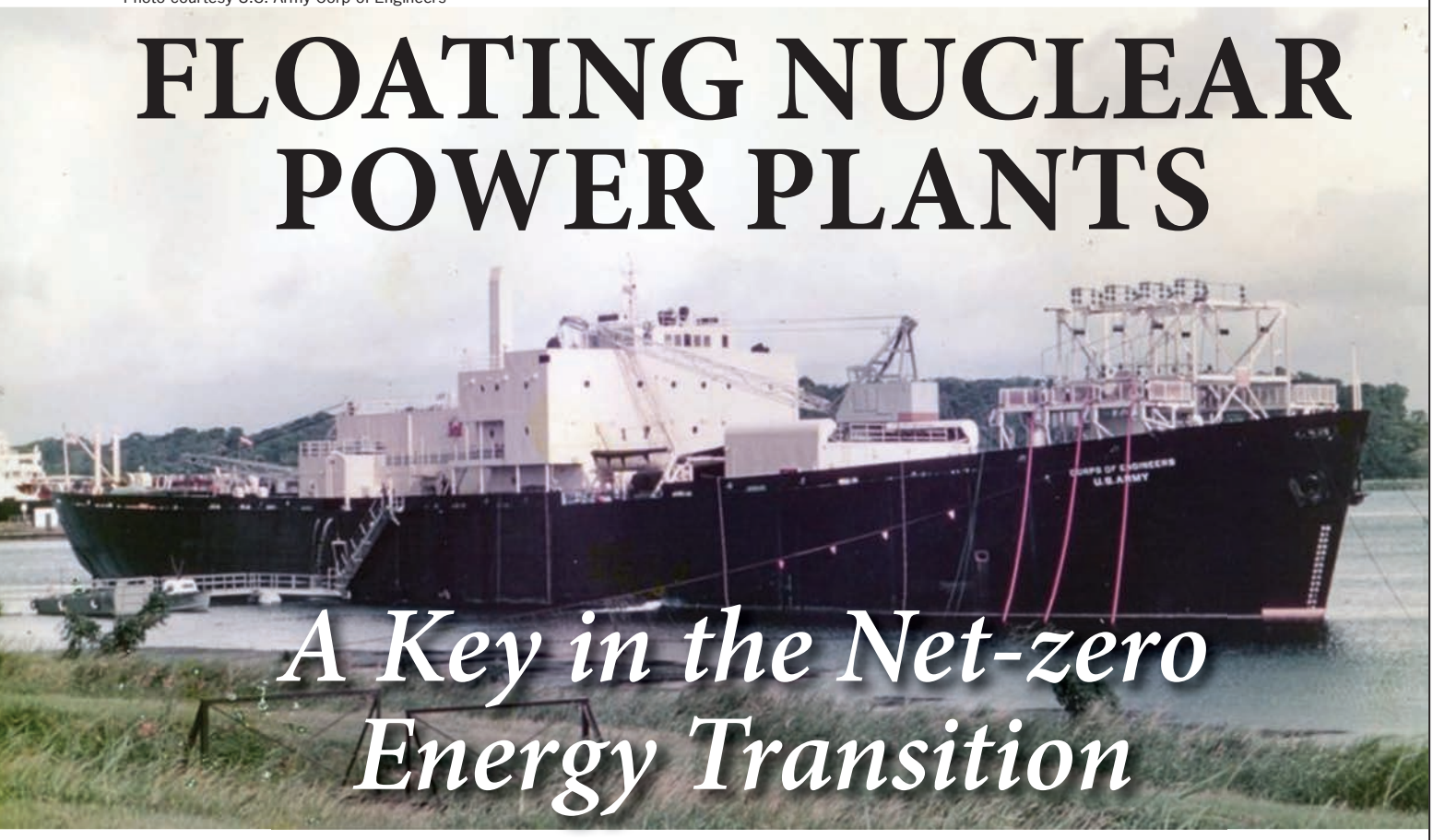
Edward Heerema, founder and president of Allseas, is one of those innovators, featured this month in **Elaine Maslin's** interview entitled *'Dutch Courage – With a Single Minded Focus'* starting on page 20. This list of Heerema's contributions to the maritime and offshore sectors are long and distinguished, from bringing us the world's largest construction vessel (Pioneering Spirit) to innovation in the pipelay and jacket lift sector. Today Heerema has his eyes on deepsea mining and the offshore wind market, regarding the latter a strong focus on the dramatically increasing size of the turbines and the equipment needed to install and maintain them, telling *Offshore Engineer*, "We think Pioneering Spirit is a big vessel, but if you take the biggest windmill of the future, she is tiny in comparison."

This month too, we interviewed another pioneer in the form of **Per Lund**, CEO, Odfjell Oceanwind, a Norwegian start-up aiming to help the offshore oil and gas industry on it's path toward decarbonizing its own operations. Odfjell Oceanwind is progressing to design and deliver Mobile Offshore Wind Units (MOWUs) that, essentially, are designed to be renewable 'plug and power' units for offshore operations. As most reading these pages know all too well, while Norway is small in population at just north of five million, it packs equal if not more punch than world heavyweights in the offshore and maritime sectors. Norway is 'green' not by slogan but by political will and choice, with the policies in place to help rationalize investment in and development of these next-generation technologies that, as history suggests, are born, nurtured and matured in Norway before being deployed for global operation.

Gregory R. Trauthwein
Editorial Director & Associate Publisher
trauthwein@offshore-engineer.com
t: +1.212.477.6700 • m: +1-516.810.7405

Photo courtesy U.S. Army Corp of Engineers

FLOATING NUCLEAR POWER PLANTS



A Key in the Net-zero Energy Transition

By Philip Lewis, Director Research, Intelatus Global Partners

Floating nuclear power plants (FNPP) may not immediately spring to mind as providing a solution to several of today's key global challenges, but FNPP development is emerging as a means of decentralized stand-alone production of cost competitive hydrogen-based fuels and clean electricity and water, according to a new report by Intelatus Global Partners.

The commercial case for deployment of FNPPs featuring small modular reactors is founded in the growing demand for hydrogen and hydrogen-based fuels.

Around 90 million tonnes of hydrogen is currently produced annually – almost exclusively produced from fossil fuels. Non-fossil fuel hydrogen production currently stands at around 0.5 million tonnes of annual capacity. The International Energy Agency calls for 80 million tonnes of clean hydrogen production by 2030. If this clean hydrogen target is to be met, green hydrogen produced by renewable solar and wind energy projects cannot meet all the energy requirements. Nuclear power will also be needed to produce low and zero carbon transition fuels.

The high temperatures generated by some reactor technologies are particularly well suited to clean hydrogen production, splitting water into component hydrogen and oxygen elements. Hydrogen produced by nuclear power is referred to as pink hydrogen, and sometime alternatively as purple, red or yellow hydrogen.

Given the storage challenges associated with hydrogen, FNPPs producing hydrogen from desalinated seawater can

Image above: **Undated image of STURGIS operating in the Panama Canal Zone. The STURGIS, a former World War II Liberty Ship, was converted into the first floating nuclear power plant in the 1960s. Before being shutdown in 1976, the STURGIS' nuclear reactor, MH-1A, was used to generate electricity for military and civilian use in the Panama Canal.**

also produce more easily storable transition fuels, such as ammonia and methanol.

In a similar concept to floating oil production, storage and offloading units and floating natural gas liquefaction and regassification systems, a floating nuclear ammonia or methanol production, storage and offloading unit will process seawater to produce hydrogen which is then combined with nitrogen separated from the air to produce ammonia or captured carbon to produce methanol. The produced ammonia or methanol are stored in tanks in the hull spaces of the floating units and then later offloaded to shuttle tankers. These low and zero carbon fuels can be used in the maritime and aviation sectors amongst others.

The Need for FNPPs for Decentralized Power and Water Production

Global population is forecast to grow to 9.7 billion by 2050 from around 7.8 billion people today – of which over 770 million have no access to electricity. Further, over 60 million people live in small developing island states, which face unique challenges for power and water supply.

Until now, those in remote and island locations have often relied on diesel generators to generate power, which is relatively costly and has negative impacts on the environment. Decentralized stand-alone power and mini grids, such as FNPPs, are one potential solution to deliver clean electricity to millions.

One advantage of nuclear power plants is that they produce large amounts of heat, which can be used for water desalination. Almost a third of the world's population is estimated to have poor access to clean water and UNESCO forecasts that up to 5.7 billion people could be facing "some level of water scarcity" by 2050. The electricity and heat cogeneration capabilities of FNPPs make them ideal for providing decentralized water production from seawater, whether by thermal distillation or reverse osmosis.

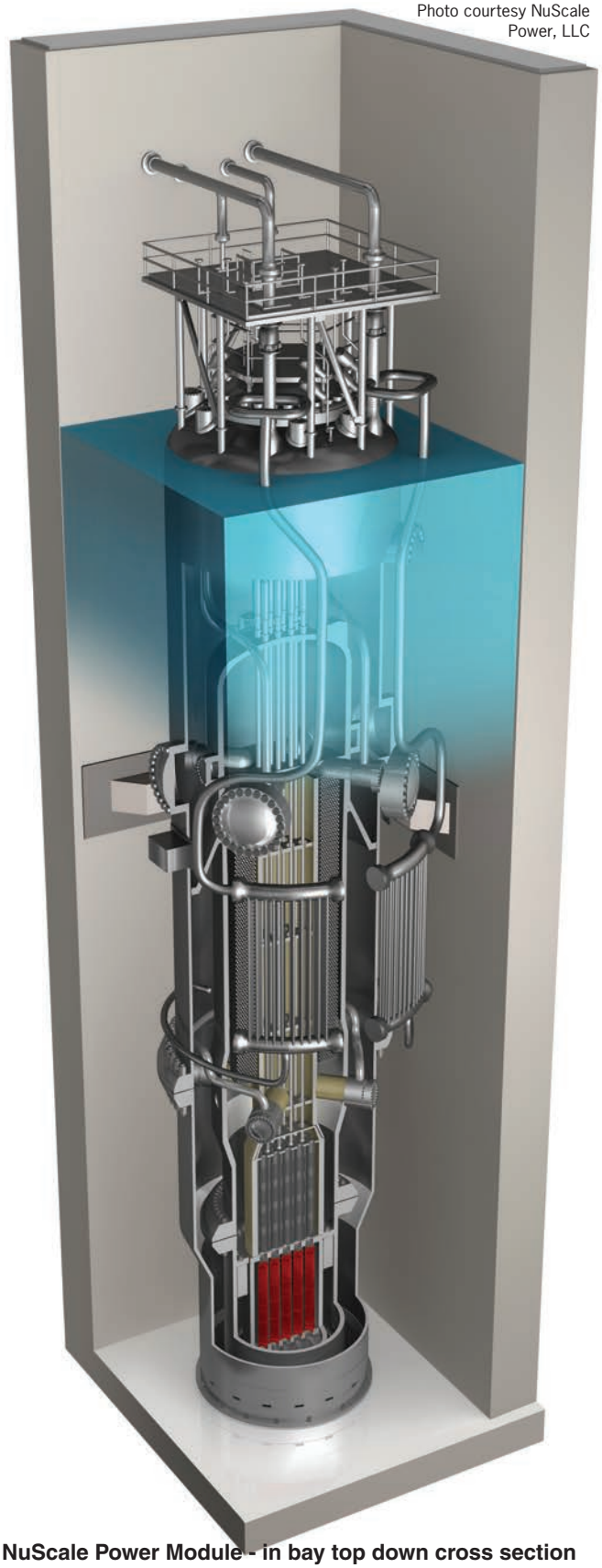
FNPPs: Not a New Solution

Conventional floating power plants have been widely deployed as a source of flexible decentralized power for decades to remote and difficult to reach areas. There are currently more than 75 floating power plants operational today.

The world's first nuclear powership used in a commercial application was the Sturgis. Operating between 1968 and 1976, the Sturgis supplied electricity to the Panama Canal Zone grid.

Building on its experience in building and operating nuclear powered icebreakers and cargo ships, FNPP pio-

Photo courtesy NuScale Power, LLC



NuScale Power Module - in bay top down cross section

neer Rosatom commenced operations of the world's newest commercial floating nuclear power plant, the FNPP Akademik Lomosov, in 2020. The company is currently building four more next generation FNPPs.

China, South Korea, Denmark, UK and the U.S. are all home to companies developing FNPP concepts.

New Technologies Aim to Address Some of the Key Concerns on Nuclear Power

Traditional site built nuclear power plants have a reputation for high costs and long construction schedules. A new generation of small and micro modular reactors seeks to address these barriers.

Small in physical size, with an electrical output of less than 300 MW, the smaller footprints of these new generation reactors make them suited to decentralized marine based applications.

The modularized approach allows for economies of scale as these reactors will be built in series in controlled factory environments and be moved by road, rail or barge. Putting the nuclear plant on a floating structure allows power and heat to be deployed where it is needed. In the case of FNPPs, the reactor modules are moved to large and experienced shipyards.

In these offshore and marine yards, quality, safety, schedule and cost are readily controlled given that the plant's construction and a large proportion of commissioning are performed using standardized equipment under strictly controlled conditions. This approach minimizes the risk of labor availability in remote areas and unforeseen ground

The reactor pressure vessel aboard the STURGIS, the Army's retired floating nuclear power plant recently decommissioned, is carefully lifted in order to be placed in the specially designed shielded shipping container to its left at the end of May 2017.

Undated image of STURGIS operating in the Panama Canal Zone

Photos courtesy U.S. Army Corp of Engineers

conditions, two key risks for site-built power plants. At a high-level, the concept is similar to floating oil and natural gas production and storage units – another example where a mature technology, in this case oil and gas processing, has been coupled with mature offshore and marine supply chains and where there are more than 400 floating production and storage systems globally today.

High profile nuclear accidents from the past, such the 2011 Fukushima Daichi reactor meltdown in Japan, the 1986 Chernobyl accident in the Ukraine, and the 1979 Three Mile Island accident in the U.S., fuel public concerns on nuclear power. Because of these risks, licensing of technology of projects is a long process.

The latest generation of reactors known as Gen-IV systems are designed to have very low likelihood and degree of reactor core damage and will eliminate the need for offshore emergency response. Gen-IV principles promote safety, reliability, sustainability, economics and proliferation resistance – which support the licencing of technology.

One challenge of deploying conventional reactor technology, as used in the majority of existing onshore and naval nuclear power plants, is the need to refuel every 2-4 years. This will result in handling spent nuclear fuel in ports. Some of the developing small modular reactors feature technology that eliminate the need to fuel during the 20-30 year lifetime of the FNPP – mitigating many of the concerns and challenges to nuclear power.

The FNPP Market Report

Intelatus Global Partners has developed a toolbox that identifies and assesses future business opportunities in designing, building, operating, and financing FNPPs, specific locations that are prime targets for using an FNPP, barriers and hurdles to market entry and development, the players and competitive landscape and optional strategies and paths for entering and positioning in this emerging market.

For more information about the FNPP Market Report, please contact Philip Lewis at +44 203-966-2492

What to expect from the U.S. Offshore Wind Market This Year

After many false starts, the U.S. offshore wind market is building strong roots for a solid future. But as the market develops from its current northeast and mid-Atlantic niche new opportunities and challenges arise.

By Philip Lewis, Director Research, Intelatus Global Partners

The U.S. offshore wind market has long been seen as not delivering on its significant potential. With an offshore wind technical potential of more than double that of the country's total annual electricity sales, the U.S. has long been seen as having the potential to be a major player in the global offshore wind market. However, until recently, the promise was not translating into reality.

But the last 12 months have changed this view, and there is reason to be much more optimistic.

Two major OCS projects with around 940 MW of capacity have reached FID and have commenced onshore construction, more than 15 GW of projects are undergoing federal permitting review, 17.5 GW of project capacity has secured offtake commitments from states, auctions containing 12-to-16 GW of potential will be concluded before the end of this year, longer term leasing plans for the Gulf of Mexico, the Central Atlantic, Oregon and the Gulf of Maine are being developed for auctions before the end of 2024, turbine component, foundation, and cable factories and Jones Act wind farm vessels are being built in the U.S. and offshore wind port development is accelerating.

In this article we discuss some of the key themes, opportunities and challenges for U.S. wind going forward. These themes are addressed in detail in our monthly U.S. offshore wind report and online project database.

$167B Spend to Deliver 51+ GW

There is a range of views on how much offshore wind will be deployed in the coming decades, from as low as 23 GW by 2050 to 110 GW by 2050.

The bullish view – The White House is targeting the deployment of 30 GW of offshore wind by 2030. Further, the administration plans to "unlock a pathway" to reach around 110 GW of capacity by 2050 or around 9% of total U.S. electricity generation in 2050.

A year ago, there were doubts raised on this target. But much has changed in a year to create the conditions to advance offshore wind in the U.S.:

- *Two major projects with around 940 MW of capacity have reached FID and have commenced onshore construction.*
- *To date, federal leases with a potential to support an estimated 40 GW of offshore wind have been awarded. Federal agencies plan additional leases supporting at least 6 GW to be awarded this year and further lease sales encompassing multi-gigawatt potential are planned in the Gulf of Mexico, the Central Atlantic, the Pacific and the Gulf of Maine by 2024.*
- *10 large developments with a potential for more than 15 GW are undergoing federal permitting review. Further, the government commits to completing the permitting review of at least six more projects by 2025 amounting to at least 4 GW of capacity.*
- *17.5 GW of project capacity has secured offtake commitments from states and more than 18 GW of future requirements have been identified.*
- *Developers have recently been selected for at least 11 GW of new Mid-Atlantic offshore lease capacity.*

A conservative view – The U.S. EIA forecast assumes 10 GW of offshore wind connected to the grid by 2030 and 23 GW by 2035. Thereafter, the EIA forecasts no growth of the offshore wind base. Based on the EIA figures, offshore wind will account for around 2% of electricity generation in the U.S. in 2050.

Based on current developments, this appears to be somewhat conservative.

Our view – We forecast 27 GW of capacity to be grid connected by 2030 and around 50 GW by 2035. Longer-term we anticipate that 110 GW of installed capacity by 2050 is achievable. Our forecast is based on developer plans, BOEM leasing and permitting activity and state committed and planned offtakes, details of which can be found in our latest U.S. offshore wind monthly report.

Our forecast of capital expenditure, annual operations and maintenance expenditure and end of life decommissioning costs by timing of final investment decision through the middle of the next decade is shown in the following table.

Forecast of CAPEX, Annual OPEX and DECEX by FID Timing

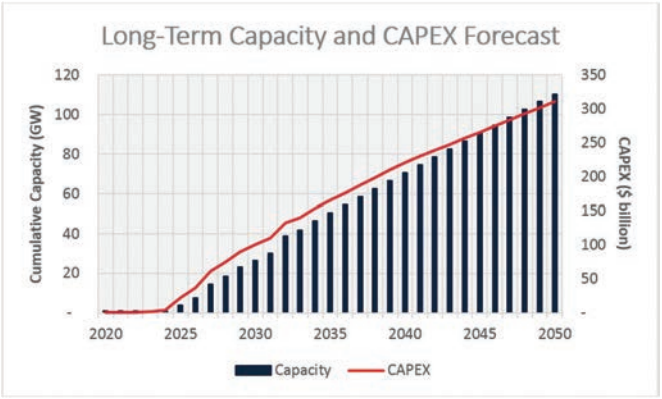
Forecast ($ billion)	GW	CAPEX	OPEX/yr	DECEX
FID made	0.9	3.5	0.1	0.4
0-18 months	1.82	14.4	0.2	0.8
18-36 months	15.7	56.5	1.6	7.1
36-60 months	11.1	34.0	1.1	5.0
Over 60 months	21.8	58.8	2.2	9.8
Total	51.3	167.3	5.2	23.1

Source: Intelatus Global Partners

We forecast that final investment decisions for close to 30 GW of offshore wind capacity will be made within the next five years.

Our current forecast for longer term FIDs amounts to close to 22 GW of projects – but this number is growing on an almost monthly basis as new capacity potential is opened up for development. In the long-term we anticipate a further 60 GW of potential to be developed taking the capital investment required by 2050 beyond $300 billion.

Forecast of Offshore Wind Capacity Development



Source: Intelatus Global Partners

Confidence Grows

2022 has already shown market confidence in the U.S. wind segment and we anticipate the trend to continue witnessed by three factors:

FIDs made for close to 1 GW of offshore wind potential – After many false starts for commercial wind farms, the first two commercial scale offshore wind projects have been permitted, reached financial close and have broken

ground. We do not anticipate further FIDs in 2022 due to the project permitting process, but the foundations are in place for multiple FIDs next year and after.

Lease price inflation – Developers committed to pay a record $4.4 billion for six leases in February's New York Bight auction. The price effectively signifies an option payment to secure the rights to assess and then develop a wind farm on the lease. The prices paid per MW of potential capacity were roughly six times more than the average paid for three Atlantic leases in 2019 – the last federal offshore wind lease sale. One developer's bid was nine times more than it paid for a lease in 2019.

Developers are committing to significant supply chain infrastructure investment and are making good on these commitments – In its March 2021 statement, the White House targeted "one to two new U.S. factories for each major windfarm component including wind turbine nacelles, blades, towers, foundations, and subsea cables".

At the time this seemed somewhat optimistic, yet through state procurement requirements and support multiple key component factories are now being built and will provide ongoing opportunities to the domestic supply chain. Investment plans in construction and O&M ports is also translating to ground being broken and projects advancing.

Foundations are in Place for Offshore Activity to Peak initially from 2023 to 2026

Achieving the goals of 27 GW by 2030 and 110 GW by 2050 will make the U.S. a significant global offshore wind market. However, developers of projects in the U.S. will need to account for a significant upswing in global offshore wind capacity and supply chain competition in the same period.

U.S. project activity will see an initial peak from 2023 to 2026. This will coincide with a spike in bottom-fixed project activity in Europe and East Asia – and an increase competition for limited supply chain resources.

- *To date, over 28 GW of offshore wind has been installed in the U.K. and Europe since the first commercial turbines were commissioned in the early 1990's. The U.K. aims to achieve 40 GW by 2030 and the European Union targets at least 60 GW by 2030 and 300 GW by 2050.*
- *China, currently the world's largest offshore wind market commissioned over 10 GW alone in 2021. Provincial plans indicate a further 75 GW of capacity will be added by 2025.*
- *Elsewhere in Asia, Japan, South Korea and Taiwan aim to deploy over 33 GW of capacity by 2030.*
- *Outside of Europe and Asia, we anticipate new market entrants in Australia and South America.*

Whereas global supply and demand of offshore construction vessels is currently in balance or in some cases over-supplied, we anticipate tight to under supply of wind turbine and foundation vessels, heavy lift vessels and cable layers from around the middle of the decade. Without new vessels, we anticipate some impact to project costs and/or schedules.

Details of our analysis of U.S. wind farm construction schedules can be found in our monthly U.S. offshore wind report.

A Lack of Investment in Jones Act Vessels

In the March 2021 White House statement on offshore wind, one ambition was to achieve "the construction of 4 to 6 specialized turbine installation vessels in U.S. shipyards, each representing an investment between $250 and $500 million." Achievement of this goal is currently behind plan.

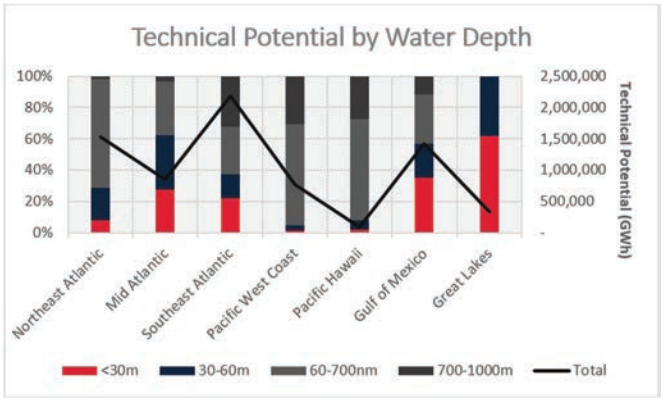
Till now only one Jones Act wind turbine installation vessel is under construction. Without additional domestic supply, developers will need to secure installation vessels from the international market – as one developer has already done for its project. However, although international supply of wind turbine installation vessels is growing, the growth the of suitable large vessels remains relatively slow and supply will be stretched in the global market around the middle of the decade – at the same time U.S. offshore wind installation activity is expected to peak.

The only other Jones Act compliant construction vessel committed to date is a wind farm scour protection/rock installation vessel.

One would expect there to be a significant amount of construction of service operations vessels (SOV) and crew transfer vessels (CTV). Both are used in the long-term operations and maintenance phase of a wind farm and will need to be Jones Act compliant. Till now one SOV has been announced as under construction – although the indications are that others are in the pipeline. In the CTV segment, three vessels are already operating, and five CTV construction contracts have been announced recently. Despite the building activity, the domestic supply and SOVs and CTVs is significantly below our forecast for demand.

Significant Opportunities Presented by Floating Wind

Close to 60% of the technical potential for the U.S. is in waters best developed with floating wind technology.



Source: Intelatus Global Partners, NREL

Floating Wind Project Construction Process

Driver	Detail/impact
Different installation model for floating wind	• On land construction of large and heavy substructure and load out for quayside assembly. • Quayside assembly of turbine to substructure featuring high and heavy lifts. • Wet storage of assembled units and waiting on weather of large and easily damaged units. • Offshore installation sequence: mooring pre-lay, towing and hook-up. • Different installation assets – the largest AHTs/AHTSs, MPSVs and OCVs where there is very limited global and Jones Act supply.
Cable lay	• Solutions still being developed for laying large amounts of dynamic cable lines with mid-line buoyancy and quick-disconnectors for O&M.
O&M	• Solutions still being developed for in-situ versus tow-to-port O&M for above water components as well as for in-water mooring inspections.

Source: Intelatus Global Partners

Federal agencies are advancing offshore leasing in California, Oregon, the Gulf of Maine and several other locations that will feature floating offshore wind solutions. The first leases are expected to be auctioned this year.

However, few realize that five floating wind projects are already currently being progressed in the Atlantic and Pacific – three in state waters and two in Federal waters. These projects will demonstrate the opportunities and challenges for the supply chain – which require a different supply chain approach to the bottom-fixed projects of the current northeast and Mid-Atlantic pipeline. The key differences are summarized in the following table.

First moves are being made on port infrastructure, but little movement has been made on the Jones Act vessels required to install floating wind projects – supply of the asset classes required is limited, presenting a risk to developers and an opportunity for vessel owners and shipyards.

Offshore Transmission Solutions will Evolve

Till now, U.S. offshore wind projects have deployed the same single line or radial connection solution that is common in much of the world's offshore wind capacity. In this concept, a developer is responsible for building the connection between the offshore wind farm and the onshore grid interconnection point.

However, various state and federal agencies are studying a range of options to deal with accommodating a large number of offshore wind farm grid interconnections in the coming years. One approach being studied is similar to that employed in several North Sea markets – offshore integrated transmission networks, where an independent transmission system operator collects power generated by individual windfarms offshore and injects the capacity to the onshore grid through a network of high-capacity offshore transmission cables. We anticipate some decisions on new approaches to be firmed up within the year.

For more information about the U.S. Offshore Wind Market Forecast, please visit **www.intelatus.com** or contact Michael Kozlowski at +1 561-733-2477 or Philip Lewis at +44 203-966-2492

DPOs AREN'T ELEVATOR OPERATORS

By Paul Kerr, KOSL

The single most important redundancy element in a dynamic positioning (DP) system is the dynamic positioning operator (DPO). DP systems have become so reliable that some vessel operators and clients have forgotten the purpose of the DPO. High reliability leaves many operators unprepared for fundamental failure modes and causes costly failures.

This is dangerous because DP systems are not actually redundant and still depend on the human operator to ensure safe operation. The design assumption is still that the DPO is ready to spring into action. This was truer when operators had to regularly correct DP system faults, but as the systems became more and more reliable, DPOs had difficulty recognising early fault indications and responding properly. The airline industry refers to this as the "bored-person-in-the-control-loop" problem.

Some people propose regular simulator testing for this. Simulator training is highly effective in the aircraft industry because the controls and response of a particular plane model are identical. Pilots that will operate a different model of aircraft or updated software need to be trained on it. A lack of familiarity with slightly different controls or response has caused numerous accidents in the airline industry. In the marine industry, controls, vessel propulsion and vessel response vary widely from vessel to vessel and over time. Marine simulators are a good start for learning basics but not for drilled response. Continuous training on each orphan vessel produces better results.

This doesn't have to be difficult. DPOs should help train each other. Can the operator reliably find the controls with his eyes closed? Can he draw them from memory and discuss possible dangers to operation? Do they double check their actions? Do they discuss normal and emergency operation and try to keep each other sharp with what if scenarios? These help ensure reliable operation and reinforce their importance. This used to be common and it needs to be encouraged.

Operators need time to "play" with equipment to get a feel for the whole system and its functions. The increased familiarity pays off when something goes wrong. DPOs who only operate the independent joystick system during annual trials are not likely to be skilled with it, despite it being a fundamental part of their job. 15 minute DPO check sheets were used to aid the DPOs in being ready to anticipate, catch and correct problems. Some vessel DP desks are set up to look pretty rather than detect problems and that needs to be changed. The position trace contains valuable information about system operation and the DP station needs to monitor related systems to quickly detect and confirm problems. DPOs need to take time to absorb the unique properties of their vessel.

DPOs don't get to simulate faults during regular operations, so annual trials are an important reminder of what some failure modes look like. Failure to maintain position or heading may indicate regular training or design changes are needed to manage what used to be a common fault. Failure to maintain position after the failure of the DP system is usually due to unfamiliarity with the IJS. Too many DPOs can't do this. A DPO who can't, isn't really a DPO, as he cannot perform a crucial expected function. Every DPO should be regularly drilled on resolving their vessel's fundamental failure modes.

DPOs are vital to vessel redundancy. The staffing and culture need to reflect this. DPOs are not doing nothing, and should not be distracted with other tasks, they are critical to ensuring safe DP operation. Operations need to recognize their tasks' importance and keep them ready for action. They should be system and vessel experts, not replaceable cogs that an operator is forced to employ.

Unfortunately, even the best people make mistakes or have bad luck. Good management recognizes this, accepts the possibility of failures and minimizes their probability. Some people are unsuitable for DPO work, regardless of paperwork, and need to be detected and filtered out. Certification, book learning, simulator training and experience elsewhere are not the same as ingrained, active, vessel specific, system understanding.

In the old days, crew were given busy work so they got used to the vessel and able to detect problems not found by sensors. Today, such actions are considered inefficient. Today's operators have more sensors but it is still very important for them to develop an intuitive, vessel specific feel for the movement, response and sounds of their vessel, and its interaction with the environment and mission.

Remote micromanaging, by some managers, consultants, clients and industry bodies, undermines real DPO responsibility and initiative. Cogs perform sub-optimally and maximize trouble avoidance, while an active and responsible DP culture covers more than just procedures. DPOs should be encouraged to evaluate and adopt improvements themselves. It is easy to inflict answers but more effective to encourage them. Standards must be maintained but how they are maintained sends a message.

"DP culture and guidelines need to be constantly renewed and refocused, especially as different missions and clients create different requirements. The mission is the purpose of the vessel, but operators need to be aware of and guard against degradation of safe DP operation in themselves and others."

Human systems tend to degrade over time as their success allows other priorities to take precedence until failure becomes a problem. We can see this process take place over time as a cycle in many industries. We have probably seen presentations where a company purposefully short-circuited safety systems for "efficiency" and got away unharmed, but we also know of the disasters where others were less lucky. Feeling safe increases tolerance of danger.

Degradation of safe operation is a dangerous and very human path that is enabled by short-term thinking. It is most dangerous when failure is rare but costly. This is the problem faced by DPOs. DP culture and guidelines need to be constantly renewed and refocused, especially as different missions and clients create different requirements. The mission is the purpose of the vessel, but operators need to be aware of and guard against degradation of safe DP operation in themselves and others.

A factory wanted to improve its operations and brought in lighting consultants, who carefully discussed what they were doing with the workers and what they hoped to achieve with each change. Every time they adjusted the lighting up or down, operations improved. Eventually, the lighting engineers figured out that it was the reinforcement of the importance of the work and the workers before each change that made the difference. Human-machine systems are affected by very human factors. Technical solutions to DP problems are worthwhile, but investing time and attention in human operations is also critical.

If you are a vessel operator, it is worth reviewing how your corporate culture and policies help encourage and maintain this protection. DPOs need to encourage and keep each other sharp, and operators need to support a sense of responsibility, loyalty and agency.

Designers need to focus on making vital information available and easily interpretable by DPOs. FMEA engineers and surveyors need to focus more on this and help

eliminate design faults early.

DP FMEAs would be more useful to DPOs if they had a section where they start with indications of problems and help in its diagnosis and correction. An FMEA review test could also be a useful tool for crew familiarization with the vessel specific redundancy concept and failure modes.

DP trials should not be rushed through, they are a practical demonstration and need to be understood and absorbed by the crew. Trials are not just evaluation, they are also training. Experienced surveyors are needed to discuss operation and system faults with the crew and help resolve issues.

Vessel engineers are also DP vital, and much of the same thinking applies to them. Safe and reliable DP operation is dependent on DPO and engineer operation and cooperation. A good working relationship is required and influenced by both system and personal factors.

Customers, which look to use vessels, should look for these signs. Clients should avoid requiring long detailed lists of requirements be posted at the DP desk and should instead present abbreviated, pithy reminder sheets, as adding to cognitive load can worsen operation. Simple, useful tools are welcome but unintentionally burdensome ones can be counterproductive.

When elevators were introduced, elevator operators were needed to ensure safe operation and reassure users. Safe, reliable, automatic systems made the operators unnecessary. DPOs are still vital to safe DP operation, and this need to be taken more seriously. We have been lulled into complacency by the promise of technology and increasing rarity of failures, but we cannot afford to forget that the human operator is still vital and needs properly supported to perform effectively. DPOs are closest to pilots, who might do "nothing" for most of the flight, but when corrective action is required, they are vital. Those also serve, who only stand and wait.

Dutch Courage – with Single-minded Focus

Our CTO this month is something of an honorary CTO. ***Edward Heerema is founder and president of Allseas****, which brought the world's largest construction vessel, Pioneering Spirit, to the market. The company, which also brought innovation to the pipelay sector, has added its latest trick to Pioneering Spirit – its jacket lift system. But Allseas is also targeting deepsea mining and has its sights on the offshore wind market.* ***Elaine Maslin caught up with Edward Heerema to find out more.***

The first time I met Edward Heerema was at the company's offices in Delft, in the Netherlands. As a Brit, I was used to not getting milk with my cup of tea in Dutch offices (or KLM flights). But, as an international company, Allseas was used to my kind and milk was offered.

We were there to discuss progress of the 382m-long heavy lift and pipelay mega vessel Pioneering Spirit. Delays in the shipbuilding process and a decision to increase the 48,000-tonne topside lift vessel's already substantial width to 124m (to accommodate even more platforms) had put the project behind schedule. It was an immense undertaking that appeared to some like a massive gamble. Would she work? With a multi-billion price-tag, it couldn't afford not to.

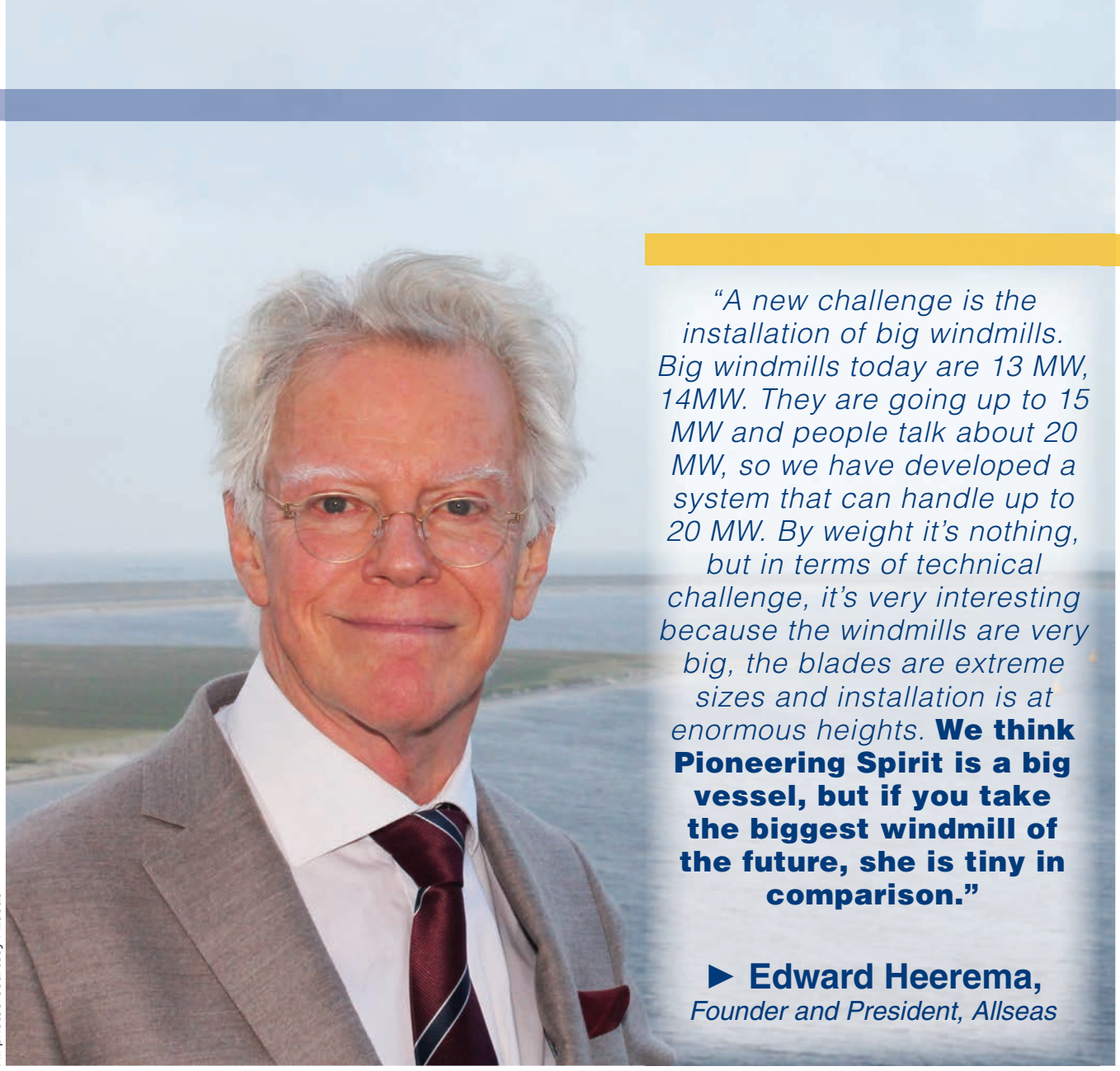
What's happened since both demonstrates Allseas' single-minded focus, but also its willingness to alter plans and flex to demands, from adapting or renaming Pioneering Spirit to offering the Brit some milk in her tea.

Edward Heerema is also someone who has confidence in engineering, whether that's in pipelaying on dynamic positioning, complex single-lift motion compensation systems or deepwater pipelay, and now also deepsea mining and installing future up to 20 MW offshore wind turbines. For him and Allseas, the engineering involved in Pioneering Spirit wasn't a gamble, even if the economics are perhaps challenging in today's market. Since its launch in 2016 to March 2022, the vessel has lifted a total of 240,000 tons of topsides in decommissioning and installation projects. This year will be a bumper year for the ship. She's scheduled to lift and transport a record 125,000 tons of platform structures, using both its topsides and jacket lift systems. Since her launch, she's also laid 4,200 km of 32-48 inch pipeline in 41 to 2,200 m water depth.

AN ESTABLISHED TOOL IN THE MARKET

Pioneering Spirit is very much now a well-established tool. "When we clarify with clients a contract or have to be on a bid list, there are no longer any more questions about whether she will work," Edward says. "She has done every project in a magnificent way. Maybe we have been lucky, because we have had hardly any weather down time, but because the vessel is so enormous it moves very little in the waves and then the motion compensation system takes care of the rest. Her workability has been great and she has never disappointed us."

Of course, the first big lift, Brent Delta in 2017, was a heart-stopping moment. "That was the first really big job," says Edward. "The first job, the Yme removal (13,500 tons) for Repsol in 2016, was very special. We were all really nervous that the system wouldn't work. Rationally, we couldn't question at all that it would work, because it had been tested and tested and simulated and simulated. But



"A new challenge is the installation of big windmills. Big windmills today are 13 MW, 14MW. They are going up to 15 MW and people talk about 20 MW, so we have developed a system that can handle up to 20 MW. By weight it's nothing, but in terms of technical challenge, it's very interesting because the windmills are very big, the blades are extreme sizes and installation is at enormous heights. **We think Pioneering Spirit is a big vessel, but if you take the biggest windmill of the future, she is tiny in comparison."**

► Edward Heerema,
Founder and President, Allseas

All photos courtesy Allseas

still, I remember very well being there on board and the button was pressed, and you hope she goes, and she went, and that was fantastic. But the real emotional success was the lifting of the Brent Delta topsides, because at a weight of 24,000 tons that was a world lifting record."

BEATING RECORDS

Since then, projects with Pioneering Spirit have become routine work, beating its own record for the world's heaviest single-lift offshore with the 26,000 ton Johan Sverdrup process platform (P1) topsides installation in 2019. Pioneering Spirit installed P1 on a Tuesday, followed by the field's 18,000 ton living quarters topsides just a couple of days later. These were two of four topsides installations Allseas is contracted to perform on Johan Sverdrup, the latest being the 20,000 ton P2 topsides, completed this March.

Despite these successes, it's been a relatively challenging period. "The amount of work, 25 lifts in five years, has been reasonable, but not impressive," says Edward. The pandemic extended the depression that hit in 2014, reducing activity. "There's not been sufficient work for everybody," he says. "None of the installation contractors have had enough work. Everybody is surviving, because even when you get a reasonable amount of work, it is at very low prices because of the enormous competition in the installation and removal business. That aside, we have done relatively well. We have got very reasonable amount of work and we've been nicely busy with installations, with removal, both big and small and some pipelay projects."

Pioneering Spirit JLS beams upended to 110 degrees

All photos courtesy Allseas

ACTIVITY GROWTH

It's clear that there's already an uptick in activity, based on Pioneering Spirit's 2022 schedule alone. An increase in offshore spending is expected to continue. Even before the war in Ukraine pushed prices up to new highs, there were also predictions that offshore upstream spending would rise to 2014 levels again, by 2030. The war is also forcing energy policy change. Some of that is about increasing oil and gas output, but also increasing renewables capacity. While Edward doesn't believe offshore wind will make any substantial dent in the dominance of oil and gas in the global energy system any time soon, he does see it as a nice addition, including a fill-in work for Pioneering Spirit.

Indeed, Pioneering Spirit completed its first offshore wind project last year, installing the Saint Nazaire offshore windfarm subsea station 2,100 ton topsides and 1,200 ton jacket, in the Bay of Biscay. This was using the vessel's 5,000 ton tub-mounted Huisman crane, installed after the vessel entered service as a useful additional tool. The same crane has since installed the 3,870 ton Hollands Kust Zuid Alpha transformer station in the Dutch North Sea and will shortly install the Beta transformer station in

the same wind farm (read more on page 42). Later this year, Pioneering Spirit will install the 10,500 ton Dolwin 6 transformer topsides, 5,000 ton jacket and bridge in the German North Sea.

THE NEW JACKET LIFT SYSTEM

Allseas will soon be targeting more and larger jackets with its new 25,000-tonne jacket lift system (JLS). The JLS was initially planned to be added to the vessel in 2016, but pipelay work with the vessel's massive stinger took precedence and since then fabrication delays and COVID have also taken their toll. However, it's now almost ready for its first project. The system has two, aft-mounted 170m-long lifting beams used to lift then upend jackets onto the vessel's deck, with the jacket then resting on top of the beams, for transport, without needing sea fastening.

Test lifts of the system were carried out in late February into early March, and systems testing will continue, leading up to lifting out the eight-legged steel jacket of Ninian Northern, 240 miles east of Aberdeen in the northern North Sea, scheduled for April.

Ninian Northern, which came on stream in 1980, ceased production in 2017 and saw its topsides removed, by Pioneering Spirit, in 2020. The remaining jacket sits in 141m water depth, making it a substantial structure, weighing around 15,500 tons with an estimated 2,000 tons of marine growth. But it's also subject of a derogation order, so that the bottom third of the jacket can be left in place, leaving the top third, weighing about 8,500 tons, to be lifted out (the jacket legs are pre-cut using a castellated pattern to prevent it from shifting).

TARGETING OFFSHORE WIND

Once proven, the JLS offers another revenue stream for Pioneering Spirit. But Allseas is also eying another task for the JLS. "A new challenge is the installation of big windmills," says Edward. "Big windmills today are 13 MW, 14MW. They are going up to 15 MW and people talk about 20 MW, so we have developed a system that can handle up to 20 MW. By weight it's nothing, but in terms of technical challenge, it's very interesting because the windmills are very big, the blades are extreme sizes and installation is at enormous heights. We think Pioneering Spirit is a big vessel, but if you take the biggest windmill of the future, she is tiny in comparison."

Edward says Allseas has developed a few solutions for these large windmill installations, based on an extension of the JLS. "When erected, the JLS is ideal to reach high and install big windmills," he says. "We're very fortunate that the JLS is very suitable for that and you can take advantage of a vessel that's immensely stable, has a good DP system and a lot of deck space." Final designs are being worked on, only targeting these larger turbines, likely on fixed foundations, but potentially also floating, and Allseas will be building one soon, Edward says.

A FUTURE FOR AMAZING GRACE?

Another project Allseas had been working on was Amazing Grace – a vessel that would dwarf Pioneering

Allseas Collector in the North Sea

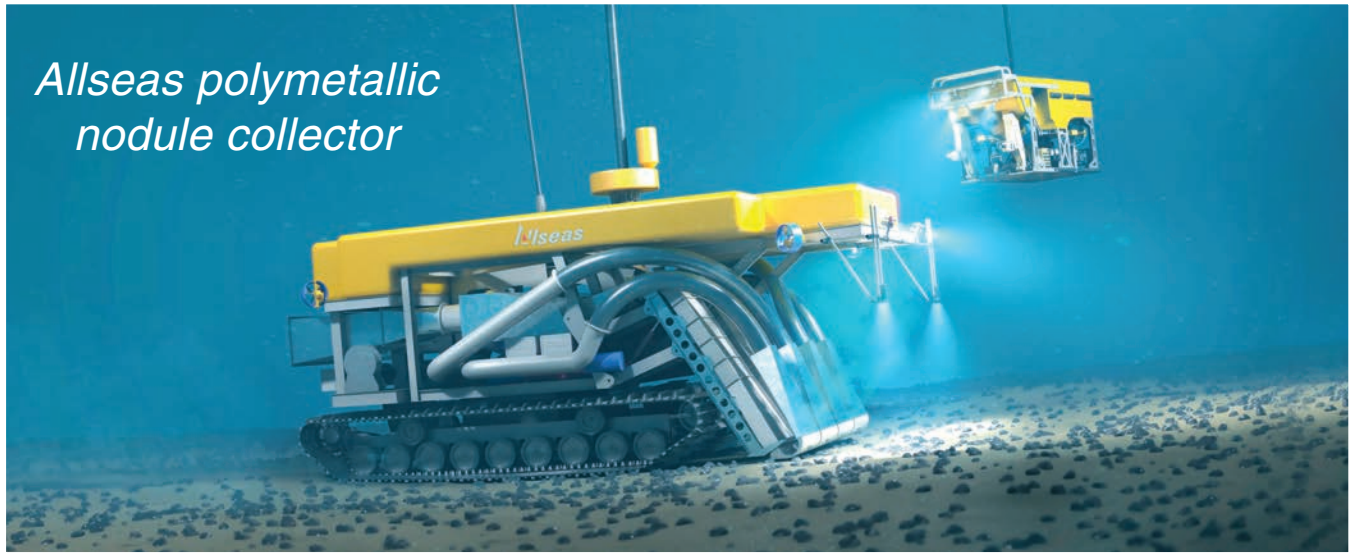
All photos courtesy Allseas

Spirit's 48,000 ton topsides lift capacity at 72,000 ton topsides lift capacity. This project was "frozen" in 2020 due to the depressed market. But that's not to say it's permanently shelved, says Edward. "We did decide to finalize the design," he says. "We've done the complete basic design so that when it is required we could move relatively quickly, do the detailed design in a year or so, and start building. We wanted to be able to say to ourselves we have a real working solution that we can build if we have to."

THE NOT SO HIDDEN GEM

Instead, Allseas has another project to focus on: deep-sea mining. The company acquired the 228m-long Vitoria 10000 drillship in 2020 to convert it into a polymetallic nodule collection vessel, in partnership with The Metals Company (TMC, formerly DeepGreen Metals Inc.). TMC's goal is harvesting polymetallic nodules, containing high grades of nickel, manganese, copper and cobalt, from the Clarion Clipperton Zone in the Pacific Ocean. These will be used for battery metal precursor materials and manganese silicate product expected to be used in manganese alloy production for the steel industry.

As well as converting the vessel, Allseas has developed and built a robotic seabed collector, a riser-based system to transport nodules to the surface and a launch and recovery



Allseas polymetallic nodule collector

system for the collector. A deployment system for the collector and the riser system has also been built, as well as an umbilical handling reel system.

According to The Metals Company, the piloted system is expected to be upgraded to a commercial system with a production capacity of 1.3 million tons of wet nodules a year by Q4 2024. The two companies are also already discussing acquiring a second vessel, a Samsung 10000, which would be converted to have 3 million ton capacity of wet nodules.

COLLECTOR TESTING

"We have built the collector, and it is being tested at the moment," says Edward. The collector, measuring 12m-long, 6m-wide and 5m-tall, was designed in house then built at Allseas's Heijningen yard in the Netherlands. "We know a lot about subsea robotics, so we were able to do a lot of that ourselves. We've used underwater trenchers for 25 years. We know the deep sea well, we've laid pipe to almost 3,000 m water, so we are in our own field there. We feel comfortable we can solve the outstanding problems."

Testing has been taking place in the North Sea. Next it will be taken down to 2,500m depths for drive tests off the Canary Islands, followed by tests in 1,500 m depths deploying the riser and the collector, connecting them, then bringing them back onboard. Then, this summer, the system will be taken to 4,500m depth in the Clarion Clipperton Zone. There, it will perform its first pilot testing of nodule collection.

Part of this will be research into how these operations impact the environment. "We are giving that a lot of attention," says Edward. "The Metals Company is conducting a very intensive research program with the science community and during pilot tests part of it is scientific research while collecting nodules. It's also part of the preparation process to get green light from ISA (International Seabed Authority)." There's also been work looking at the potential plumes created during collection, which has been a concern. "What we've observed is that when plumes do form they settle within a few hundred meters. So it looks very favorable. But of course, we are taking all criticism and worries seriously and do a very thorough evaluation of how we affect the seabed with our system."

BLADEBUG
trialling at ORE Catapult Levenmouth Demonstration Turbine
BladeBUG

WINDS OF ROBOTIC CHANGE

By Elaine Maslin

Whether we realise it or not, robotics and robotics systems are starting to impact our daily lives. From warehouse picking systems through to high-end medical devices through to your mowbot lawnmower, each tends to be specialized to its own task. A similar trend is now starting to play out in the offshore wind space where it's hoped that robots can make operations safer and more efficient.

According to a report, The Economic Opportunity for Robotics in Offshore Wind and Key Energy Markets by the Offshore Renewable Energy Catapult (ORE Catapult), published last year, opex costs could be reduced by up to 9.5% by the end of this decade. That could increase up to 27.1% once all robotic innovations on the books have been realised. Turbine availability would also increase, but by a more modest 1.07% and up to 1.87% respectively.

For floating wind farms, the opex savings could to be more, at up to 18.8% by the end of 2040, and up to 25.8% once all robotic innovations have been realised, says the report. To put that in context, operations and maintenance activities typically contribute between 15% and 35% of the lifetime cost of an offshore wind farm.

"Endurance is one of the qualities of robots and that's where one of the wins is," says Michael Corsar, CTO at Cambridge based innovation firm Innvotek, which has been working on a number of concepts, from crawlers to drone systems. "It can work continuously, it doesn't get cold, doesn't need tea breaks."

Amphibian

Some systems – beyond established offerings such as ROVs deployed from crewed vessels – are already starting to take their first steps. Amphibian, developed by Innvotek, with ORE Catapult support, is one. It's a tethered crawler designed for use in splash zones down to 60 m subsea, measuring 800 mm by 600 mm by 350 mm and 40kg, with an automated tether management system. Tapping the power on the turbine, it uses powered magnets to crawl on the surface of monopiles, inside and outside, or any other steel surface, including curved or domed structures.

"It can clean scale and biofouling and carry a variety of inspection payloads, including wall thickness using ultrasonic testing and close visual inspection," says Corsar. "We want to do those critical sections we can't get to with rope access, divers, ROVs or scaffold, and in the splash zone."

The idea came about because of a "buzz" around the aging process of foundations. "First generation design foundations reaching 10-15 years old were coming of age and were corroding perhaps more quickly than people would like or expect, and a solution was required that didn't need divers or ROVs. There are a large number of monopiles, 5,000-6,000 in the North Sea, all with similar problems with corrosion and biofouling. Monopiles are 30-40m deep, 8 m in diameter; there's a lot of surface area that needs to be inspection, a lot of length of weld that needs to be inspected."

Amphibian is currently "halfway automated". It has to be driven to a weld, but once there it can run an automatic inspection. "The three-year road map is to do an entire monopile without anyone except deployment and retrieval," says Corsar.

While designed for offshore wind, Amphibian is already being used in other industries, including onshore power generation, and it's also being demonstrated for onshore

Innvotek

wind tower inspection. It also has application in shipping, to perform UWILD activities, as well as oil and gas, where the company has been working with Oceaneering on risers and caissons, says Corsar.

Robot bolt tensioning

Using the same platform, Innvotek is now also working on another robot designed to perform bolt inspection and tensioning. This vehicle will have "a lot more features and a lot more intelligence in it in terms of understanding its environment and capability in terms of tooling. Routine inspection and cleaning, physical interaction with the asset to torque up a bolt." The project is about nine months in, and then computer vision to identify bolts and then orient and align tooling and then do 99% of the torqueing itself; "it will just need a go, no-go command".

The platform will use a distributed approach to localization, says Corsar, which means that it uses different sources of information, such as existing knowledge of the asset, e.g. bolt spacing.

"In a relatively fresh development we're starting to team up with another company looking at BVLOS comms via satellite where hopefully all the robot control can be done from the shore, within the next 12 months, using low latency satellite communications."

Innvotek is also part behind the Firefly Inspect project, with partner Mapair. The project involves a drone that uses infrared technology (a 1,000W heat lamp) and AI to inspect for hidden imperfections composite structures (a technology initially developed for inspecting plane wings). A trial system, complete with an OptiTrack motion camera technology for navigation, was demonstrated at ORE Catapult's Blyth test facility earlier this year.

BladeBUG

Another robot, BladeBUG, is looking at turbine blade inspection and surface preparation, as part of repairs. Company founder Chris Cieslak came up with the idea in 2014, while working as a blade turbine engineer. In 2017, he decided to go full time on the idea, supported by ORE Catapult. It's a six-legged robot, with each leg having its own vacuum cup system to help it creep across and work on blade surfaces. It's tethered and human operated via a semi-autonomous motion system – the operator uses a joystick to tell it to move forward, back, left or right, and the robot scans the surface to plan how to move its feet.

"It's designed to be taken offshore so it's small, compact and lightweight (600mm-wide and -long and weighing 20kg). It's about trying to change the mindset of wind. It's very reactive, currently. They wait for damage to get severe enough to send out rope access crew. During that period the blade is becoming more inefficient. [With BladeBUG you can] start to see a problem and treat it early, potentially preventing cases where you could get a catastrophic defect."

A common issue is leading edge erosion, which happens when rain hits the blade as it travels at up to 200mph, making its smooth profile rough and pitted. This effect then accelerates, says Cieslak. As is the case for a chip in a car windscreen, early treatment can prevent a catastrophic failure.

A lot of the development work has been on the blade walking capability, which was proven on ORE Catapult's 7MW trials turbine at Blyth. It's also been developing its capabilities, which include testing the lightning protection system on blades and UT inspection, to see any issues un-

manned aerial vehicles (UAVs/drones) can't spot.

"Drones are fantastic for a quick global inspection, to find an area with problems, BladeBUG can then ascertain how serious they are or do the repairs," says Cieslak. "We're the next stage follow up inspection and [can] either repair or provide more information to a repair specialist onshore, which means the rope access team can go and there won't be any surprises."

The next goal is a repair module to perform cleaning and sanding of areas before treatment. Imagine a power sander moved across the blade surface using the body of the BladeBUG, which has control equivalent to a CNC machine, says Cieslak. A challenge is certification, but that will come, he says.

A future vision is for a fully autonomous tetherless system controlled from shore, working either turbine to turbine or as resident robots on each turbine, supporting future live online monitoring systems. However, it's still early days. The company has a number of early adopter trials planned.

Deployment from USVs

A lot of focus has been around using uncrewed surface vessels (USV). These are already being used regularly for site survey work. A number are trying to deploy underwater robots from USVs. Fugro has already been doing this, for inspection operations using its Blue Essence USVs, with plans for larger vehicles. However, it's delivering drones or blade crawling robots via USVs that many see as offering a significant opportunity.

The Drone Swarm for Unmanned Inspection of Wind Turbines (Dr-SUIT for short) is aiming to deploy aerial drones for offshore wind farm inspection from USVs. It is now being led by Airborne Robotics with partners Ocean Infinity, the University of Portsmouth, and Bentley Telecom. The group has said it plans to have a system demonstration in 2022.

MIMRee

This follows on the heels of the MIMRee project (Multi-Platform Inspection Maintenance & Repair in Extreme Environments). The vision of the just two-year project, which concluded last year, was for a Thales Halcyon USV to detect blade defects using an onboard camera system able to scan moving blades, developed by Thales during the project. It would then be able to signal the blades to stop and launch a drone able to transport a six-legged 'blade crawler' onto them to perform a repair.

"It was a very ambitious forward-thinking approach, trying to see how far we could go on that road map," says Hamish Macdonald, Project Engineer at ORE Catapult. "In the end, we achieved what I thought were some really impressive prototype technologies that we could test

ORE Catapult

in representative environments."

That included landing a drone on the USV, which included developing a global mission planning software that communicated everything to the drone and also the moving turbine camera system – which had just been an idea at the start of the project. A deployment system was developed for the drone to carry a crawler (an early prototype of a BladeBUG was used), but this had to content with weight limitations enforced by the U.K.'s Civil Aviation Authority (which was reduced to 25Kg during the project).

"We can see there are short term opportunities that could be focused on and brought to commercialization sooner and other considerations more to do with manipulation and repair that are a bit further on," says Macdonald.

An early win is to perform more drone inspection remotely via USVs, he says, although there are some hurdles around regulations, Maritime Coastguard Agency considerations and licensing on USVs and beyond visual line of sight operations.

"I think wind farm developers are keen to see innovations like this, robotics is an innovation area that's here to stay and something they want to see robust and commercial enough to be a solution," says Macdonald. "Seeing projects like MIMRee is really helpful. I think there are aspects that could be realized in the shorter term that they would be keen to explore also."

Communications

To make all this work, these multiple robots will need communications. A future plan is for each wind farm to have its own communication platform connected to shore and then within the wind farm local wireless connections for the ecosystem of other robots operating in that environment, says Corsar.

"The hub on the farm would provide more than just communications, it would provide the power for the crawlers and low hanging fruit in this space is the UAVs," he says. "For our platform, it would probably be a low earth satellite link to shore, as it will be more ubiquitous to use sat comms rather than farm by farm basis communications. But it will have bandwidth concerns, so it's on us to develop control systems that are not required to pass big amounts of data."

But there's some way to go yet before this vision is realized. Amphibian has gained traction in the oil and gas sector, despite having been designed for offshore wind. "Oil and gas is very much more mature around integrity management. Offshore wind isn't quite as mature in inspection requirements and inspection techniques. It's a younger industry still finding its feet. Equally its assets are younger and not falling to pieces. So there are a number of factors holding us back [in offshore wind]."

Thales

INTERVIEW: PER LUND, CEO, ODFJELL OCEANWIND

A look inside Odfjell Oceanwind, a Norwegian start-up that plans to decarbonize the offshore drilling industry by using giant floating wind turbines, mobile offshore wind units. ***Per Lund, CEO explains.***

All images: Odfjell Oceanwind

Per, to start, please give a 'by the numbers' look at Odfjell Oceanwind.

Oceanwind was started in 2019 by a group of founders with many years of experience in floating wind. The following year, Odfjell Drilling was invited to co-invest in the company and to develop global floating wind specialists. [The investment was made and the company name was changed to] Odfjell Oceanwind. Today we have our own proprietary product, the mobile offshore wind unit (MOWU), and we are developing the first projects aiming for deployment in 2024.

I know you're still in the startup phase, but how big is the company today? And looking ahead, what's your projection for the coming five to 10 years?

Today, we are about 40 people working in Odfjell Oceanwind to support the design of our mobile offshore wind units, which are based on a deep sea semi-floating wind foundation, while also setting up for the production line and preparing for operations.

To predict how this will look in five to 10 years is not easy in the market for floating wind. When you talk about permanent floating wind farms, it's in an extremely rapid growth phase with new large projects and license plans being announced almost weekly. Our ambition is to become a global leading player in floating offshore wind, and where that will bring us in size is not easy to say. But personally, our first natural target is to become the largest company in the Odfjell Drilling Group.

How does your previous experience translate into your current role as CEO?

Being a naval architect by education and career, I've never been afraid to try new things. And I've always been intrigued by new market opportunities. I love a challenge, and I tend to grasp new technologies fast. In particular, my strengths lies in the crossroad between technology and business development. Seeing a market, seeing a technology and trying to pair the two to develop business.

In a recent interview describing Odfjell Drilling's capabilities and capital discipline, the CEO was quoted as saying "We've never built anything on speculation. Everything that we did was against contracts and income." Is this the philosophy of Odfjell Oceanwind also?

The Odfjell family is an old ship owner family, very conscious about risk taking, certainly in the offshore drilling market. The renewable business with floating offshore wind, where we sell a commodity in power, electricity, will

probably not fluctuate as much. So that may mean we'll have some more appetite to take risk, but these are early days so we will balance risks and reward, continuing to build on everything we've learned in Odfjell Drilling. We know the importance of maintaining a good balance sheet.

Can you discuss the business plan for your future mobile offshore wind units?

Leasing is one of the business models, and with that model we will operate similar to our fleet of drilling rigs, but with longer contracts than we have for the drilling rigs since the mobilization cost will be relatively larger for these wind turbines compared to a drilling rig. There is also significant scope in connecting the power systems between the wind turbine and the consumer side.

But we are also offering our mobile offshore wind units for sale, where we continue to provide the operations and maintenance. In Norway, which is our primary market, the tax regime for oil and gas is very much in favor of the operating companies owning these units.

Recently, we have also been approached by wind farm developers with inquiries about our deepsea semi floating wind foundation, which is designed to be equally applicable for permanent wind farms in harsh environments. So in that respect, our business model also includes being a design house and a solutions provider, providing technology for wind farm development.

The lease model has proven to be quite attractive for many oil and gas operators [particularly when there is] uncertainty in regards to how long they will be able to keep the oil and gas assets producing.

So the whole concept of a multi-location design that can be redeployed proves very attractive, and it's kind of a circular economy approach, which is new to the oil and gas business.

Can you share insights on proposed day rates?

At this stage we do not share day rates publicly; this is a very early market. We like to keep our cards close to chest, but just like in any other market, it needs to make financial sense for our clients. Most of our projects right now are for electrification of production platforms, not so much drilling rigs but production platforms where the oil company either will purchase or rent the MOWU for providing power to these installations.

As I understand it, the first units are expected to be produced by 2024, part of this funded by Enova. Do you know how many MOWU's will be built in the first batch? And are you still planning to secure contracts first?

The first units will be built towards contracts and we are planning two to five units for the first batch in '24. And then we will gradually step up the production in our production line. So the initial units will all be built after we've secured contracts, but later, as the concept and the market is more proven, we will evaluate investing on speculation.

But again, we will have to apply our experience in risk taking from the drilling market. We are not speculative, but if we see that making investments can accelerate the market adoption, we will consider it.

I know we're still relatively early, but can you discuss the expected cost to build the MOWUs?

At the moment we are keeping our cards close to our chest, but of course our ambition is to become cost leaders. Like others have said, we believe that the key success factors for driving down the cost will be scale, and also learning. This is why we think it's so important to get started with production.

Can we take a little bit deeper dive into the technology itself and specifically your partnership with Siemens Gamesa and Siemens Energy? From what I understand, two versions are planned, among the world's largest.

First of all, we have chosen a relatively conventional design for the floating wind foundation, our deep sea semi. This is the technology that we know very well through our 50 years as pioneers in offshore drilling.

On the turbine sites we like to go as large as possible because there's economies of scale. Currently, 11 MW is the largest version commercially available from Siemens Gamesa for floating wind, but we will change to the 14 MW as soon as that becomes available in 2026. The deep sea semi foundation that we're designing for the first batch is made to take the 14 MW turbine cells.

Staying on that same technology thread, can you explain what exactly WindGrid is?

WindGrid is a concept that we developed in order to provide uninterrupted power supply for off-grid applications. Today, our clients normally produce their power with gas turbine generators, and an efficient co-existence between the wind turbine generator and the gas turbine generator was important to release the potential in renewable wind

All images: Odfjell Oceanwind

power. The WindGrid provides sufficient stiffness to the power grid to maintain grid stability when we are running purely on wind power, and that enables us to stop the gas turbine generators in periods with sufficient wind power generation. And equally when the wind stops blowing, or if we have a failure on the wind turbine generator, we have sufficient energy stored to buy us time to start up the gas turbine generator again. The WindGrid enables efficient, cooperation between the gas turbine generator and the wind turbine generator, meaning we are able to increase the emission reductions from what you typically see if you purely connect the wind turbine generator to grid.

When we add the wind with module, we see that we can get it up to 60 to 70% reduced emissions or reduced fuel consumption.

Can you discuss the relationship at the moment with Odfjell Drilling?

The whole reason we chose to invest in OceanWind was that we already had the vision with Odfjell Drilling to be able to drill wells with zero emission, and having MOWUs was one way for us to get there. We have access to all the [Odfjell Drilling] experience, all the harsh environment, all the engineering expertise, when it comes to all facets of designing, owning, operating harsh environments, steel structures. So we can piggyback on all that learning.

What are the financial drivers to adopt this technology?

In Norway, the authorities have said that the companies that emit pay high CO2 taxation. The intention is to create a positive business case for making these investments. So in Norway, there is a financial framework for lifting these kind of investments. In the U.K., for example, they don't have the same tradition for high emission fees. They do have the ETS quota system, but they don't have a CO2 taxation. So this varies a bit (by geographic region). We are Norwegian, we like the Norwegian model, we see that it works.

Let's look at your solution, the MOWU, the rigs in particular. What modifications are required aboard the rigs and platforms to make the MOWU connection?

That can be a bottleneck, so with our concept we tried

to make it as simple as possible because we are going to be mobile; and you are not very mobile if it takes a fortune to establish the solution in each location.

First, we keep all the transformers on the MOWU itself, and we step down to the same voltage as the main switchboard voltage on the host installation in order to keep the modifications to a minimum. But obviously you will have to upgrade and modify your power management system to reflect this coexistence between the wind power generator and the gas turbine generators, but in general terms, we try to design the system and integration for minimum required modifications.

You recently signed an agreement with the Norwegian oil company OKEA to potentially power its giant Draugon platform using your MOWUs. Can you share more information on this?

We have built rigs for contracts, then the contract expires and what do you do if there's no market? We wanted to counter that risk by having an agreement with an operating company, with an asset with a long time horizon, where we could move the units. They're still producing power to a meaningful grid. So instead of putting them at the dock where you make no money, we have this flexible arrangement with OKEA and are looking to use Draugon as a more flexible storage area where we can take our units when they go from off contract, locating them there for a few years until we can bring them onto a new contract. That was important to keep up utilization of the units.

Sticking on that deal for a moment, we noted that it includes an interesting proposal for flexible storage location for your floaters. Can you explain how this works?

So for example, if we have a client that wants to deploy one of our MOWUs for a period of six, eight, 10 years, that means that we can offer to buy it back when the operating company has ended the production for that specific field. They will struggle to find new use for the MOWU in their own portfolio. With this flexible arrangement, we can offer to buy it back and deploy it to Draugon, and then we continue to produce electricity onto their grid. So that's what we mean with the flexible storage. It's like a parking lot for our MOWUs; still making money while parked.

All images: Dril-Quip

ADAPTING SUBSEA TECHNOLOGY TO

Reimagining uses for innovative technologies originally designed for critical service in subsea developments could open the door to safer CO2 storage and usage.

By John Mossop, Dril-Quip

ENABLE CCUS

The Dril-Quip SBTe can be incorporated into a template attached either to a pipeline or marine buoy for CO2 injection and easily connects to flexible risers and monitoring equipment.

The energy transition occurring worldwide is redefining energy production and consumption and consumer perceptions of the oil and gas industry. Today, many consumers want a more sustainable method of energy generation in line with global pledges on climate emissions and control, and financial institutions are increasingly basing investment decisions on environmental, social and governance (ESG) performance. This new focus has led to wide-ranging programs with the common goal of finding economical ways to decarbonize industrial zones.

Improving carbon capture, transportation, utilization and storage is a critical step on the road to reducing the greenhouse gas (GHG) emissions produced by these large industrial emitters. And, CO2 abatement is essential to achieving carbon reduction commitments for the foreseeable future.

As new methods of energy generation are introduced to industrial zones to reach decarbonization targets, more efficient ways must be found to transport CO2 away from these areas to underground storage. While there is broad agreement that change is necessary, the way forward is unclear. Lowering the carbon footprint of industrial operations without negatively impacting quality of life will be a challenge.

Dril-Quip is proactively addressing this issue with creative problem-solving, developing solutions that will reduce GHGs and enable safe and reliable carbon capture,

transportation, utilization and storage. The company officially pledged to be a part of the broader solution by becoming a participant in the United Nations Global Compact (UNGC), the world's largest sustainability initiative, in early 2021. The UNGC aligns companies to support its universal principles on human rights, labor, environment and anti-corruption.

NEW APPLICATIONS FOR PROVEN TECHNOLOGIES

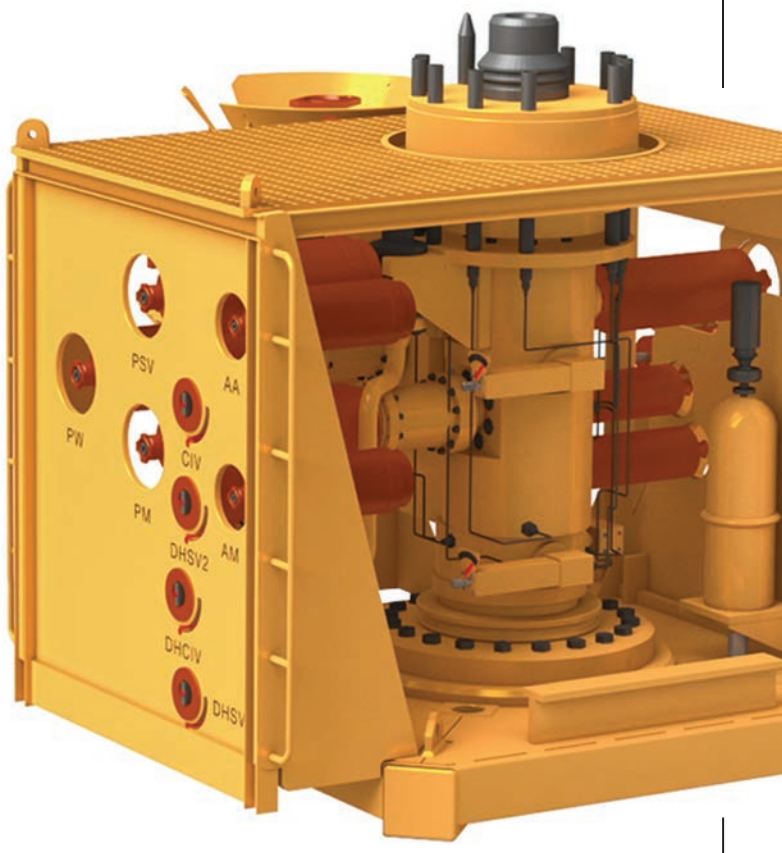
Exceptional engineering delivers solutions that reduce the time, cost, and risk involved in complex processes. Developing these innovations, however, is anything but simple. It requires the ability to consider challenges from a different point of view and use that perspective to create designs that resolve issues in a novel way.

Dril-Quip used this approach to develop its e-Series products – solutions that fundamentally change some of the 'norms' for the oil and gas industry. The company has staked its reputation on these new concepts. And now, building on years of experience and success, including the recent installation of several 'serial number one' solutions, it is introducing game-changing technologies for CO2 transportation and storage.

TRANSITIONING INNOVATIONS FOR CCUS APPLICATIONS

One of the products Dril-Quip has introduced for carbon capture, utilization, and storage (CCUS) applications is the lightweight, compact Dril-Quip SingleBore Vertical Tree System or SBTe. Based on Dril-Quip's field-proven, shallow-water tree, the SBTe can be configured for CO2 service and incorporates a self-aligning feature that simplifies tree installation.

The SBTe, which is designed to handle the harsh conditions associated with CO2, is fit for purpose for CCUS applications. Dril-Quip's in-house metallurgists specified material that is lighter than other commonly used solutions and applied their cladding expertise to ensure reliable performance even in the harshest subsea injection conditions. Recognizing that the purity of the CO2 could become an issue over time as carbon emitters make plans to capture increasing volumes of CO2 from industrial operations, the tree can manage CO2 impurity levels as low as 92%. Rated for 5,000 psi maximum pressure and temperatures as low as -46°C (-50°F), the tree is available as a hydraulically powered or fully electric solution. The electric version provides enhanced long-distance power distribution and management and enables faster data transfer/communications for optimal digital monitoring.



Automatic space-out adjustment enables the tubing hanger to self-adjust to variances in the hanger's position. The stab subassembly allows the tubing hanger to be precisely aligned and installed like a casing hanger without the need for a lead impression trip. When the tubing hanger is landed, a pressure test verifies the hanger is in the correct position. Then, a hanger lock mandrel is placed with a tubing hanger running tool, creating a flat lock mandrel-to-lock ring interface. Its coupler body houses 13 hydraulic and two electrical coupler lines that rotate +/- 180 degrees to connect to corresponding couplers in the tubing hanger. Drilling and completion can be carried out without suspending the well or pulling the BOP stack.

Coupled with Dril-Quip's wellhead technology, the agnostic SBTe design can be an integral component of any comprehensive storage and injection infrastructure. It can be incorporated into a template attached to either a pipe-

Dril-Quip leveraged its wellhead technology and tree innovations to develop a lightweight, compact and economical solution for long-term carbon storage and injection applications.

line or marine buoy for CO2 injection and easily connects to flexible risers and monitoring equipment.

The ability to step back and examine existing technologies and envision something different is a core capability that gives Dril-Quip advantages in developing CCUS solutions. The SBTe system design reduces hardware and significant operational steps and as a result, lowers the carbon footprint. It is a clear example of looking at installation challenges from a different perspective and using mechanical engineering ingenuity to introduce a unique product.

SYNERGIES IN COLLABORATION

While Dril-Quip is working independently to develop technologies to advance CCUS initiatives, it also is collaborating with companies that complement its strengths and capabilities.

One such partnership was formalized in late February 2022 as a collaboration agreement with Aker Solutions. Within this agreement, Dril-Quip will provide CO2 injection trees and wellheads incorporating Aker's proprietary control systems and electrification components. The partners will cooperatively target opportunities where they can add significant value, specifically in the North Sea where the industry is leading the charge with respect to active CCUS projects.

Dril-Quip is pursuing additional partnerships, including one focused on marine shipments of CO2. The company is actively working with onshore and marine logistics companies as well as storage development organizations to develop a 'shore-to-seabed' methodology that will allow industrial zones to load, transport, inject, and store CO2 in a manner that is cost-effective, safe, and reliable and that also reduces operational carbon emissions.

THE PATH FORWARD

As governments implement carbon taxes around the globe, the economic benefit of storing CO2 must be realized, and technology will pave the way. Dril-Quip is committed to being part of the solution by providing innovative, economical solutions to help the industry achieve its CO2 injection and storage goals.

Sourcing Model Has It All Configured Out

By Oliver Farrell, Systems & Technology - Structuring & Competitiveness Leader, Baker Hughes

A more stable oil price is instilling confidence among operators to bring capital developments back. But, after years of industry volatility, they're looking for greater levels of certainty in the project environment. Product structuring is not an entirely new concept but it's increasingly coming into its own as a positive influence on project economics.

The practice of engineering to order – of sourcing bespoke, preferentially engineered solutions that reflect the specific demands of individual projects – has been the default approach for many operators down the years.

It results in a resource-intensive and highly complex design and engineering effort, and those characteristics often flow through the supply chain, necessitating development to support execution. It might call for new suppliers or changes to processes, machining and manufacturing techniques – even new raw materials. At a time when operators have a laser-like focus on costs and efficiencies after their experiences of the past few years, the principles of product structuring are increasingly gaining traction as they look for ways to optimize overall field economics. Instead of engineering to order, the concept of product structuring is based on configuring to order. The methodology for creating such a market-ready model involves several identified steps, and at Baker Hughes, we've adopted those in establishing a subsea product structuring proposition that's already been utilized by customers internationally.

The foundations of product structuring

Put simply, we looked closely at the functionality our customers' need to deliver projects, both those that are going live and those that are coming down the road. We harnessed the knowledge derived from that exercise to develop structured solutions with the optimum level of options to configure rapidly. The objective is to offer the best options to meet the functionality required across multiple projects, while minimizing the variance of significant components, in effect, to reduce the number of building blocks needed to satisfy the requirements of the job in question.

That development process in turn has a significant impact on the materials, parts and manufacturing landscape – by minimizing variance, it is possible to embed new certainty about future requirements in the supply chain, and that can prove pivotal in terms of yielding bottom-line benefits for customers. Based on that longer-term stability, we have worked with our portfolio of suppliers to put frame agreements in place to consolidate our ability to reduce cost and cycle time.

The application of standardization

It's important here to stress the distinction between product structuring and standardization. The latter is essentially about fixing and limiting options; while this provides benefits at material and component building block level, standardizing at the final product level can inhibit features which add value to the project. Product structuring offers the optimum balance of flexibility and standardization; allowing features to be configured into the product to address project need, whilst standardizing at the building block level to allow cycle-time and cost to be meaningfully impacted.

At Baker Hughes, we've worked to add a further dimension to the process, by developing a bespoke tool, a live product e-configurator, which in essence presents a menu of pre-engineered options to customers. It strengthens the ability of the structuring model to strip significant periods of time from the commercial and execution processes associated with project execution.

A project-wide perspective

The front-end functionality is inevitably focused to a

Photo Baker Hughes

Structured deepwater horizontal xmas tree

large extent upon engineering, but it's important to recognise that product structuring is about much more than engineering. It's about some of the fundamental principles of successful project execution – from supply chain sourcing and internal manufacturing to project management and quality assurance.

And it's against the backdrop of the bigger project picture that the gains of product structuring – improving the economics of subsea fields – begin to materialize. It influences cost, certainly, but perhaps even more importantly it serves to reduce the cycle time to first oil. From an overarching economic perspective, it could be argued the latter can have a greater material impact than the former.

It's broadly acknowledged that the industry cycle time for Xmas trees is around 18 months. We are now targeting – and achieving – a cycle time of 12 months because of the applied principles of product structuring. We're delivering on such timeframes partly because we're eliminating initial engineering work and immediately embarking on parts procurement through our supply chain agreements. And if you're taking six months out of the cycle time for a piece of infrastructure that's critical on the path to first oil, that can only change the economic profile of the development for the better.

Building on the benefits

At a project level, we've calculated that the application of the product structuring model by Baker Hughes teams yielded overall cost savings of $2 million on one particular project. Typically, we estimate it is yielding cost reductions of between 10% and 30% on individual developments.

The benefits of product structuring are also secured in a more rounded sense by some of the generic attributes of the approach – the efficiencies, enhancements in processes and quality, and risk mitigation derived from repeatability.

We'll continue to move it forward as a concept, in part by applying the methodology around new solutions we bring to the market as well as our existing products. Conversely, product structuring provides a very stable foundation for innovation and as industry trends evolve – with, for example, the growth in all-electric subsea systems – it directly supports our product development agenda. In addition, we anticipate that digitization and automation will present significant opportunities to further refine the process.

It all points to an industry future in which product structuring, by leaning out the entire product manufacturing process, can increasingly help to deliver on industry imperatives.

Photo by Bartolomej Tomic

TenneT's Substations Getting Ready for Vattenfall's Giant Offshore Wind Farm

By Bartolomej Tomić

TenneT, an electricity transmission system operator with activities in the Netherlands and in Germany, late in March installed the topside of the second offshore transformer platform built to serve Vattenfall's giant Hollandse Kust Zuid offshore wind farm in the Dutch North Sea.

Following the installation of the first transformer platform, the Hollandse Kust Zuid Alpha, in December 2021, TenneT had offshore installation firm Allseas install the 3,950t Hollandse Kust Zuid Beta topside on a 44 meters tall, 2,900t jacket previously lowered on the North Sea seabed in the Dutch North Sea.

On what was a rather foggy Monday in the North Sea off Scheveningen, Allseas on March 28 used its 382-m Pioneering Spirit installation vessel, a true behemoth, to lift the HKZ Zuid Beta topside, and lowered it on the jacket.

The topside had arrived from Dubai, where it was built by Petrofac and Drydocks World, to Rotterdam aboard Boskalis' semi-submersible heavy transport vessel Mighty Servant 3 just days before the installation, which, according to Allseas, went quickly and smoothly.

Per Allseas, it took only three days between the loading of the Beta topsides aboard the Pioneering Spirit in Rotterdam to finalizing the set-down and welding onto the jacket.

Drifting Bulk Carrier

However, just a month before the installation, the HKZ Zuid Beta project faced a scare when the drifting Maltese-registered Julietta D cargo ship hit the HKZ Zuid Beta jacket in stormy weather.

A total loss would have caused a lengthy project delay and hefty additional costs, ***Offshore Engineer*** understands, as it would've called for a new jacket to be built and moving and securing the topside ashore, as well as potentially having to face an issue of not having a suitable installation vessel, as the Pioneering Spirit, due to its own schedule and other projects, might not be nearby for the second attempt.

Luckily, a subsequent inspection by TenneT proved that the jacket suffered only minor damage, and that it was safe for the topside to be installed, thus avoiding any potential delays.

TenneT inspected visible damage above water, but it also carried out underwater surveys to determine any damage to the substructure.

"This underwater investigation took more time due to relatively high waves and poor visibility. The investigation now shows that the damage is limited to paint damage and a few dents on one of the legs of the platform and damage to one of the four landing platforms for working vessels," TenneT said.

Announcing that the jacket is safe to receive the top-

side, Joris Engelen, TenneT's Platform Project Lead, said, "When designing and building our jackets, scenarios are taken into account that a ship of limited size may collide with the jacket. After the initial fright of the collision, we set up and implemented an extensive investigation plan in cooperation with the parties involved. The jacket is expected to be in operation for many years."

He said that it was a relief that the inspections and the investigations showed that the topside installation could proceed safely and as scheduled.

The repairs of the damage on the jacket are scheduled to be carried out after the topside installation.

While the incident had potential to negatively affect the project budget and schedule, there is also a silver lining in that it immediately prompted the industry to search for ways to prevent similar incidents from happening again. Read more on this in the box below right.

HKZ Alpha ready to connect

Following the successful installation, the HKZ Beta High Voltage Alternating Current (HVAC) offshore transformer platform with a 700MW capacity, and built by Petrofac and Drydocks World Dubai, will now be prepared for the connection to Vattenfall's wind turbines.

According to TenneT, the Hollandse Kust Zuid Alpha transformer platform, to be used for a connection for offshore wind farms Hollandse Kust Zuid I and II is now ready for use.

"TenneT completed the installation and energization of the offshore grid connection. Wind farm developer Vattenfall can now connect the wind turbines to the high voltage grid." TenneT said in a statement sent to *Offshore Engineer*.

Marco Kuijpers, Director of Large Projects Offshore, said, "With the energization of the Hollandse Kust Zuid Alpha connection, the offshore grid that TenneT is building in the North Sea is starting to take shape. Hollandse Kust Zuid Alpha is the first connection of an offshore wind farm to the Maasvlakte and has a capacity of 700 MW. The energization of Hollandse Kust Zuid Beta later this year will add another 700 MW from wind farms Hollandse Kust Zuid III and IV."

As mentioned, the platforms form part of the grid connection that connects the offshore wind farm zone to the Dutch mainland at the Maasvlakte.

Located 20 km off the Dutch province of Zuid-Holland, the Hollandse Kust Zuid (HKZ) wind farm zone covers an area of 235.8 km2.

The platforms will convert voltage of the electricity produced at the wind turbines, which have yet to be installed, from 66 kV into 220 kV, and will then transport the electricity is shore via subsea cables, to an electrical substation at the Maasvlakte.

At this substation, TenneT said, the voltage is converted into 380 kV. Finally, the electricity is transported to the high voltage grid via high voltage station Randstad 380 kV Zuidring, TenneT explained.

Petrofac was responsible for the engineering, procurement, construction, and offshore installation of the HKZ

Credit: TenneT

Credit: TenneT

Alpha and HKZ Beta platforms.

Commenting on the HKZ Beta topside installation, Sami Iskander, Petrofac CEO, said, "The safe installation of the Beta topside is a significant milestone in the delivery of this important energy transition project. Everyone involved should be proud of this achievement."

TenneT's Kuijpers added, "I am very pleased that the project was installed safely and I compliment Petrofac and Allseas on this. Wind energy plays a crucial role in the energy transition, also in industry, and I am proud that TenneT, together with our partners, can contribute to a sustainable future in this way."

The turbine installation for what will be a 1.5 GW offshore wind farm project, is expected to start in the coming weeks, *Offshore Engineer* understands.

In a tour hosted by TenneT on March 30, where members of the media, including the *Offshore Engineer* author, had the opportunity to sail around the two HKZ platforms aboard Chevalier Floatel's DP Galyna vessel, one could also see multiple transition pieces installed on monopile foundations and ready to host Siemens Gamesa's powerful 11MW wind turbines.

The construction on what is expected to be the world's largest wind farm once operational is being done in phases.

According to Vattenfall's annual report, the first phase ran in 2021 and saw the installation of the first 34 monopiles. The second phase, to installation the remaining 106 monopiles starts in April.

Cadeler's Wind Osprey jack-up installation vessel will install 140 Siemens Gamesa wind turbines, with a set of components for four complete offshore wind turbines planned to be loaded from Maasvlakte on the Wind Osprey each trip. Each turbine will have a tip height of 251m and a rotor diameter of 200m. The turbine blades will be 97m long.

Once fully operational in 2023, Hollandse Kust Zuid, which will be the first subsidy-free wind farm area in Europe, at 1.5GW capacity will be the world's largest wind farm, too.

It will generate enough electricity to power more than two million households and is expected to operate for 25-30 years.

HKZ Beta Platform lift

Credit: TenneT

Testing Barriers

The incident with the Julietta D ship hitting the HKZ jacket prompted research by the Dutch maritime research institute MARIN into the potential barriers aimed at averting collisions between ships and wind turbines.

"A collision with an installed wind turbine carries a real risk of the turbine toppling onto the vessel, seriously endangering crew, passengers, the ship itself and the environment," MARIN said in March, announcing that three innovative concepts were tested.

The first concept involves a string of surface buoys secured by drag anchors (Illustration 1). The second concept comprises a smart suspension net between fixed poles (Illustration 2) and the third is an anchored underwater hook line designed to catch the anchor of the drifting vessel (Illustration 3). MARIN built scale models of all three solutions and ran tests in its Offshore Basin on 17 and 18 March to see if the barriers were capable of deflecting a scale model comparable to the Julietta D in storm conditions.

"The first results are promising," MARIN said.

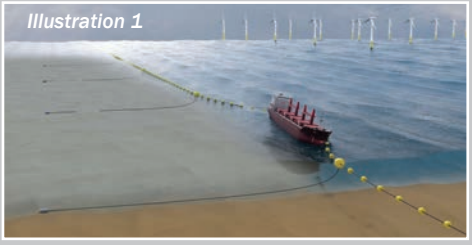


Illustration 1

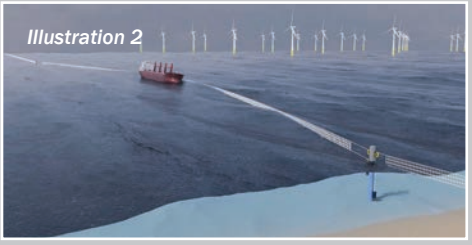


Illustration 2


Illustration 3

Images: Marin

Photos courtesy Balmoral Offshore Engineering

Drill Riser Buoyancy Solution inspired by the Sea Turtle

Aneel Gill, Product R&D Manager, Balmoral Offshore Engineering, explains how Balmoral Comtec's new Drill Riser Buoyancy solution was inspired by nature.

A natural phenomenon was industrialized using biomimetic engineering resulting in a structure capable of offering VIV efficiencies that dramatically improve riser motion and drag.

"With this development, we looked at several different ways of reducing vortex induced vibration, and it was our director who asked, 'Have you seen a sea turtle? Have you seen the shape?'," said Aneel Gill, Product R&D Manager, Balmoral Offshore Engineering. After a bit of digging by Gill and the Balmoral R&D team, the shape, the geometry, the pattern, all made sense.

The result is DuraFloat LDV (patent pending) technology which integrates vortex induced vibration (VIV) suppression and drag reduction into drill riser buoyancy modules to increase rig efficiency without compromising safety or structural integrity.

The system is designed to provide optimum uplift values while offering up to 75% VIV suppression efficiencies which dramatically improve riser motion and drag in onerous subsea current environments compared to traditional drill riser buoyancy.

"The LDV uses the same foam systems which Balmoral has used for 40 years," said Gill. "These systems are designed for taking impact and dynamic load-outs," said Gill. "The LDV is there to minimize the dynamic loads caused by currents [and other forces]. This improves the operational window for the driller."

The hex design eliminates the need for ancillary suppression equipment and helps reduce time-consuming activities when running and removing drill stacks.

Additionally, it is recognized that reduced riser motion due to VIV suppression dramatically improves the fatigue performance of subsea equipment resulting in further cost savings by extending the service life of wellhead and conductor/casing equipment.

SVA R2

Image courtesy Bosch Rexroth

Autonomous Directional Drilling

Image courtesy Schlumberger

Winners of OTC 2022

Spotlight on New Technology Awards

Bosch Rexroth

(Booth # 2306)

Technology: SVA R2 – The world's first electric Subsea Valve Actuator with safety by springs, as compact as hydraulic actuators

Here is how Bosch Rexroth describes its SVA R2 tech:

"Imagine removing all the hydraulics of your subsea equipment, reducing its footprint without adding power cables or complex batteries. Qualified for 4,000 m depth, the SVA R2 electrifies subsea valve actuation — improving safety and productivity.

The challenge presented to Bosch Rexroth was to design an extremely compact electric actuator with fail-safe mechanism by springs, including all necessary electric sensors, drive and control components. Additionally, energy efficiency should enable it to run up to 4 actuators sharing a single 96W power supply. Finally, the system should reduce costs by increasing quality, requiring extensive standardization work using industrial and automotive field-proven technology.

Stepping up to the global challenge of electrification and remote operation, the SVA R2 is the key enabler to protect the environment and reduce costs of subsea installations. The smart, connected, and efficient TRL4 qualified product is a disruptive innovation which does not compromise safety and cost."

Schlumberger

(Booth # 1916)

Technology: Autonomous Directional Drilling 2022

Autonomous Directional Drilling (ADD) isn't one tool or technology, Schlumberger says.

It amalgamates the fullness of well construction operations to drill from spud to TD, using an autonomous system that constantly analyzes its position, formation characteristics, conditions and trajectory to optimize steering, well placement and overall drilling performance—reducing cost per foot drilled and improving productivity.

Autonomy starts with the ADD predictive steering workflow that leverages cloud computing and machine-learning models to formulate the best plan based on available data. The resulting digital-drilling program facilitates the analytical tasks that a traditional directional driller takes while steering and implementing the well trajectory. In between are surface and downhole automation. Surface automation comprises digital acquisition systems along with surface-related steering automation and energy management workflows and downhole automation, or an autonomous downhole control system. It is an industry first that can manage inclination, azimuth and dogleg severity (DLS) downhole—autonomously eliminating decision latency.

Schlumberger

(Booth # 1916)

Technology: ReSOLVE iX extreme-performance instrumented wireline intervention service

The ReSOLVE iX extreme-performance instrumented wireline intervention service leverages intelligent downhole technologies to optimize

ReSOLVE iX

Image courtesy Schlumberger

Pure Oil Recovery Technology

Image courtesy R3 Environmental Systems

Galea™

Image courtesy Expro

results in extreme conditions, such as HPHT, sour and restricted-access environments. Conventional intervention tools rely on surface measurement to guide deployment, which for some extreme condition applications makes intervention an unviable option. ReSOLVE iX service overcomes this by using a combination of innovative hardware, automation and digitization, enabling operators to monitor and control intervention operations in real time and take immediate action to address downhole challenges.

Because each intervention is unique, the service is customizable to solve specific objectives, including slot cutting, fluid spotting, tubular cutting and plug setting. The ReSOLVE iX service has completed numerous jobs for more than 40 unique intervention applications.

R3 Environmental Systems (Booth # 1281)

Technology: Vacuum-Assisted Pure Oil Recovery Technology

R3's Vacuum Assisted Pure Oil Recovery technology is a safe, energy-efficient, and environmentally friendly solution for recovering drilling fluid and water from waste that is generated during oil and gas drilling activities, R3 says.

The recovered fluid (Second-Source Drilling Fluid) has been independently verified as a chemical and physical equivalent to virgin drilling fluid, meaning it can be used as a direct substitute for virgin drilling fluid in the formulation of new drilling mud products. As a result, companies can significantly reduce the amount of virgin drilling fluid that they need to purchase, transport, and eventually dispose of. The unit is designed as a series of modules, making it highly portable and accessible for companies with remote exploration sites anywhere.

Expro (Booth # 2626)

Technology: Galea - Autonomous Well Intervention System

According to Expro, Galea is the world's first fully autonomous well intervention system, aimed to maximize production while reducing intervention costs, HSE risks, and the carbon footprint of operations.

The system replaces larger, conventional and more labor-intensive wireline rig-ups for a range of routine slickline operations. It can be configured in a variety of operating modes ranging from fully autonomous to manual to suit a range of applications on and offshore.

Galea deploys a tool string into the well either at regular intervals or as defined by the well conditions in fully autonomous mode. The system performs a pre-programmed intervention sequence in semi-autonomous mode, initiated locally or remotely. When in manual mode, quick rig-up intervention compared to conventional operations is enabled.

The system also reduces the impact of operations on the environment around the well site. A small self-contained intervention package located at the well site all year-round eliminates the need for repetitive environmentally disruptive wireline unit or truck operations required for traditional approaches.

Managed Pressure Drilling

Image courtesy Oil States via OTC

Merlin™ 15K HPHT Riser System

Image courtesy Oil States via OTC

Oil States and TotalEnergies

(Booth # 1940)

Technology: 15K High Pressure, High Temperature (HPHT) Riser System for Subsea Drilling Applications in Shallow Water

Oil States and TotalEnergies have developed the Merlin 15K HPHT Riser System, which enables cost-effective drilling of shallow water HPHT wells with a jack-up rig while offering superior fatigue performance and improved safety with automated connection make-up. The system is believed to be the first-of-its-kind design-rated for sour service applications.

Oil States Industries

(Booth # 1940)

Technology: Managed Pressure Drilling & Riser Gas Handling System

According to the OTC, the Oil States MPD and RGH Joint is a step forward in integrating Managed Pressure Drilling and Riser Gas Handling into a drilling riser. The system's innovative design solutions, such as retrievable packers and pull-in bridle, provide reduced NPT, fast rig-up time and improved riser gas handling.

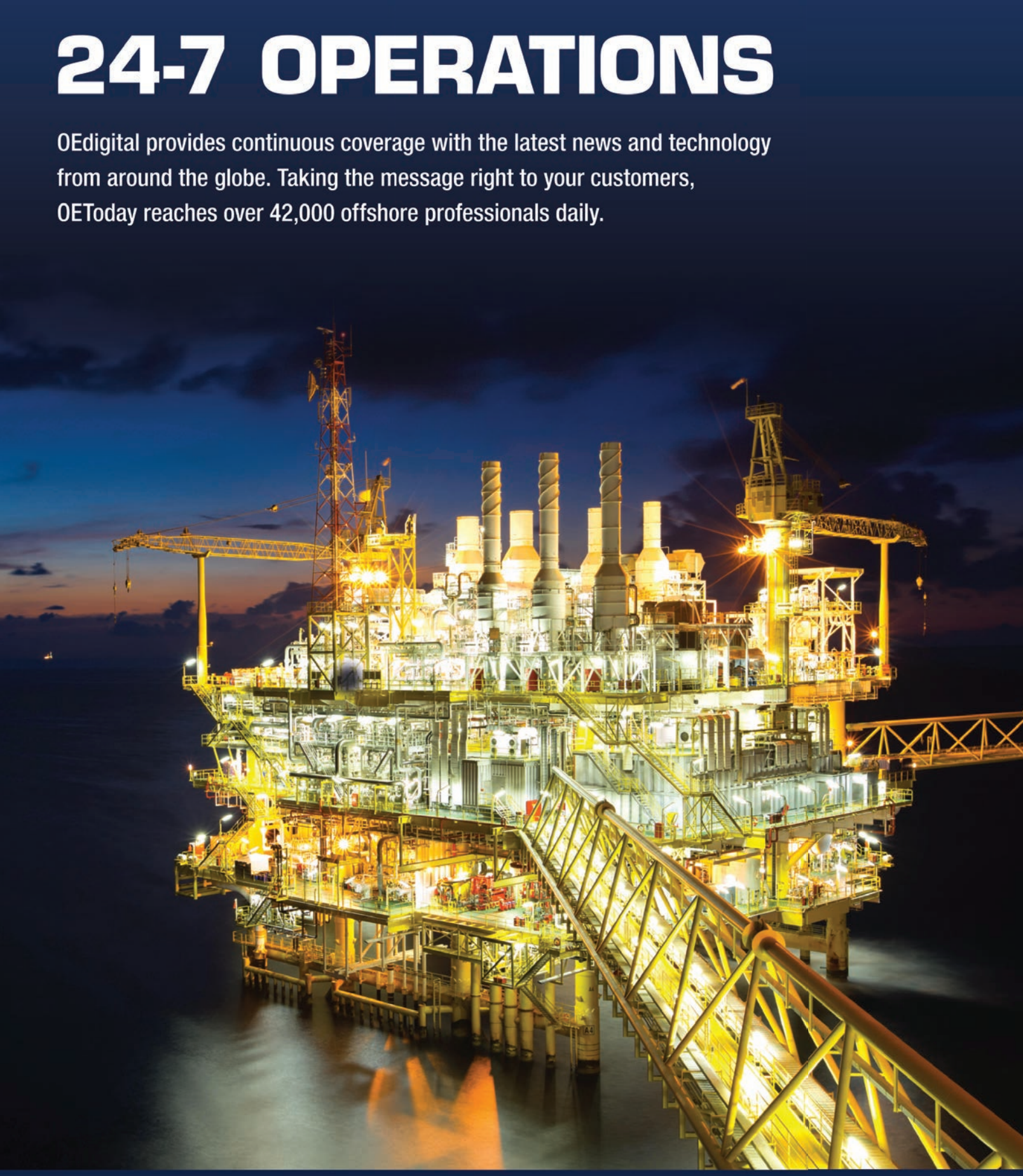
2022 Spotlight Small Business Winners

* **ClampOn**, producer of ClampOn Subsea Flow Temperature Monitor (Booth # 3631)
* **CoreAll**, producer of CoDril (Booth # 3553-1)
* **HYTORC**, producer of MXT+ Hydraulic Torque Wrench (Booth # 1743)
* **HYTORC**, producer of HYTORC Connect Software App (Booth # 1743)
* **Rocsole Ltd,** producer of ROCSOLE Intelligent Level Detection & Data Analytics for Sand Management (Booth # 2672)
* **Subsea Shuttle, LLC,** producer of Subsea Shuttle, LLC (Booth # 356)
* **Aquatec Group**, producer of KINEKtron® (Booth # 3382)

ADVERTISER'S INDEX

24-7 OPERATIONS

OEdigital provides continuous coverage with the latest news and technology from around the globe. Taking the message right to your customers, OEToday reaches over 42,000 offshore professionals daily.



OE OFFSHORE ENGINEER

Learn more at

OEDIGITAL.COM

THE FUTURE OF OFFSHORE ENERGY & TECHNOLOGY.


ABS
DELIVERING OUR VISION OF
TOMORROW'S ENERGY, TODAY.
LEARN MORE TODAY
www.eagle.org/offshorewind
www.eagle.org/offshorewindvessels