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LDAR

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Follow the Northern Lights
Carbon Capture & Storage (CCS) Gains Steam

A Floating Future
Acteon CCO Barry Parsons Discusses Opportunities in Floating Wind

Subsea Construction Vessels
A Heated Market Gets Hotter

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Northern Lights

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DEPARTMENTS

THE FUTURE IS NOW

The Offshore Technology Conference has regained some positive momentum, but it remains a shadow of its former self – at least in terms of exhibitor footprint – as the industry continues along the path of transformation. While traditional oil and gas undoubtedly remains the world's dominate fuel of choice for a generation or two to come, the winds of change are undeniable, with 'energy transition' and 'offshore wind pavilions' encroaching on precious OTC floor space, which up until only a few short years ago would have seemed absurd.

As has been written and reported many times, transition for the traditional oil and gas sector is not necessarily a bad development, as the nascent offshore wind – particularly floating offshore wind – presents a market in dire need of offshore oil and gas technologies and experience at a scale not before seen.

"This is not a small, kind of, maybe thing; this is big, it's global and it's happening right now," is how Barry Parsons, CCO, Acteon, described floating offshore wind when we met with him recently. Make no mistake, there are plentiful challenges – legislative, geopolitical, technological – to evolve this market from today to the promised land of the mid-2030s, which offers the prospects of hundreds of GW of power coming from floating wind. But the wheels are in motion, and if the market develops to only a percentage of its promise, there will be plentiful work for many.

Focus stays on the environment via a pair of features from Wendy Laursen and Bartolomej Tomic.

The former examines **fugitive methane emissions**, looking at how new and evolving technologies are helping the industry boost their leak detection and repair (LDAR) strategies.

The latter looks at the role of emerging **carbon capture and storage** techniques to help companies get the theoretical 'Net Zero' target. In this edition, Tomic takes a deep dive into the Northern Lights offshore carbon capture and storage project in Norway, a country with long experience with offshore CO2 storage.

Check out the 2023 Media Kit via the QR Code Below

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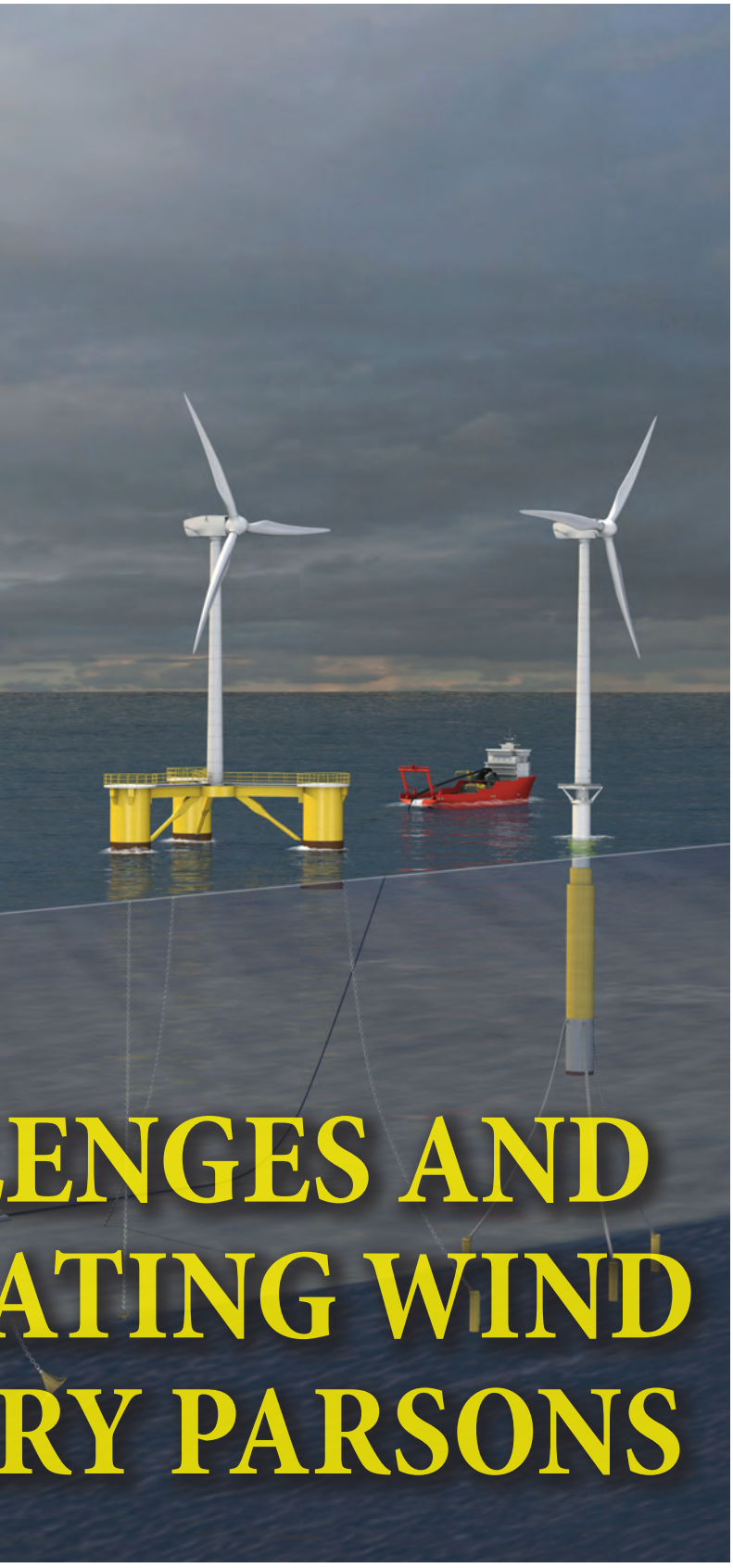
All images: Acteon Group

EXPLORING THE CHALL
OPPORTUNITIES OF FLO
WITH ACTEON CCO BAR



LENGES AND ATING WIND RY PARSONS

While the fixed bottom offshore wind dominates today, in the not-too-distant future floating wind will be the answer to efficient and voluminous renewable offshore wind power. Acteon CCO Barry Parsons discusses the technologies being developed and the planning being put in place so that his company can capitalize on this fast-growing market.

By Greg Trauthwein

> ***"What we do at Acteon is sector agnostic. At the end of the day, we're providing services for marine infrastructure. If there happens to be a wind turbine, or an oil and gas production platform, or a fish farm, or some sort of technology that you and I haven't even dreamt of yet at the top of that infrastructure, it doesn't fundamentally change the solution that we're providing."***
>
> **Barry Parsons, Chief Commercial Officer, Acteon Group**

"This is not a small, kind of, maybe thing; this is big, it's global and it's happening right now."

Barry Parsons is succinct in his summation of floating offshore wind, a renewable solution that is widely touted to be the future of offshore wind energy, premised on the flexibility to move the turbines further offshore to deeper waters where an estimated 80% of the wind power potential resides.

As with any market promise, there is also peril, and in his recent interview with Offshore Engineer TV Parsons is quick to discuss not only the market potential but the hurdles that will need to be cleared to fully realize this potential. But make no mistake, Parsons and his Acteon team are bullish on the future of floating wind, with the organization offering an enviable breadth and depth of offshore engineering experience and technologies to efficiently, effectively build and service offshore floating wind fields globally, cradle to grave.

Acteon Group: By the Numbers

The $700m Acteon Group has a global footprint, with 2,200 employees staffing 104 locations in 21 countries. Most of its engineered solutions were born in offshore oil and gas, with many of its technologies having ready applications in the burgeoning offshore wind sector, too. Set up across three operating divisions – Data and Robotics; Engineering, Moorings and Foundations; and Energy Services – Parsons said "The connecting DNA is that we provide services to assess, design, build, install, inspect, maintain and remove marine infrastructure."

That installed base is centered on offshore oil and gas, but it is changing. Today, 25% of Acteon Group's business is outside of oil and gas – predominately focused on offshore wind – "and at last count, the offshore wind installations are growing at around 22-25% annually," said Parsons.

To date Acteon has installed approximately 2,500 offshore wind turbine foundations; it has supported approximately 1500 additional mooring spreads offshore, as well as approximately 800 drilling campaigns and more than 300 decommissioning projects.

While many companies born in the oil and gas industry face challenges in leveraging that experience, engineering

and technologies to offshore wind, Parsons contends that it is here that Acteon has the edge.

"What we do at Acteon is sector agnostic," he said. "At the end of the day, we're providing services for marine infrastructure. If there happens to be a wind turbine, or an oil and gas production platform, or a fish farm, or some sort of technology that you and I haven't even dreamt of yet at the top of that infrastructure, it doesn't fundamentally change the solution that we're providing."

Hurdles to Leap

Despite the promise, in offshore wind – both fixed and floating – there remain technical and logistics hurdles to clear.

"If you think about a typical oil and gas project, the focus is getting it right and keeping everybody safe," said Parsons. "In offshore wind, the safety focus is the same, but we're not installing one of something; we're installing dozens, or sometimes hundreds of something. So that notion of cycle time and repeat and efficiency, it gets a focus that really drives the commercial value in offshore wind that's a little different from oil and gas."

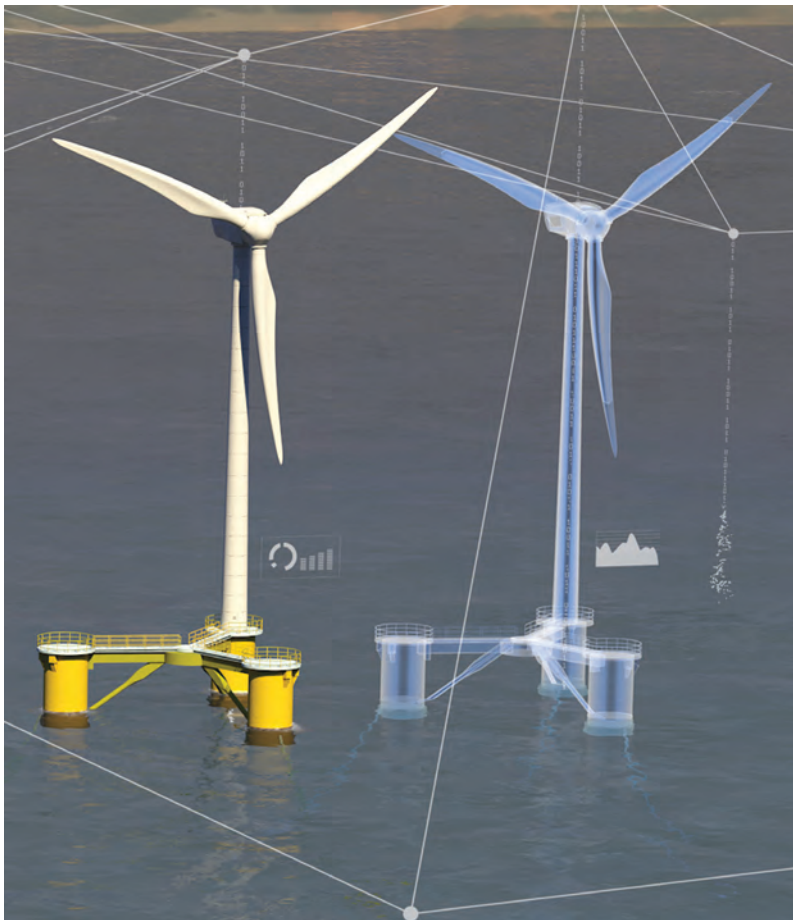
As the size of the projects and the individual wind turbines grow, so too do the technical challenges. Acteon Group is working diligently to leverage its considerable oil and gas experience – and working to develop new technologies – to create and refine solutions that are still many years away from commercial installation.

"A couple of technological challenges spring to mind," said Parsons. "In fixed bottom wind, for years, all the monopiles that have been driven are eight meters or less in diameter. Now, we're talking about 12-, maybe 14-meter diameter monopiles. Developing a technology to be able to install those doesn't exist right now, so we're working on that."

In floating wind, the focus is on cost-effective anchors, specifically the challenge of taking an anchor solution that is proven in offshore oil and gas but getting that system at a suitable cost for floating "is going to take a lot of work."

And whether the solution is fixed or floating, a critical element is fully understanding the seabed conditions. "As we continue to find more and more challenging soil conditions in installing offshore wind farms, finding faster, more reliable ways to obtain the geotechnical samples that we need is an increasing area of focus and something that we've been working on for the last couple years."

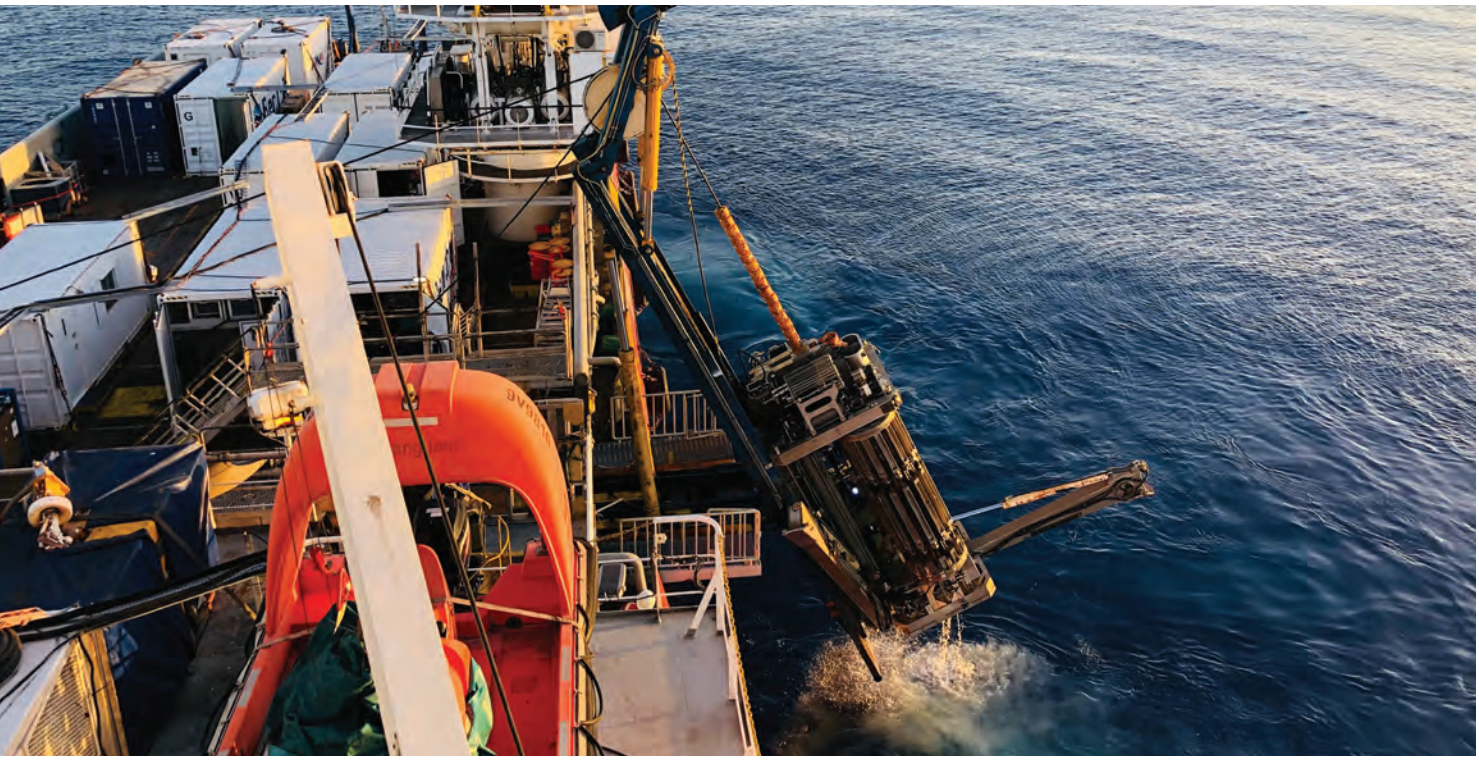
Parsons said that Acteon has two specific developments underway right now – one that has been granted a patent, the other one patent-pending – developments focused on



"providing tension in those mooring legs for offshore wind installations that don't require another big expensive vessel and a lot of expensive equipment left in the water. These mooring installations are effectively going to be permanent, operating for decades, so reducing the value of the equipment in the water is really important."

In step is another perpetual challenge: carbon footprint reduction. To this end, Acteon is engaged in several technology automation development programs, the first aimed at reducing the number of large, costly, crewed vessels at sea. "We're testing some autonomous surface vessels that let us do twice as much data acquisition for half of the carbon footprint. We're also "commercializing the next generation of our seabed drilling and sampling robot, called PROD5, to increase productivity and cut costs for offshore renewables."

Finally, he sees the issue of variability in designs that could slow the floating wind roll out. "There's somewhere [in the neighborhood of] 80 different competing floating hull designs," said Parsons. "I think standardizing to some degree, at least by market, is going to drive a tremendous amount of value."



Floating Wind's Future is Now

There has been much focus on the emerging floating wind market of late. According to Philip Lewis, Director of Research, Intelatus, there are tens of GW of floating wind projects slated for development through the 2030s, including these widely discussed projects:

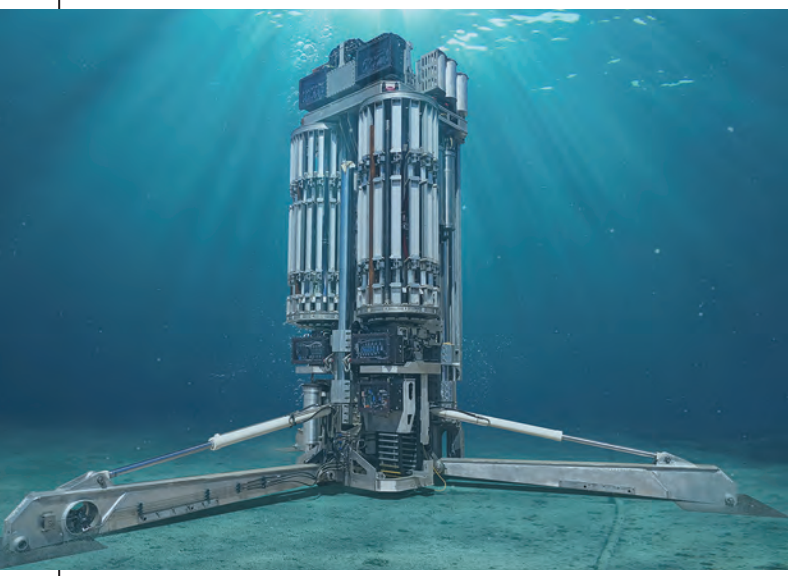
- The U.K. is forging ahead with commercial scale floating wind developments through the Scotwind and INTOG awards of at least 24 gigawatts (GW) of floating wind capacity representing close to 1,500 floating turbines that will come on stream through 2030.
- 4 GW of capacity through the Celtic Sea floating wind auctions.
- The U.S. has awarded floating wind leases with a potential of more than 8 GW of capacity in the Pacific and will move ahead with large floating wind leases in the Atlantic this year.
- Norway is planning to award 1.5 GW of floating wind capacity at Utsira Nord this year and France is targeting bring 750 megawatts (MW) of floating turbines on stream at the end of the decade in the Atlantic and Mediterranean.
- Spain and Portugal announced multi-gigawatt floating wind aspirations.
- In Asia Pacific, despite permitting hurdles, the prize is more than 8 GW of floating project potential, mostly off the east coast Usan region. Australia and Japan are also the subject of much interest.

The list of offshore floating wind is long and growing, and the allure of floating wind is the ability to place the units further from land in deeper water, providing access to stronger, more reliable wind sources that house an estimated 80% of offshore wind resources. Another attraction to deeper waters further from shore is the availability of offshore real estate with fewer competitors and conflicts.

"Clearly, offshore power generation is not the only use of offshore real estate," said Parsons. "We're competing with the fishing industry and transportation, as well as protected environmental areas. All that complexity increases as you approach the coast on the continental shelf."

While projections generously indicate an uptick in the offshore floating wind in 2026/27 and beyond, Parsons is keen to point out that the technology development conversations are already being conducted at pace. "We have commercial agreements in place for floating wind projects in Korea, the UK, the United States, France, Norway and Italy. This is big, it's global, and it's happening right now. And I think maybe some people if I can be blunt, are asleep at the switch. [To be clear], this is today's problem. The installation's going to happen tomorrow but figuring

Acteon is commercializing its next generation of seabed drilling and sampling robot, called PROD5, to increase productivity and cut costs for offshore renewables.



out how we're going to do that is happening right now."

Projecting 'where and when' is a conundrum facing many companies in the space, and while Parsons was reluctant to pick the frontrunners, he said: "In terms of a commercial scale project, I have a feeling that South Korea is going to be first," said Parsons. "Number two gets confusing: the UK probably; the US possibly."

Logistics, Logistics, Logistics

As the size of turbines and projects grow for both fixed and floating offshore wind, the challenges within are not limited solely to technical solutions. The size and volume of components and systems that need to come together seamlessly required a well-planned supply and logistics chain, as quayside facilities – themselves in evolution to handle the traffic – are going to be at a premium.

"That complex logistics and supply chain challenge is going to be significant," said Parsons. "And [Acteon] has a substantial track record over the decades of managing reasonably complex logistics and supply chain ourselves."

Specifically for floating wind, the mooring system is where a lot of the value, complexity and cost is tied up. Here, Parsons sees the breadth of the Acteon Group offers as a substantial competitive advantage in helping players – new and old – navigate the process.

"Within Acteon, with our stable services, we can connect the geophysical survey to select the geotechnical points of interest, acquire those samples, do that analysis and recommend the right mooring system, the right anchor solution for the best performance and cost for the project," said Parsons. Today Acteon has two agreements with offshore wind farm developers "of some note" to take established, tried-and-true mooring systems that were developed by Acteon for oil and gas, and to tailor them for a specific floating wind requirement.

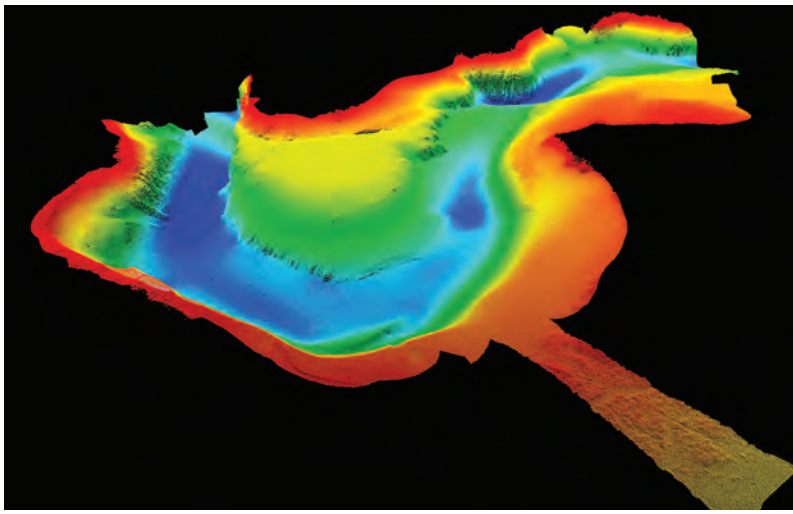
Parsons said he is "really encouraged" to see that there has been a lot of early engagement on floating wind with the developers. "They keenly recognize the technical challenges, as well as the cost challenges that this industry is up against," said Parsons, "and getting up that curve is going to determine the winners and the losers in this space."

In fact, he said that one floating project customer in the UK highlights the trend.

"Typically, customers would procure the geophysical survey first, then they acquire the geotechnical service, and we go out and take samples," said Parsons. "This customer's done it differently. They've engaged us early enough that we're going to deploy both. So, the geophysical does the initial acquisition, we select the geotechnical acquisition sites and acquire those samples, and then we cycle, and we're back in the field with geophysical. The whole idea is to drive efficiency."

"That complex logistics and supply chain challenge is going to be significant," said Parsons. " [Acteon] has a substantial track record over the decades of managing reasonably complex logistics and supply chain ourselves."

Deploying both geophysical survey with geotechnical acquisition is a customer-driven engagement that is designed to drive efficiency.

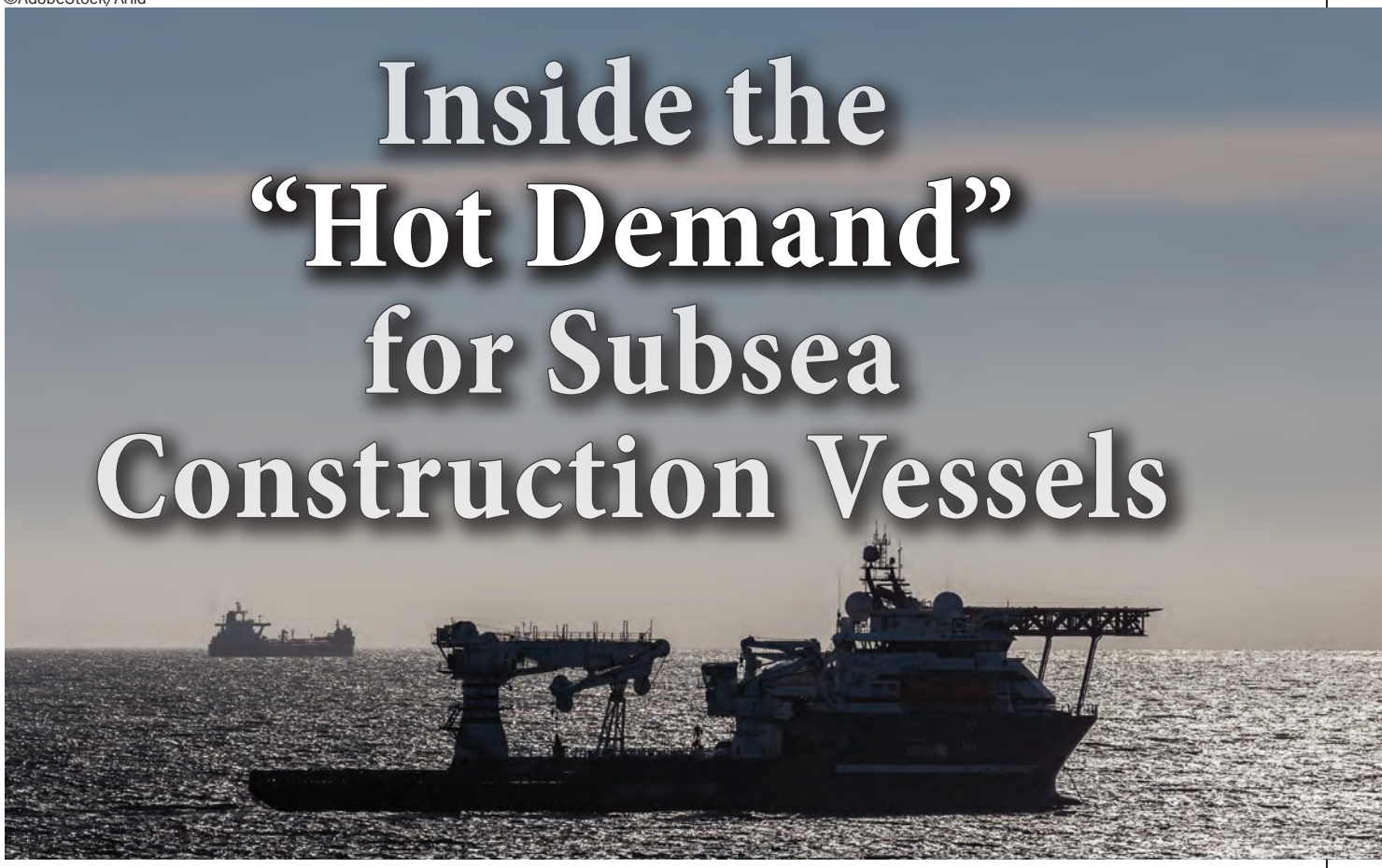


Think Global, Act Local

The promise of offshore wind is usually wrapped up in the renewable energy/decarbonization discussion that dominates many industries today, but for Acteon and its brethren in the sector, it is a genuine business opportunity. Barry Parsons, CCO, Acteon Group, put the challenge and opportunity in perspective, with insight on how Acteon's next-generation technology development today can help.

"We already mentioned it, but the notion of supply chain complexity, particularly at the scale, is a challenge." He said Acteon is engaged in discussions with one client that has a floating wind project with 200 turbines. "If you figure 200 turbines, with four mooring legs per turbine, you're talking about 800 anchors in a single project installed over a few seasons," said Parsons." That's years and years of anchor installations for oil and gas, and we're going to do this in one project. Just think about the amount of chain and anchors, and never mind all the hulls at quayside, and the complexity of managing it all; it's going to be enormous."

This challenge brings opportunity, particularly with the global spread of projects. While traditionally the equipment for the project would be manufactured far from the project and shipped in, "I think, driven in part by our regulators, but also in part by practical economics, it's going to make a lot of sense to fabricate more of this equipment closer to where the project is being installed," said Parsons. "This generates a lot of local value in the local community. This is not terribly complicated to fabricate, but there's a lot of it. So doing it locally is a real opportunity."



Inside the "Hot Demand" for Subsea Construction Vessels

A rising tide lifts all boats, as the saying goes, and while the offshore industry is currently experiencing a wide-ranging surge, there are vessel types and specific market segments that are expected to benefit more than others.

By Jesper Skjong, Analyst, Fearnley Offshore Supply

A rising tide lifts all boats, as the saying goes, and while the offshore industry is currently experiencing a wide-ranging surge, there are vessel types and specific market segments that are expected to benefit more than others.

One such segment is the offshore construction vessel (OCV) types, which to an increasing degree have found themselves in hot demand from both oil and gas developments as well as offshore wind activities.

While vessel definitions and abbreviations in this space can vary, for the purposes of this article, we will focus on what we at Fearnley Offshore Supply define as subsea construction vessels (CON), anchor handling construction vessels (AH-CON), light construction vessels (LCV), and multi-purpose supply vessels (MPSV) above 68m length overall.

When we examine the fleet development within these asset classes specifically, we find both similarities and differences compared to the offshore support vessels (OSV) fleet overall.

Here as well, the market experienced an unprecedent-

ed fleet growth between 2008 and 2014, with shipyards churning out 18 newbuilds per year on average. The total OCV fleet thus tripled during those years. However, the subsequent stagnation since then was quite stark for OCVs, with only around five such assets delivered per year on average from 2015 onwards.

The current orderbook for these vessels is virtually nonexistent and only consists of a handful of theoretically potential newbuilds that were all ordered during the last newbuild spree and still awaiting completion.

Another point worth noting is that given the relatively high barriers to entry compared to other OSV segments due to the complexity of operations, Fearnley Offshore Supply expects few, if any, future newbuilds to be ordered from new ventures outside of the industry.

Lead time for key maritime equipment, both high-end as well as core machinery, is also having an impact on the potential for OCV newbuilds. Recent yard quotes for such vessels schedule delivery up to 36 months from agreement, meaning that we are more than likely looking at 2026, at the earliest, before any new capacity will hit the market.

Surging OCV Demand from Multiple Directions

The market activity that drives OCV demand, on the other hand, is not only surging, but is actually pulled in multiple directions simultaneously. The sheer number of subsea projects set for development in the years to come, with its associated subsea trees, manifolds, risers, flowlines and umbilicals, and other infrastructure, has seen vessel demand already this year exceed 2014 levels.

In fact, subsea technology has now matured to a point where it is sometimes seen as a preferred technology, even in shallow water regions. This is especially true for the host of developments that will tie into and benefit from existing infrastructure. A good example of this effect can be observed in the number of subsea components expected to be installed in the Persian Gulf, a region that has seen very limited subsea developments historically on account of its benign waters.

Moreover, this effect can be measured in that subsea infrastructure has recently seen and is expected to continue to see its market share increase compared to conventional offshore O&G infrastructure.

Additionally, we expect the growth in offshore E&P investment to predominantly take place in deep- and ultra-deepwater regions, thus adding tremendous vessel demand going forward. Specifically, for OCVs Fearnley Offshore Supply forecasts demand levels to remain high throughout this decade, around or above 2014 levels for 8 of 10 years.

In addition to the O&G-derived vessel demand, significant OCV demand has come from offshore renewables, a trend that is expected to continue in the future.

While the vast majority of this demand comes from offshore wind, some projects, such as tidal turbines have also required high-capacity assets from the OCV fleet. A substantially tighter supply of relevant and suitable assets is already apparent, and considering the forecasted activity in the offshore wind segments going forward, the market for OCVs is set to not only surpass the previous market boom but even eclipse it.

A Show of Confidence

Over the past 12 months, we have seen a real sentiment change in the market, and shipowners in the OCV segment are now showing a confidence we have not seen for nearly a decade.

With a severely limited number of available vessels at any time, owners are demanding far better terms such as higher dayrates or longer firm periods, and some are even refraining from bidding on less lucrative vessel opportunities if terms are not satisfying.

For short-term or seasonal contracts in connection to specific project developments and campaigns, dayrates are already well into six figures, and multi-year firm contracts have also re-emerged in the market.

Better market terms, in combination with high replacement costs, has seen secondhand prices for OCVs increase significantly.

This year we have recorded several units well into their teens having been sold at more than or close to newbuild cost.

Moreover, with rising geopolitical tensions and increasing importance of subsea infrastructure such as fiber optic cables, a number of high-end units have been picked up by non-offshore and governmental buyers at significant premiums.

The scene is now set for subsea vessel owners, especially those with assets not tied up on long-term contracts with yesterday's rates.

We see the bargaining power already returning, leading to solid cash flows and likely reversal of impairments from the prolonged downturn.

In a somewhat normal market, we could argue that the current market conditions would trigger supply additions. However, the current balance sheets of most traditional players prohibit any action as of today. As such we expect the market to not only further improve but also remain in the owners' favor for years to come.

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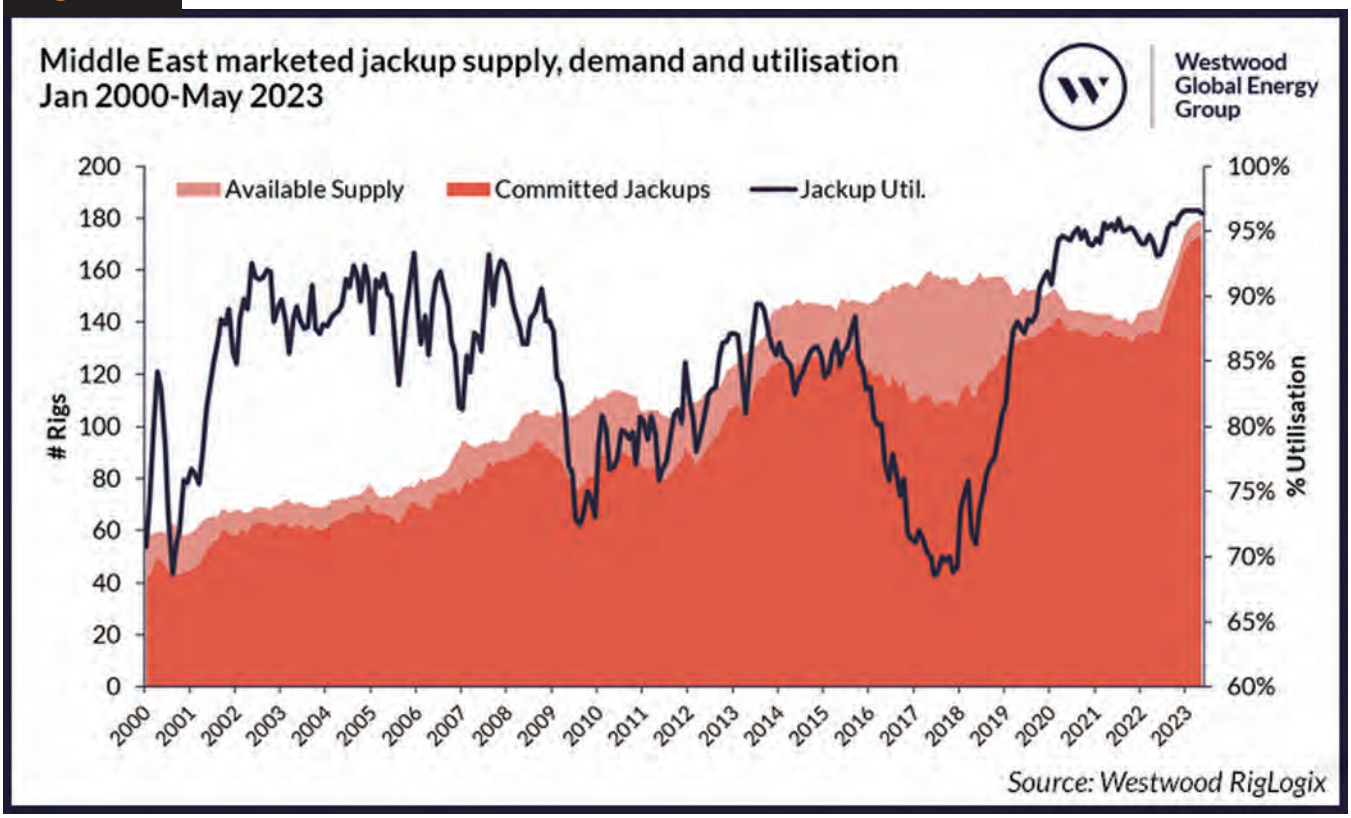
THE RISE OF THE MIGHTY MIDDLE EASTERN JACKUP MARKET

By Teresa Wilkie, Research Director, RigLogix

Figure 1



It's hard to believe that once upon a time the Middle Eastern jackup segment comprised of less than 60 units when today marketed supply sits just shy of three times that amount (180 units). Over the past two decades, this region has suffered similar blows as the rest of world off the back of oil price crashes and global pandemics, but overall, supply and demand growth has been monumental, and it doesn't appear to be showing signs of slowing.

The area is driven majorly by national oil companies (NOCs), such as Saudi Aramco, ADNOC and Qatar Gas', operations in shallow waters. Between 2000 and 2010 supply of jackups in the area increased 87%, from 60 to 112 rigs, off the back of 96% demand growth in the same period. Utilisation during this 10-year cycle averaged out at a strong 85%.

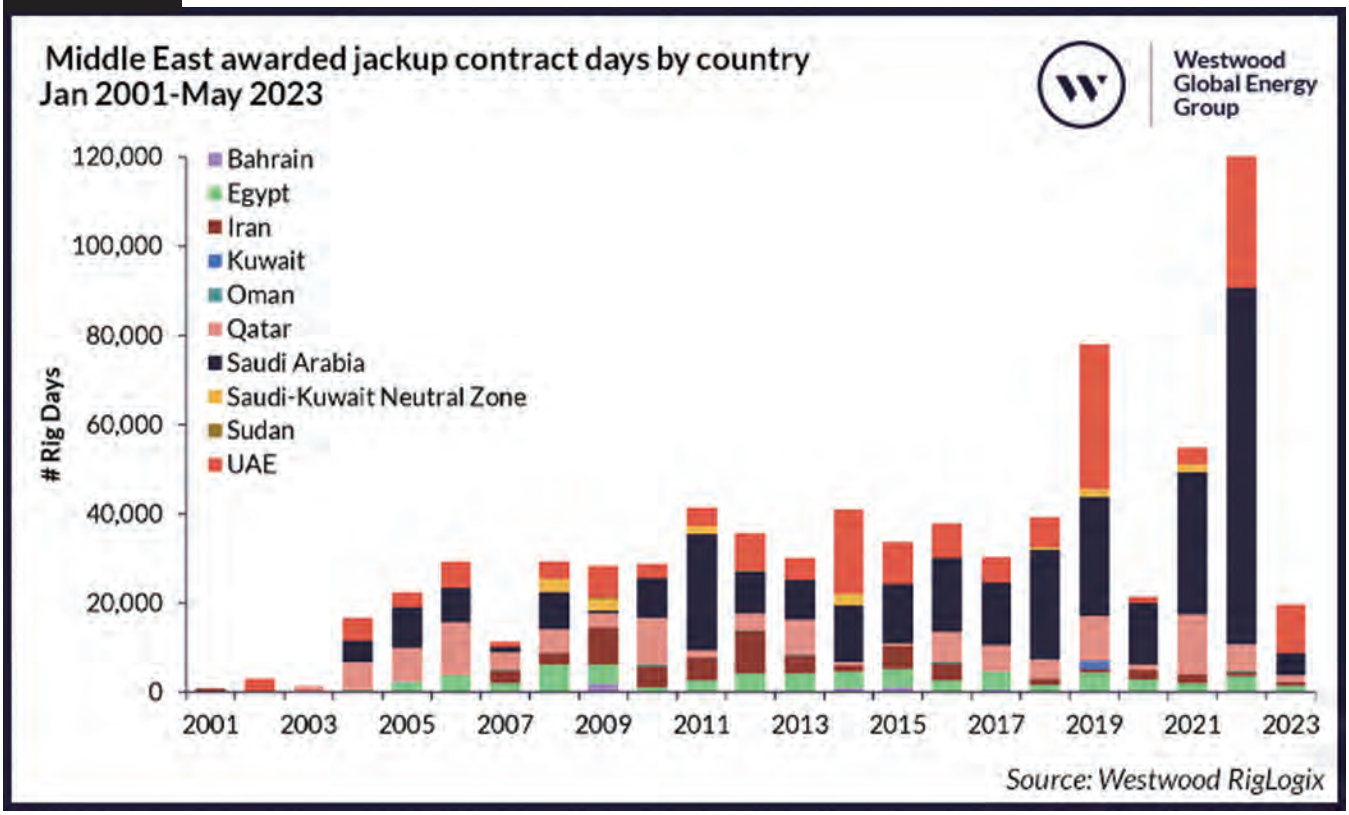
Although it slowed in comparison to the previous period, the next decade of 2011-2020 brought further growth of 31% in supply and 57% in jackup demand, despite lower oil prices and a market downturn, which was in turn followed by the further blow of the Coronavirus pandemic in 2020. During this era, committed utilisation averaged just three percentage points behind the 2000-2010 period at 82%.

The last two-and-a-half years have been even more interesting for this distinct. Averaging out at a whopping 95% committed utilisation between January 2021 and May 2023, and reaching the current high of 97% (as of late May 2023), demand has been steered by NOCs' renewed focus on increasing domestic oil and gas reserves and production through additional exploration and development drilling campaigns. During this period, jackup demand increased by 27% (37 rigs) and supply reacted as needed in line with this growth at 26%.

Contracting activity off the scale

Highlighting just how serious these operators are to ramp up activities is the enormous number of awards that have been made during the most recent period. For instance, from 2010 to 2020 awarded contract days

Figure 2



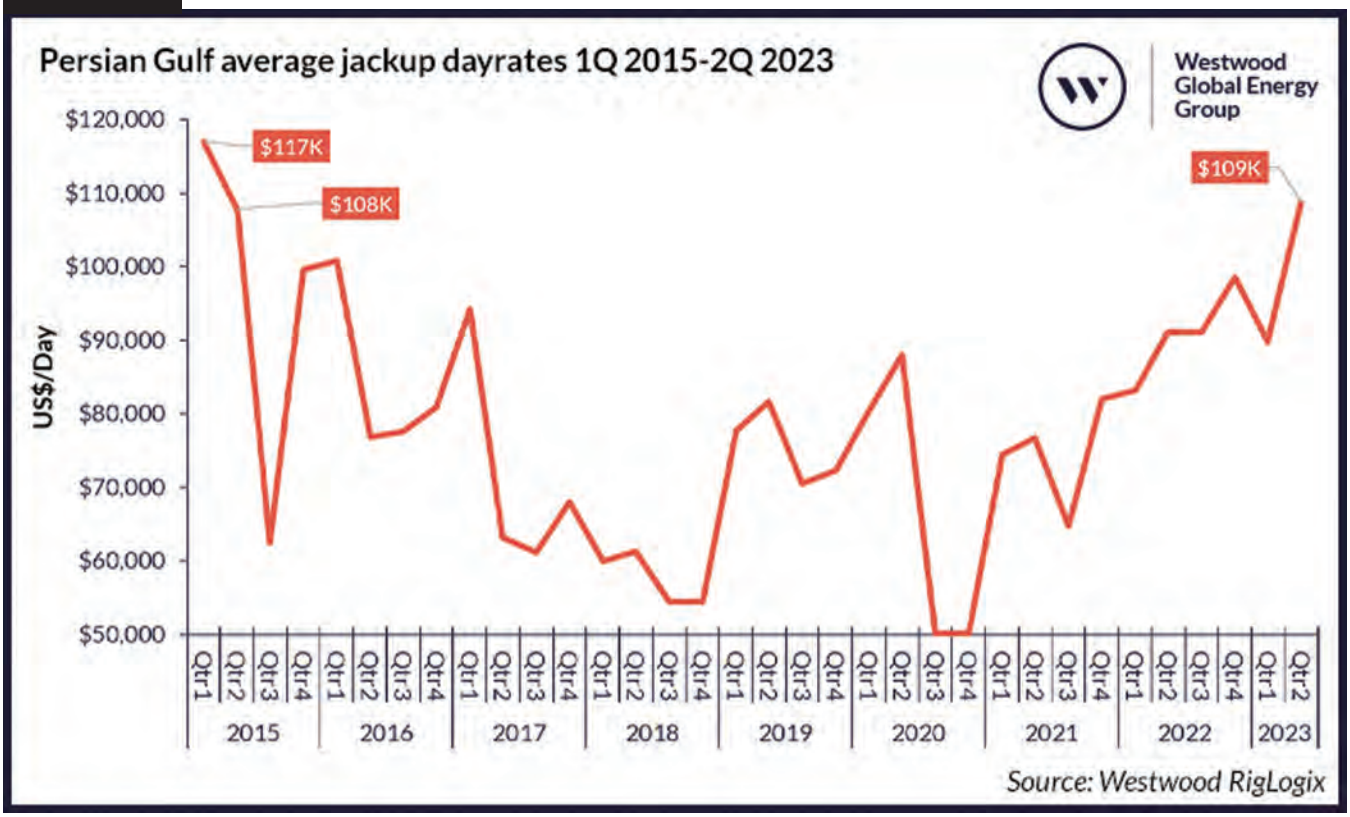
for jackups in the Middle East totalled 38,829 days or 106.3 years of new contract backlog but during the much shorter January 2021-May 2023 period, operators secured 64,913 days of jackup contract days (177.8 years), which is 67% more backlog added than the previous decade combined.

Further multi-year, multi-rig tenders are also out in the market from Middle Eastern players. Of the almost 29 years of demand already out at a tender or pre-tender stage, 52% is for operations off Saudi Arabia, 39% for Qatar, with the remaining demand either from Emirati or Omani waters.

Of course, to fulfil this ever-increasing demand, rig managers have been, and still are, looking outside of the domicile to find enough capacity and have been buying up newbuilds and older tonnage from shipyards or other companies, not to mention heavy reactivation programmes, several of which are still ongoing.

With global marketed jackup utilisation now sitting at 92%, however, finding extra rigs will not be an easy job. Worldwide, there are still 27 warm or hot-stacked units with no future work yet in place, though four are in the Caspian Sea and unlikely to be moved, most remaining active supply availability is in Europe or the Far East. Of the 57 cold-

Figure 3



stacked jackups, which could in theory be considered for reactivation, over 60% have been idle for five years or more. While in terms of stranded or newbuild capacity, there is a choice of 17 jackups in Chinese and Singaporean shipyards.

Dayrates heading northward

With the combination of tightening jackup supply and growing demand, both regionally and globally, this has brought about a spike in dayrates, especially in the Persian Gulf area. Between early 2015 and late 2018, dayrates in this area were almost halved from a high of $117,000 per day to just above $50,000 per day. Some recovery in pricing was witnessed in 2019, but then quickly slashed again during the pandemic.

Between late 2020 and the present day, however, average leading edge dayrates for jackups in the Persian Gulf have increased 118% to an average of $109,000 per day in late May 2023. Over the past year, fixtures have been awarded at a low of $70,000 to a high of $155,000 per day. Recent market sentiment suggests that as the supply/demand gap continues to restrict, combined with reactivation and newbuild delivery cost economics plus inflationary pressures, dayrates in the region are set to continue their northward trajectory.

The evolving FPSO landscape – healthy demand, changing procurement strategies

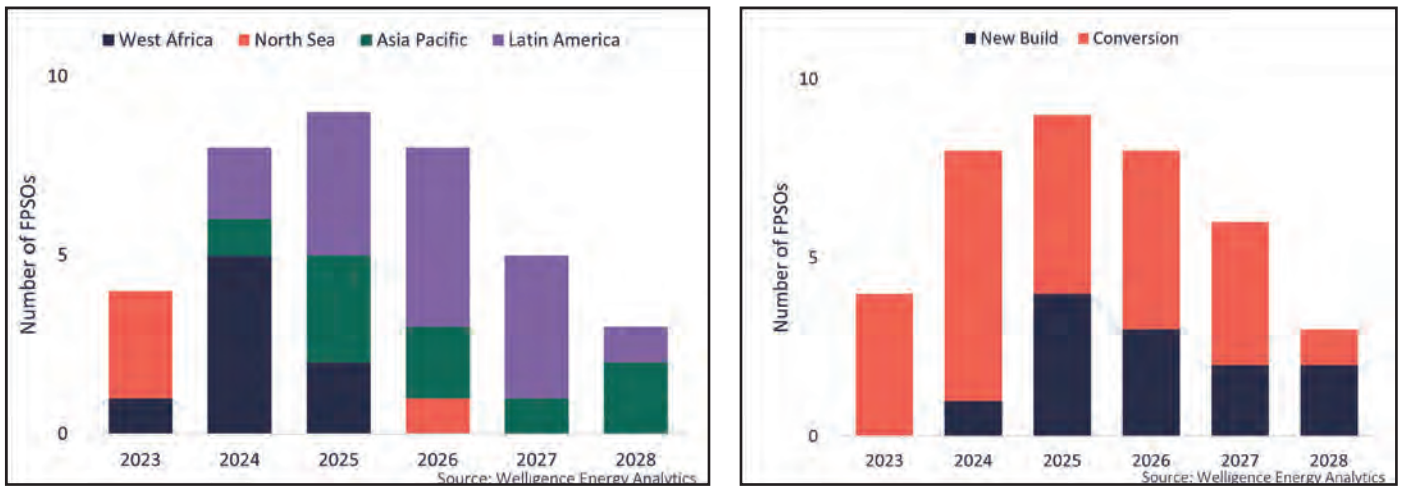
After a slowdown in activity during 2020/2021 due to soft commodity prices, demand for FPSOs is picking up.

By Obo Idornigie, VP Upstream Research at Welligence Energy

After a slowdown in activity during 2020/2021 due to soft commodity prices, demand for FPSOs is picking up.

And with exploration hotspots like Namibia's Orange Basin and the East Mediterranean delivering new finds, the FPSO market outlook is healthy. But shipyard capacity constraints are beginning to weigh on delivery, leading to cost concerns. Furthermore, FPSO demand is competing for yard space with other construction projects.

To mitigate delay risk and cost overruns, some E&Ps have reviewed their FPSO procurement strategies. The Build Operate and Transfer (BOT) model and use of stan-



*FPSO demand forecast (by region)**

***Demand is based on FPSO contract award year**

dardized hull designs are becoming more popular.

Strong demand outlook, but capacity constraint headwinds

We expect 35 FPSO projects with an estimated contract value exceeding US$50 billion to get the green light by 2030. At least a third will be new builds, and nearly half earmarked for Brazil and Guyana. The next hotspot could be Namibia, where TotalEnergies and Shell's exploration success could yield multi-FPSO development programs. The yards in China are the go-to for new-build FPSO hulls and conversion work, but capacity is strained.

Although new FPSO demand will not be as overheated as in 2014/2015, hull fabrication is now competing for yard space with other projects like FLNG vessels, floating regasification units and wind turbine installation vessels.

China dominates the FPSO hull fabrication market

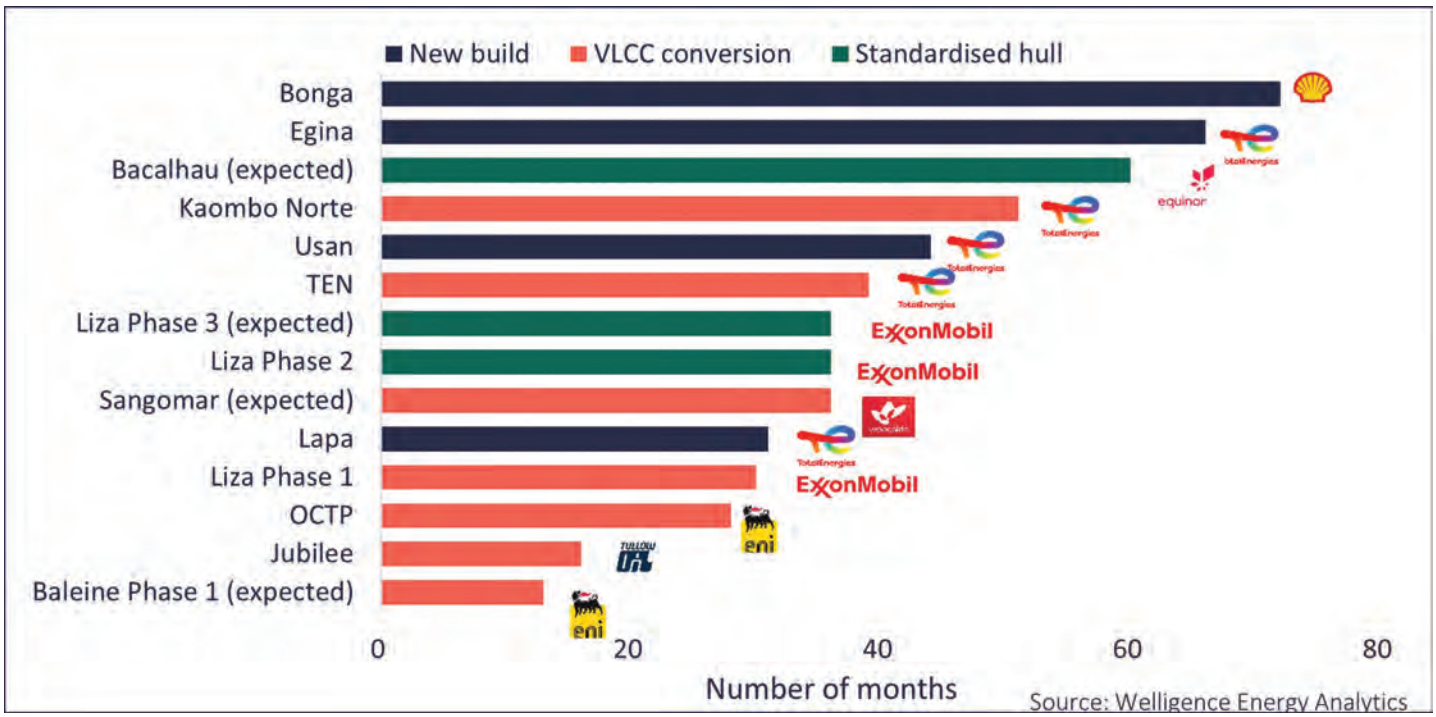
Historically, the large drydocks (Samsung, Daewoo, Hyundai) in South Korea built the majority of the large, complex FPSOs. But they have been surpassed by the Chinese yards, which have beaten them on price and delivery time. On the conversion side of the market, Singaporean yards like Semcorp and Keppel dominated, but also now face strong competition from China.

- SBM's multi-purpose floater hulls (its Fast4 Ward standardized hulls) were built at the Shanghai Waigaoqiao Shipbuilding (SWS) yard
- Modec has also launched its own standardized hull (M350 Hull), which is being fabricated for Equinor at the Dalian shipyard in China for the Bacalhau project in Brazil
- Cosco Shipping Heavy Industry orders include bp's Greater Tortue Ahmeyim (GTA) FPSO

E&P procurement strategies are evolving

The main FPSO contracting models have been turnkey (used for large, new-build FPSOs) or lease contracts (used for VLCC conversions). But the Build Operate and Transfer (BOT) model is becoming more popular, as is the use of standardized hull solutions.

- **The BOT model:** Under this approach, the FPSO is owned and operated by the FPSO contractor for a period before being acquired by the operator. The incentive is on the contractor to deliver on time and budget. ExxonMobil used it with the Liza Unity FPSO in Guyana.
- **Standardized hull:** ExxonMobil and Petrobras have been early adopters of SBM's Fast4ward standardized new-build hull solution, which offers shorter delivery times. The Liza Unity FPSO was operational in less than 36 months from FID. This lead time is more consistent



Lead time for FPSO projects operated by selected IOCs (FID to first oil)

with that associated with VLCC conversions than new builds. Wellgence considers TotalEnergies and Shell to be strong candidates for this approach in the event their Namibia finds require multiple FPSOs.

- **Redeployment:** There is still appetite for re-using existing FPSOs, bringing obvious cost and delivery benefits – this approach is attractive for use in early production systems.

Eni is to deploy an existing FPSO at Phase 1 of its Baleine development in Cote D'Ivoire, and it may also redeploy a cylindrical FPSO (a first in Sub-Saharan Africa) for Phase 2. Equinor has earmarked the Petrojarl Knarr for its long-delayed Rosebank development in the UK North Sea, and Aker Energy has identified the Ocean Yield-owned Dhirubhai 1 FPSO for Pecan in Ghana.

- **Reducing emissions:** This is a priority – emissions associated with production and processing on FPSOs account for around 60% of the total. Cutting gas consumption for new FPSOs is a key reduction lever, and contractors are working closely with operators to explore technologies to improve efficiencies.

Equinor's Bacalhau FPSO will use combined cycle turbines, and more operators will likely go down this path. Aker Carbon Capture is developing an FPSO carbon capture solution, and it's reported this technology will be deployed on two Petrobras FPSOs. However, there is a cost – we estimate the combined cycle gas turbine will increase the topside costs by 20-30%.

FUGITIVE METHANE EMISSIONS:

Photo Source: SeekOps; Photo Credit: Arcadis Australia

LDAR campaigns are getting smarter

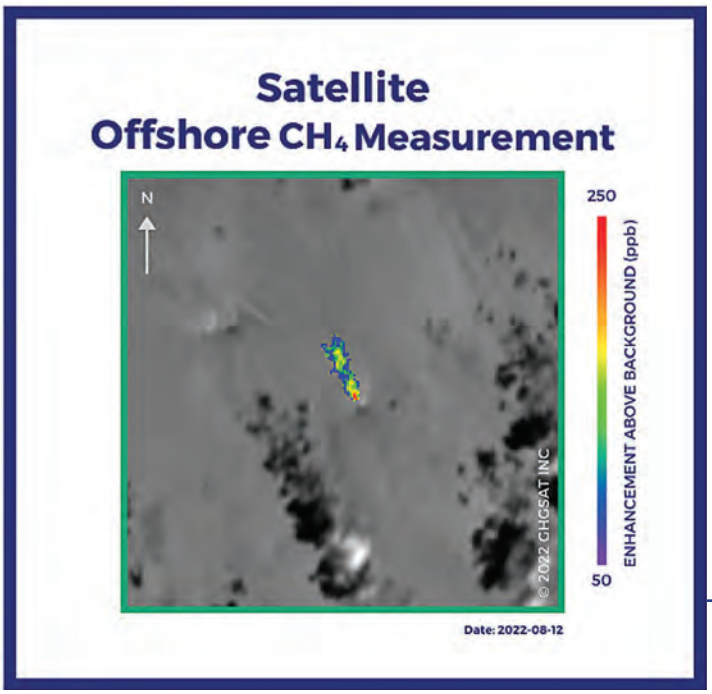
SeekOps can detect methane concentrations down to 10 parts per billion, pinpoint sources and quantify emissions as low as 20g/hr using wind data in its algorithms.

Top down or bottom up, new technologies are helping the industry boost their leak detection and repair (LDAR) strategies.

By Wendy Laursen

As the world approaches 1.5°C, the presumed threshold of dangerous warming, action to reduce methane releases is seen to be a way of buying time for achieving longer term CO2 cuts.

However, as ABS points out in its recent Sustainability Insights paper, current emissions estimates may be underreporting the truth. Princeton University and Colorado State University researchers concluded that five times more methane is being leaked than reported from oil and gas producing platforms in the UK North Sea.



GHGSat

Estimates of methane emissions based on satellite data are already known to be imprecise offshore where reflections from the surrounding water can impact the readings, but that is changing. In 2022, Chevron partnered in a pilot to test GHGSat satellite technology developed for offshore environments. Subsequently, GHGSat detected what was the smallest offshore methane emission ever seen from space. It was observed at an oil and gas platform in the Gulf of Mexico and measured at approximately 1,500 kg/hr.

According to Oil and Gas Climate Initiative (OGCI) 2021 performance data, venting and fugitive leaks account for over 60% of aggregate upstream methane emissions. Therefore, LDAR continues to be an industry priority, and new technologies are improving leak detection and quantification.

Texas-based Seekops has developed a miniature methane spectrometer which is mounted on drones for offshore methane detection analysis. Based on NASA technology used on the Mars Curiosity rover, it can detect methane concentrations down to 10 parts per billion, pinpoint sources and quantify emissions as low as 20g/hr using wind data in its algorithms. Testing has demonstrated accurate quantification of emissions offshore to less than 10% uncertainty.

The drones operate around 20 meters downwind from a facility, pinpointing particular sources, such as gas turbine exhaust streams, on different levels within the platform.

Chevron partnered in a pilot to test GHGSat satellite technology developed for offshore environments.

Seekops has developed a miniature methane spectrometer based on NASA technology used on the Mars Curiosity rover.

Photos on this page: SeekOps

Photos on spread: Wintershall Dea

A bit further out, several hundred meters from a flare, the Seekops technology is still sensitive enough for accurate measurement of unburnt methane.

Business is heating up.

The US and EU are looking to make emitters pay, but customer and corporate goals are becoming important too, even in places where the regulations are not as developed. "It's early days in many places for measuring and reporting emissions. A lot of operators are still figuring out their strategy," says Dave Turner, Business Development Director – Asia Pacific for SeekOps. "Here in Southeast Asia, where there's hundreds of platforms, you can inspect a lot of them very quickly using a drone."

As detection technology grows in sophistication, a top-down approach is supplementing the more traditional bottom-up approach to LDAR. The aim, says Turner, is to validate bottom-up measurements using a directly measured independent method. Companies are looking to quantify methane emissions at a macro level to reconcile the numbers obtained by identifying specific leaks with drone-mounted or fixed sensors and hand-held tools.

Environmental service providers, such as Texas-based Encino Environmental Services, offer a range of services for detection, quantification, and mitigation, and hand-held equipment is becoming more compact, facilitating rapid on-site assessments. The intrinsically safe optical gas imaging camera Mileva 33 OGI, for example, weighs less than 1.5kg without batteries while still being able to detect methane leaks of less than 0.35g/hr.

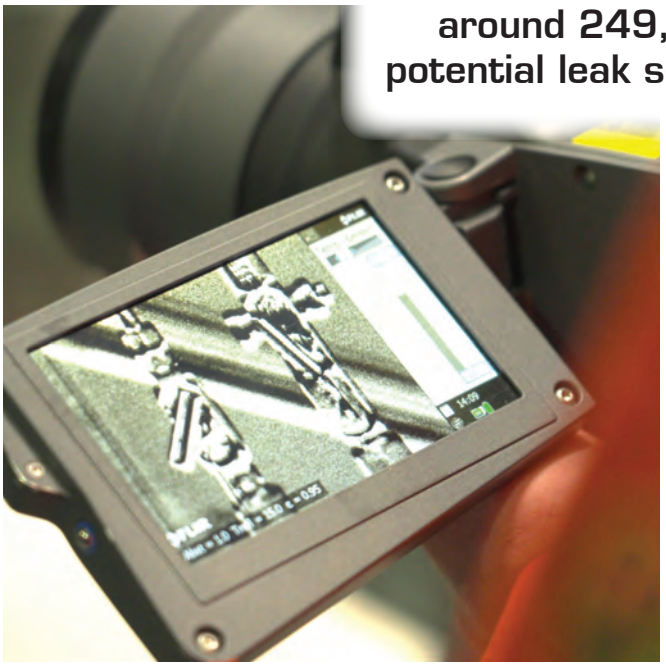
Wintershall Dea used two specialist contractors (TP Europe and The Sniffers) in its 2022 LDAR campaign along with various measuring tools - Optical Gas Imaging with an infrared camera can cover 2,000-5,000 sources a day, while sniffing can cover 700-800 sources a day. An ultrasonic internal valve leak device was used to check vent and safety valves, and a bagging technique provided accurate quantification. Drones and airplanes were used to measure emission sources that were difficult to access. In Germany alone, Wintershall Dea found around 249,000 potential leak sources. These were either immediately repaired or tagged and repaired shortly after, and the company's methane intensity in 2022 was 0.08%, already below its target of 0.1%.

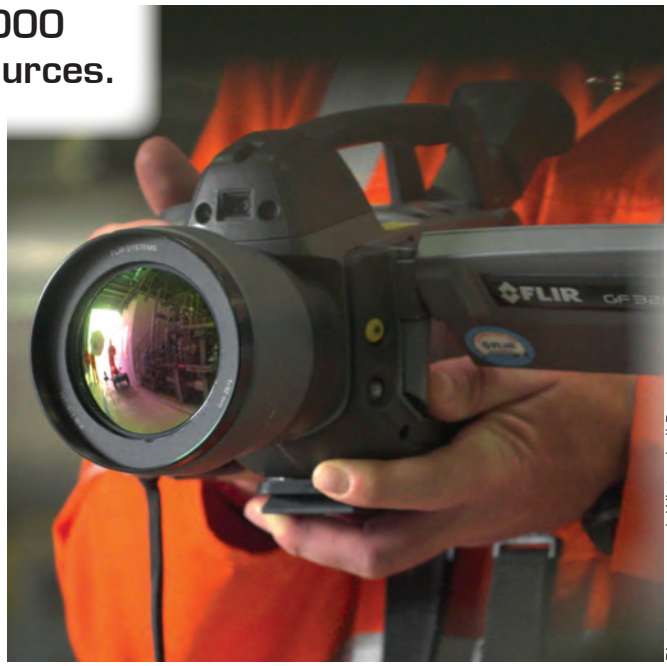
In 2022, Woodside commenced development of source level, bottom-up methane inventories for its assets and then used top-down methods to assess their accuracy and completeness. Drone-based facility measurements were conducted at several of Woodside's offshore assets in Australia and the Gulf of Mexico. The program included a trial of the Providence Photonics's video imaging spectro-radiometry technology for flare monitoring, Mantis Lite™. Abatement measures included retrofitting dry seals on compressors and minimizing use of high emitting compressors.

A recent DNV study highlights that key strategies for reducing methane emissions include minimizing venting from processes, improving leakage management and applying optimized maintenance procedures. Across the industry, solutions have also included moving away from pneumatic actuators that use process gas to electric components and the inclusion of fugitive gas recovery systems that send the gas to the flare. Meanwhile OEMs are reducing methane slip from their power and pump systems.

Leaky valves and improperly made fitting connections

In Germany alone, Wintershall Dea found around 249,000 potential leak sources.

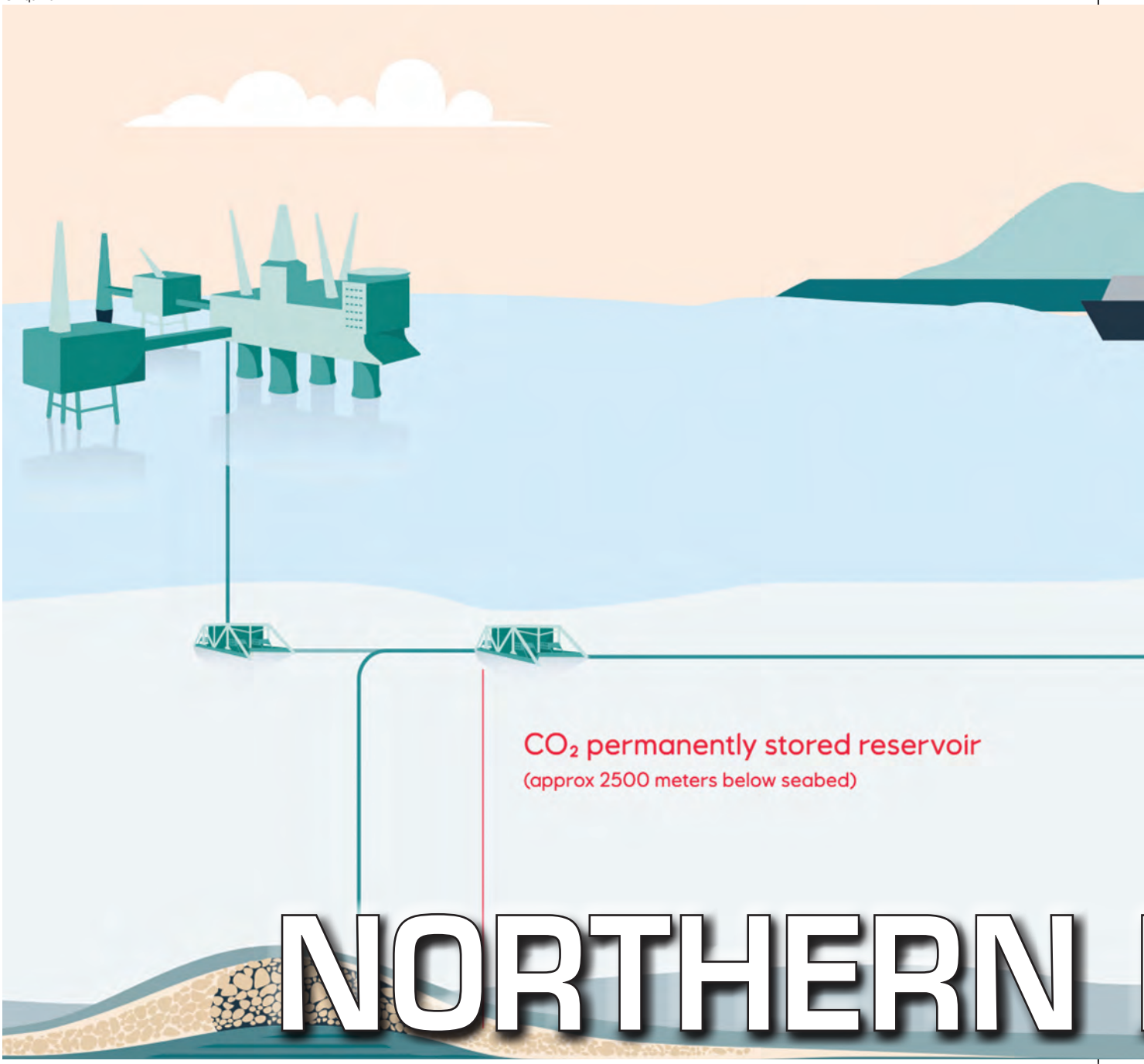




Photos on spread: Wintershall Dea

are primary culprits for uncontrolled fugitive emissions of gases on offshore platforms, says Michael Aughenbaugh, Associate Market Manager, Swagelok. Fugitive emissions from dynamic and static seals on valves, pumps, and flange connections can be mitigated using low emission (Low-E) valves, he says. Manufacturers should guarantee that the valves will not leak above 100ppm for five years or the valves should be tested to ensure leak rates are no greater than 100ppm. "It's best to capture certain details about those leaks for auditing purposes, as well, so you can identify areas for improvement," says Aughenbaugh. "A leak that comes back frequently may indicate the need to redesign the fluid system or add supports to reduce vibration."

Beyond LDAR campaigns, longer-term strategies are being put in place. Wintershall Dea uses an internal carbon pricing metric when making investment decisions and is committed to offsetting its residual upstream GHG emissions by 2030. Woodside has invested in String Bio, a developer of a patented process that converts methane into a protein suitable for animal and human nutrition. So, as well as the value of recovered gas, there is the potential for new revenue streams to add value to abatement strategies.



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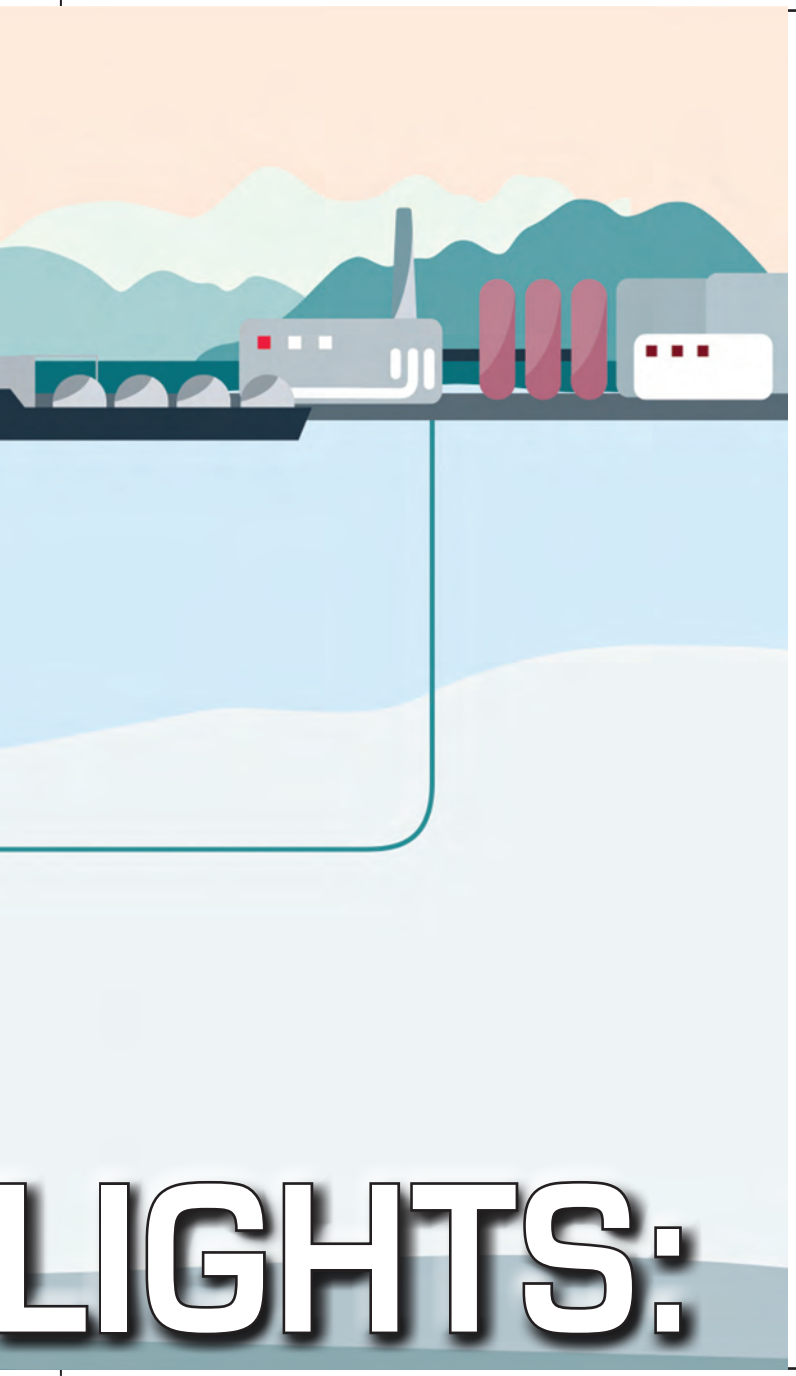


LIGHTS: HE PATH ISSIONS

In the global quest for achieving net zero emissions and slowing down global warming, carbon capture and storage (CCS) technology has merged as an important solution. Among the notable projects being developed in the field is the Northern Lights offshore carbon capture and storage project in Norway, a country with long experience with offshore CO2 storage.

By Bartolomej Tomic

The transition to a sustainable energy future requires innovative solutions that go beyond simply halting fossil fuel projects.

Carbon capture and storage (CCS) has emerged as a critical technology to address emissions from hard-to-abate industries.

"CCUS is a necessary bridge between the reality of today's energy system and the increasingly urgent need to reduce emissions. Not only can it avoid locking in emissions from existing power and industrial facilities, it also provides a critical foundation for carbon removal or negative emissions," Dr. Fatih Birol, Executive Director at the International Energy Agency, said recently.

In a speech in October 2022, Kadri Simson, European Commissioner for Energy, said, "I believe that CCUS has incredible potential in our race to reach climate neutrality. And without CCS and CCU, it will be practically impossible to limit the global warming to the 1.5 degrees Celsius objective."

She said that the Commission modeling showed that the EU will need to capture and utilize or store between 300 and 640 million tonnes of carbon dioxide per year by 2050

The Transocean Enabler Rig was used to help estimate the capacity of the Northern Lights storage.

Transocean

to meet its climate goals.

There's been a notable recent surge in offshore carbon capture and storage news, with offshore storage licenses recently either granted or pending in the U.K. and Norway, a giant offshore CCS project sanctioned in Malaysia, as well as projects planned for the U.S. Gulf of Mexico.

For now, let's focus on a project that, while not yet pumping CO2 under the seabed in Norway, already has significant milestones to show for and will soon be ready for operation – the Northern Lights.

The Northern Lights – a celestial phenomenon name for a project that's mostly about the areas below the seabed – is led by a joint venture between Equinor, Shell, and TotalEnergies, which entered a partnership to work on the offshore CO2 storage project back in 2017.

Back in 2019, while the project was still being in the works and yet unsanctioned, Equinor's then Chief Executive Eldar Saetre said Nothern Lights could become the world's first cross-border CO2 storage.

Since then, the project has been approved, backed by the Norwegian government, offshore storage capacity and offshore injection tests completed, Northern Lights JV company formed, some cross-border CO2 transport deals struck, transport ships ordered, and recently, significant onshore works completed in Øygarden municipality in Norway, where CO2 receiving terminal is being built.

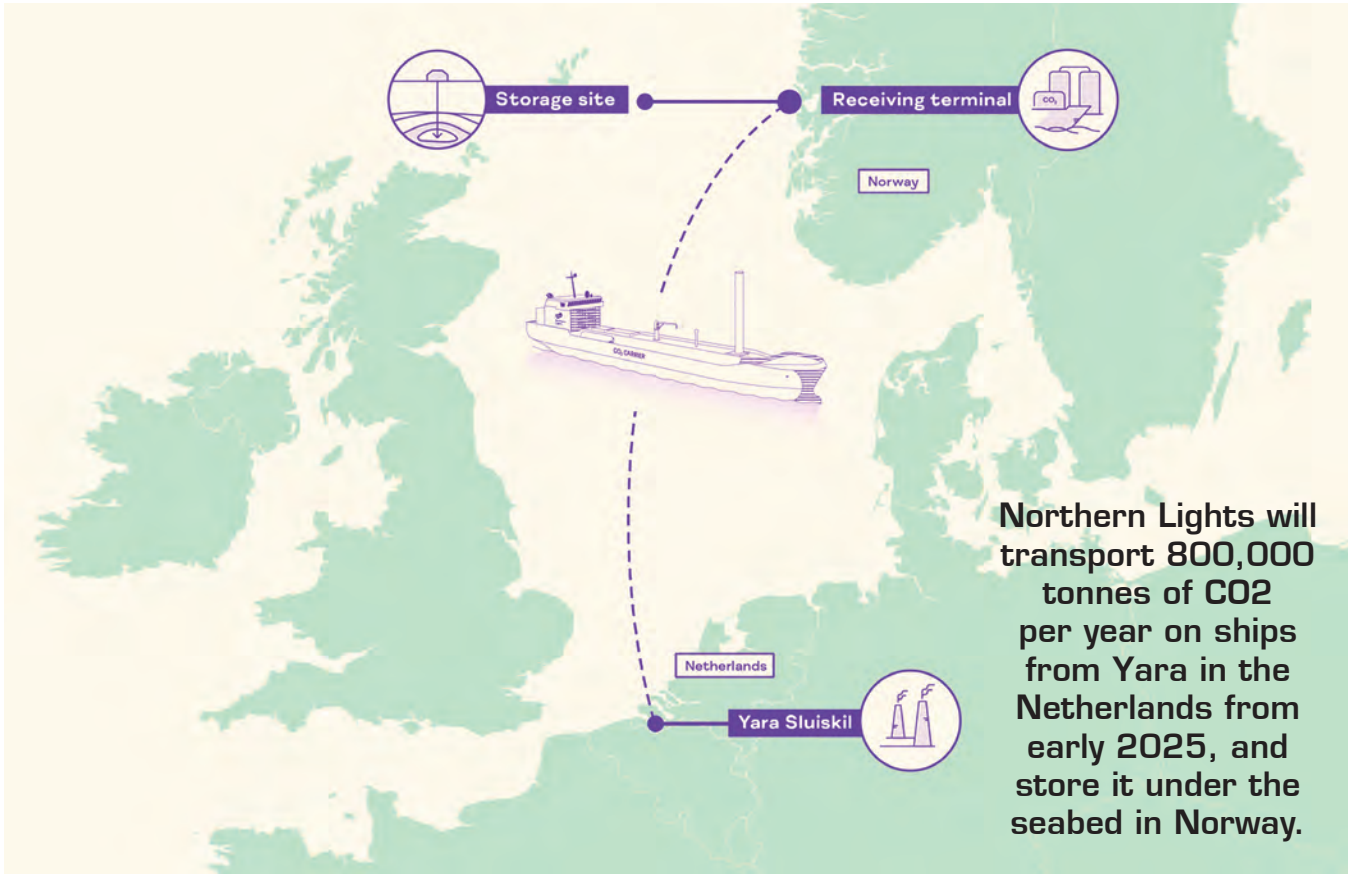
THE SIZE

The Northern Lights JV plans for the project to have an initial storage capacity of 1.5 million tonnes CO2 annually, with the captured CO2 set to be permanently stored in a saline aquifer, 2,600 meters beneath the seabed.

The plan is for CO2 from emitters who sign deals with Northern Lights JV to have their CO2 offtaken by liquefied CO2 carriers, shipped to the onshore plant in Øygarden for an intermediate storage, and then transported by a 110 km pipeline to an offshore subsea storage.

While the initial storage capacity is 1.5 million tonnes of CO2 per year, plans are in place to increase capacity as demand grows across Europe.

In 2020, Northern Lights drilled the first CO2 exploration well that confirmed that the reservoir in the Johansen formation, at 2.600 meters depth, is suitable for safe and permanent CO2 storage.



Northern Lights

Offshore drilling operations in 2022 at the EL001 storage license (granted in January 2019) confirmed the storage capacity of at least 5 million tonnes CO2 per year.

The wells were been drilled using Transocean's semi-submersible drilling rig Transocean Enabler.

Worth noting, the European Commission in January 2022 announced that EU countries had agreed to award Northern Lights €4 million for Front-End Engineering Design (FEED) studies for the expansion of the Northern Lights CO2 transport and storage capacity to over 5 million tonnes per year.

The planned expansion will include subsea facilities and capacity increase of the onshore receiving terminal in Øygarden.

CLIENTS

As part of the first phase of the project, 80% funded by the Norwegian government, Northern Lights has reserved 800,000 tonnes of CO2 per year for the Heidelberg Materials cement factory in Brevik and the Hafslund Oslo Celsio waste-to-energy plant, to fulfill its obligations as the transport and storage component of Longship, the Norwegian Government's full-scale carbon capture and storage project.

Apart from this, in August 2022, the Northern Lights joint venture struck its first commercial deal. The agreement was signed with fertilizer maker Yara, to store CO2 captured at Yara's Dutch operation. Under the agreement, 800,000 tonnes of CO2 per year will be transported on ships from Yara in the Netherlands from early 2025.

Announcing the Yara deal, Shell's then CEO Ben van Beurden said, "We are proving that this actually works. The fact that it can is a major breakthrough because this is now a pathfinder project for similar projects in Europe."

Another vote of confidence for the project came in May, 2023 when the Northern Lights joint venture signed a deal with Orsted to transport and store 430,000 tonnes of biogenic CO2 emissions per year from Orsted's two power plants in Denmark.

Børre Jacobsen, Managing Director of Northern Lights, then said, "This agreement confirms the commercial potential for CCS and demonstrates that the market for

Illustration of the Northern Lights 7,500 m3 CO2 ships.

Northern Lights

Northern Lights/Equinor

transport and storage of CO2 is evolving rapidly."

The deal was signed after Ørsted won public funding from the Danish Energy Agency under the first Danish tender of the CCUS Fund to develop a CO2 capture hub for the biomass power stations Asnæs and Avedøre, from which CO2 will be shipped to the Northern Lights reservoir.

"From 2026 Northern Lights will be shipping the first cargo of biogenic CO2 from Denmark to Norway," Børre Jacobsen said.

In May 2022, Northern Lights JV also signed a memorandum of understanding with Cory, a U.K. based waste management and recycling company, for Cory to potentially ship carbon dioxide from its 'energy from waste operation' on the River Thames in London to Northern Lights' subsea CO2 storage facilities. A firm deal has yet to be signed.

In its annual report for 2022, Northern Lights said that its existing agreements had fullfiled the capacity for the first phase of the project, with the customer pipeline for commercial volumes for the phase 2 development progressing. According to Northern Lights JV, half of these prospective clients come from waste incineration and cement companies, along with hydrogen, refineries, and steel/metal companies.

BUILDING LIQUEFIED CO2 CARRIERS

In October 2021, Northern Lights ordered two CO2 carriers for the project from China's Dalian Shipbuilding Industry Co.

The Chinese shipbuilder is building two 130-meter-long liquefied CO2 carriers, each with a cargo size of 7,500 m3.

Northern Lights adapted ship designs used for transporting liquefied petroleum gas, adding a liquefied CO2 carriage system and insulation to maintain a temperature that keeps the CO2 in a liquid state, including a special high-tensile-strength nickel steel alloy with a tank wall thickness of 50 mm.

The two vessels, designed to transport liquid CO2 with purpose-built pressurized cargo tanks, are expected to be ready for delivery by mid-2024.

Being built for a project that aims to reduce emissions, the vessels themselves are designed for low-emission operations. The main fuel for the ships will be LNG. Other innovative technologies, such as a wind-assisted propulsion system and air lubrication are planned to be installed to reduce carbon intensity by around 34% compared to conventional systems.

The Danish marine pumps specialist Svanehøj is supplying deepwell cargo gas pumps for the two CO2 carriers.

First steel for the ships was cut in November 2022, and the keel laying ceremony was held in April 2023. The ships, classified by DNV and sailing under Norwegian flag, are expected to be delivered in 2024. Once delivered they will be operated by "K" LINE on behalf of Northern Lights JV.

ONSHORE STORAGE TANKS

In its 2022 annual report, Northern Lights said that the Øygarden CO2 receiving terminal had been more than 75% completed by year end.

Since then, the percentage has increased, as the company on June 2 said that it had installed all 12 CO2 storage tanks at the plant.

These tanks, standing at 32.5 meters tall, boast a capacity to store nearly 700 tonnes of CO2 each.

They will serve as an intermediate storage for the CO2 brought in by the ships, before being transported into the subsea aquifer. Aker Solutions was responsible for the lifting and installation of the tanks.

Also, the terminal could be expanded by a second jetty to cater for additional volumes of imported CO2 from larger ships, additional intermediate storage for CO2 with additional volume, and additional CO2 export pumps, as supported by the EU, as mentioned earlier.

FIRST MOVER

In the 2022 annual report, Northern Lights' Jacobsen said, Northern Lights CCS is a key technology to decarbonize hard-to-abate industries in Norway and Europe, and reach the goals set in the Paris Agreement, achieving net zero emissions by 2050.

"The message from IEA and the IPCC is clear; net zero is near impossible without CCS.

"In 2024, we will be ready to receive CO2 volumes, initially through Longship (Norcem and Celsio), and then also commercial volumes. One of the defined key success criteria for the Norwegian Government, and for us, is to demonstrate the potential in CO, transport and storage as a service.

"It is an important part of our mandate to share our knowledge and experience as a catalyst for creating a commercial CCS market. Northern Lights is a first mover, and we encourage others to follow."

Did you know?

Northern Lights, while the first project of the kind in Norway, is not the first offshore carbon storage project in the country. Namely, according to the Norwegian Petroleum Directorate, since 1996, CO2 has been removed from the Sleipner Vest gas in the North Sea and injected in the Utsira Formation. One million tonnes of CO2 from the Equinor-operated Sleipner field are stored in the subsurface every year.

Also, according to NPD, since 2007, 700 000 tonnes of CO2 per year has been stored at the Snøhvit offshore field in the Barents Sea. CO2 is separated from the gas in the process facility on Melkøya before it is sent by pipeline down into a reservoir located around 140 kilometers from land. Regular surveys are performed to monitor how injected CO2 fills the storage area.

ENERGY TRANSITION:

WHAT IS AN OFFSHORE VESSEL OPERATOR TO DO?

The energy transition is moving ahead amid recovery in offshore oil & gas and growth in offshore wind, leaving vessel owners that serve these markets with big questions about energy carrier and energy converter selection for their newbuilds.

By Philip Lewis, Research Director of Intelatus Global Partners

WHAT IS DRIVING THE CHANGE?

The foundations of energy transition in the offshore and marine segment can be found at global, regional, national and local levels:

1) At a global level, International Maritime Organization (IMO) measures cover vessel energy efficiency (for vessels over 400 gross tonnes) and carbon intensity (for vessels over 5,000 gross tonnes) but do not necessarily impact offshore support vessels (OSV). However, the IMO strategy on emissions is expected to be revised at MEPC 80 in July of this year. Full decarbonization of the maritime sector by 2050 is expected to be discussed but unlikely to be agreed. Measures such as greenhouse gas fuel standards on a well-to-wake basis and some form of carbon pricing are expected to be discussed for implementation through this decade. What we have then is a bit of a moving target.

2) Currently, vessel movements related to the installation of wind turbines in Europe are not subject to the Monitoring, Reporting and Verification (MRV) reporting requirements. However, as our table summarizes, some key numbers for the revised EU MRV and Emissions Trading System (ETS) schemes.

3) At a national level, and of importance to floating wind, we note for example Norway's support of partial or full electrification of vessels or the use of hydrogen and ammonia as energy carriers.

4) Now let's take a local level look within a country. The California Air Resources Board's (CARB) Commercial Harbor Craft regulation defines emissions standards for vessels calling into state waters and stricter amendments are currently under review. These will likely impact the anchor handlers involved in California offshore wind projects.

In addition to these regulatory conditions, we find several other main drivers for choosing low or zero emissions fuels, including:

1) Vessel charterers are seeking more and more to manage their Scope 1, 2 and 3 emissions, including emissions associated with their own or chartered-in vessel operations.

2) Shareholders in listed companies may demand that vessel operations impact less on the environment.

3) Finance and insurance providers in certain markets have become more interested in incentivizing investments that have less of an environmental impact.

4) A younger workforce who are increasingly less motivated to choose careers in industries associated with hydrocarbon related emissions, such as oil & gas and marine operations.

Included	GT	EU MRV	EU ETS
Offshore	400-5,000	2025	To be evaluated
Offshore	>5,000	2025	2027
CO2		In force	2024
CH4 & N20		2024	2026
Voyages and port-calls within EU/EEA		100% by 2026	100% by 2026
Voyages into and out of the EU/EEA		100% by 2026	50% by 2026

WHAT ARE THE CHOICES?

As per the chart below, there are many choices of lower carbon, carbon neutral and carbon free energy carriers, some of which (ringfenced by the green dotted line) can be seen as more suited to shorter sea voyages typical of most of the offshore oil & gas and offshore wind fleet.

Depending on the trade and fuel supply, we see an increase in the number of hybrid energy systems, combining an internal combustion engine (dual fuel for flexibility) or a fuel cell with battery energy storage and shore power connections.

AND WHAT ABOUT THE CHALLENGES?

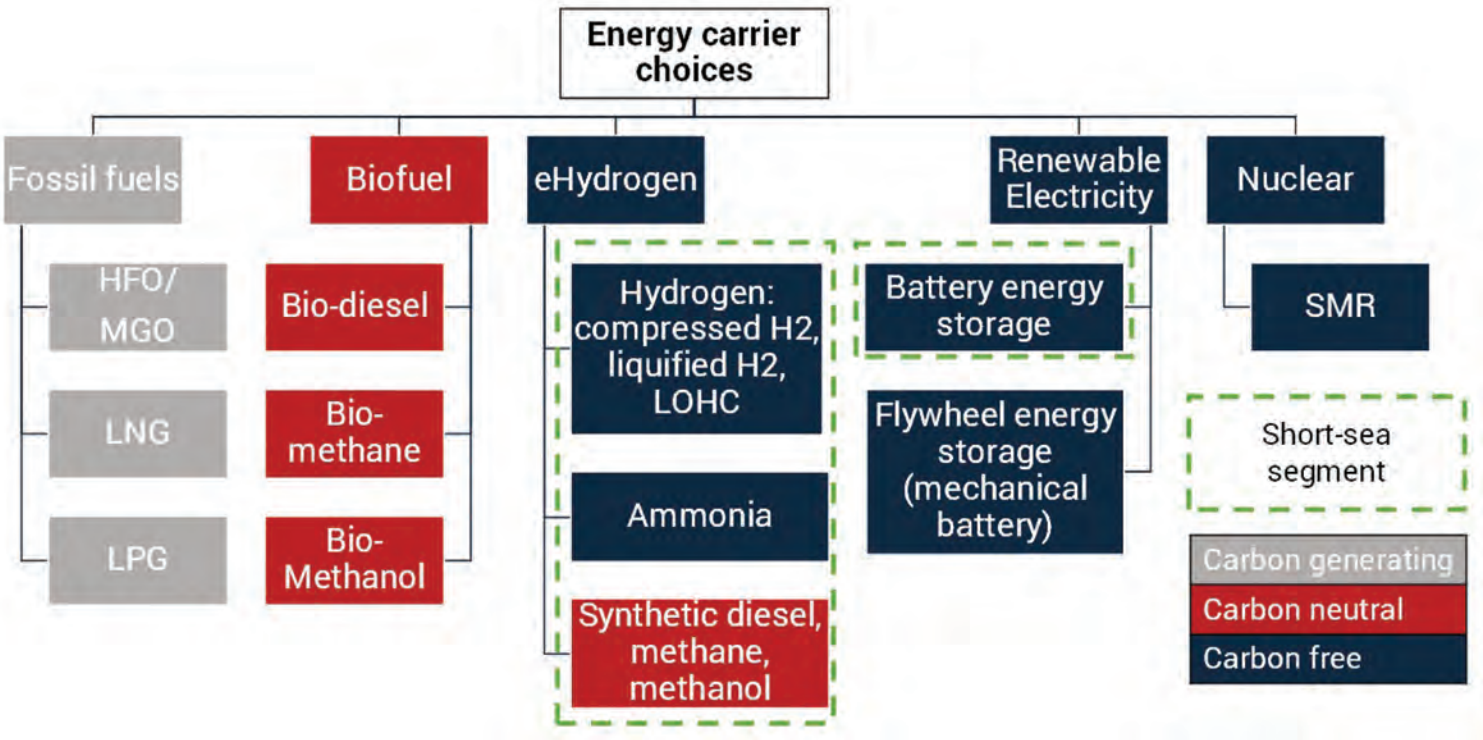
The first challenge is to choose the energy carrier(s) and the energy converter for a vessel. This will often be dictated by trade patterns, vessel size, local factors and the availability of internal combustion engine, fuel cell and/or battery energy storage system options.

Securing a supply of fuel is the next challenge. At present, most low and zero emissions fuels are in very limited supply. Further, the scale of most offshore vessel operating companies and trading patterns does not allow most owners to replicate what liner companies like Maersk have done, which is secure 1.4 to 2 million tonnes per year methanol supply from nine supplier partnerships in Asia and the Americas, and continue to review a further 30 partnerships in regions including Europe, Africa and the Middle East.

If you can get the fuel, the next challenge is the cost of the fuel. Carbon pricing, in markets like Europe, will help this situation, but at a fundamental level, green hydrogen, e-methanol and e-ammonia cost more than marine diesel and gas oil.

As many people know, certifying bunker quality is a major challenge today. But the challenge will only become more daunting. Taking methanol as an example, methanol can be produced from coal (brown), natural gas (grey), from carbon capture from another combustion process (blue), renewable sources (green) or nuclear (pink). The final product is always CH3OH. The question is how to ensure that the methanol in the tank is green.

And finally, there are a range of technical and operational barriers ranging from toxicity of certain fuels, lack of sufficient bunkering infrastructure, the impact on onboard storage based on the large volumes required to store hydrogen, ammonia and methanol, available of internal combustion engines, availability of fuels cells and battery energy storage systems and crew capabilities.



WHAT ELSE CAN WE CONSIDER?

On top of the energy carrier/converter choice, there remain several other tools for lowering emissions intensity available to owners to consider, depending on the size of vessel. These include:

- Ship design and hydrodynamics: Hull-form, ship size, propulsion improving devices, propellers, rudders & material optimization, air lubrication, hull coating/cleaning and propeller cleaning.
- Energy assistance from wind or solar sources.
- Logistics and digitalization: Speed reduction, weather routing, trim, draft, and ballast optimization, autopilot software, engine de-rating and vessel size.
- Waste heat and/or kinetic energy recovery.
- After treatment measures such as carbon capture and storage.

© AdobeStock/David Maddock

The Logistics of Offshore Wind

From geopolitical trials to a squeezed supply chain, the offshore wind sector is facing stronger headwinds than ever before. Third-party logistics partners are increasingly an option to help developers circumnavigate these issues.

By Erland Ebbersten, Group Vice President – Energy & Marine, GAC

The global drive to harness offshore wind power is making it a busy time ahead for the sector as countries seek ways to wean off fossil fuels, produce more zero-carbon power and become more energy-independent.

But it is a journey fraught with challenges. Like other sectors, offshore wind projects face global inflationary and supply chain pressures which raise uncertainties in long-term commercial and investment decisions.

Further, their financial viability is coming under question amid rising energy prices and costs of raw materials used in the construction and servicing of offshore installations. This is especially the case as offshore wind farms become bigger and more widespread than ever.

Although significant, such challenges should not deter investments in offshore wind as advancing technologies are making the construction and maintenance of offshore wind farms more viable, cheaper and operationally safer. Most importantly, harnessing wind power is a valuable way for countries to bolster renewable energy capacity and secure a greener future.

Taiwan's Renewable Energy Goals

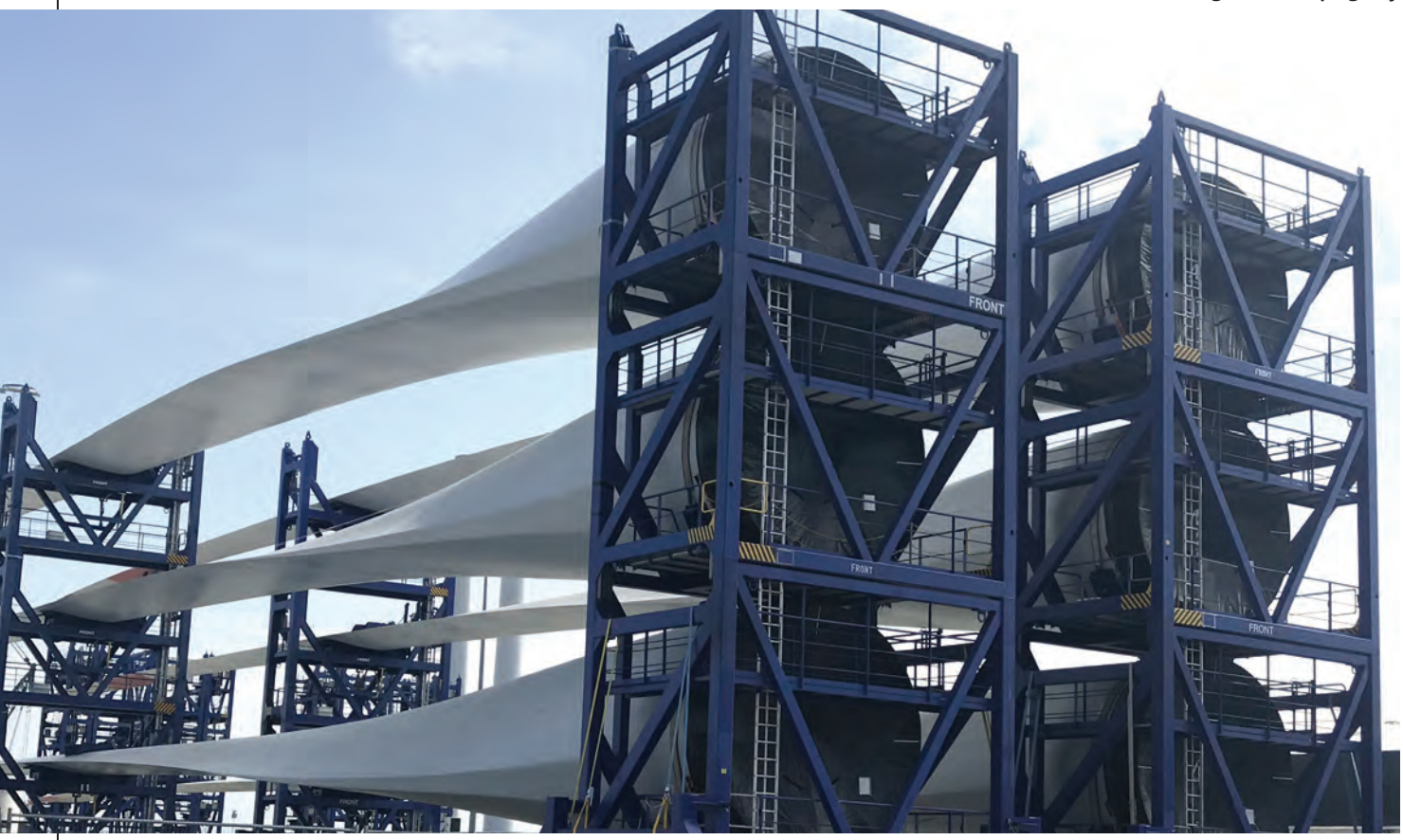
A prime example is Taiwan which has ambitions to become an offshore wind powerhouse. The island aims to increase the share of renewables in its electricity supply to 70% by 2050, with an expansion of wind deployment earmarked as a natural and necessary step in that process.

Half of that capacity is on track to be built by 2035 with more than 130 offshore wind farm projects currently under development including the Greater Changhua wind farm project, which is being supported by global shipping and logistics services provider GAC.

Two of the windfarms – Changhua 1 and 2a – were delivered last year. Once operational, they will have a capacity of 900 MW, generating enough power to meet the needs of a million households.

Technology, particularly unmanned surface vessels (USVs), played a critical role in this project. They reduced the on-site work force and manpower costs, and

All images: GAC Ship Agency



minimized the need for technical experts and diving teams to operate in high-risk situations.

USVs enable operations and maintenance players to collect on-site data to aid faster and smarter decision-making. Information gathered related to weather patterns, water currents, seabed conditions and more are valuable when planning other offshore wind farm projects.

Operational Challenges

Since the Changhua wind farm project began in 2018, it has faced a number of operational challenges. First, developers have had to meet Taiwan's local content requirements for the use of the country's supply chain, manufacturing industry and regional labor.

Second, the Taiwan Strait is prone to severe weather conditions which pose difficulties and delays for construction of offshore wind farms. Taking typhoon seasons into account, developers only have a six-month window to carry out installation projects.

To overcome these challenges, as well others relating to project equipment and labor shortages caused by global supply chain squeezes, developers need to carefully plan ahead and seek the right support during early stages, particularly since these projects can take several years to materialize.

Strengthening support

GAC opened a new office at Taichung Port in Taiwan in November 2022 to strengthen offshore operations support for projects like Greater Changhua. GAC Taiwan draws on the Group's global experience from other offshore projects to deliver world-class services to the country's burgeoning offshore energy sector.

Taichung port has undergone a number of infrastructure upgrades, including tailor-made wharves and new quays to support both pre-construction and under-construction offshore wind farms off Taiwan's west coast.

GAC provides offshore support, in addition to ship agency and husbandry services, barge and tug support, crew transportation and emergency response: all vital

All images: GAC Ship Agency

and sometimes unsung components of offshore energy projects.

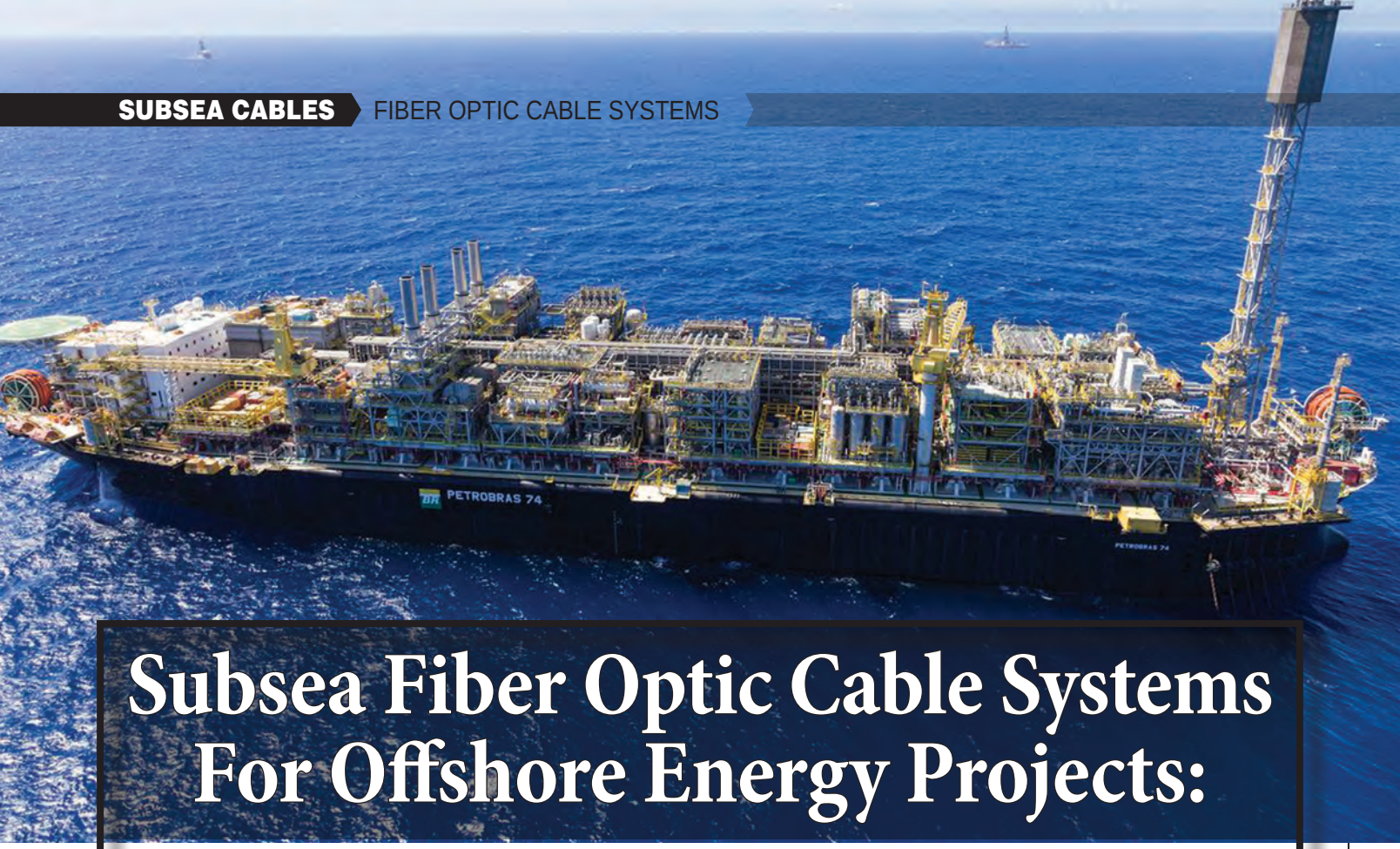
Gathering Pace

Beyond Southeast Asia, offshore energy construction and maintenance projects are also gathering pace. Mainland China, the United Kingdom, and several countries in Northern Europe are clear market leaders in the sector, while Brazil and the United States are ramping up production.

Based on data from leading energy trade association RenewableUK, the output of the global offshore wind sector now stands at 1,174 GW across 38 countries – an increase of 508 GW over the past 12 months. It is in these offshore hubs that GAC developed the experience that it is now applying to support other projects in Taiwan, India, Singapore and the Middle East.

All are vulnerable to their own regional challenges but the core issues they all face - geopolitical, inflationary or environmental - can drastically impact the overall supply chain, as well as the cost of key items such as turbines, blades, substructures and electrical components.

Increasingly, the sector is being called upon to be flexible to remain competitive, ensure projects stay on schedule and keep costs low. Project managers need to work closely with their partners and support networks to adapt to the ever-changing risks, especially as offshore wind farms grow in size, output and global significance.



Subsea Fiber Optic Cable Systems For Offshore Energy Projects:

Q&A With Pioneer Consulting's Austin Shields

Pioneer Consulting, a subsea fiber optic telecommunications consulting and project management company, was last year awarded a contract by Zemax-Planova Consortium to provide expertise related to the Petrobras Malha Óptica fiber optic system project, offshore Brazil. The project will link 13 FPSOs and one platform with two cable landing stations in Praia Grande, São Paulo, and Rio de Janeiro. Offshore Engineer has recently interviewed Pioneer Consulting's Director of Client Solutions, Austin Shields, to learn more about the project and the subsea fiber cable trends in offshore energy in general.

OE: Thank you for taking the time to speak with us today. Could you introduce Pioneer Consulting to our readers and provide an overview of the company and the services it offers within the offshore energy sector?

Pioneer Consulting is an international telecommunications consulting, engineering, and market research company that advises clients on the planning and implementation of submarine fiber optic cable networks during all phases of system development. Our accurate, insightful, and thorough advisory services provide clients with objective and independent guidance in support of their projects and strategic goals. Pioneer's capabilities range from market analysis and feasibility study to system design and engineering and supply, in addition to providing full-scale project implementation and management.

Within the offshore energy sector, Pioneer offers all consulting services applicable to other telecommunication projects, while leveraging over 20 years of experience in navigating the complexities of the oil and gas and offshore energy sectors. Pioneer provides clients with the project knowledge and planning they need. This is accomplished through deep understanding of the nuances related to the special products and rigorous requirements that are associated with offshore energy projects, which often include strict offshore asset restrictions, health and safety specifications, special powering and optical design principles, and the unique subsea equipment designed specifically for these types of projects.

OE: What are some interesting trends and practices you are seeing today when it comes to the adoption of subsea fiber optic cable technology in the offshore energy industry?

Recent trends in modern fiber optic communication systems point towards a growing need for robustness and reliability. Current systems are being designed and manufactured with redundancies in mind, both with respect to transmission paths (i.e. mesh networks) and at the component level. Not surprisingly, the main goal of any fiber optic communication system is to facilitate reliable communications, however, owners have been pushing for networks that also increase safety, automation, and monitoring -- specifically in the oil and gas sector. Expanding the usage of these networks on different fronts is also a recent trend in the industry, with suppliers working to provide more than just communication applications for their cable products. Suppliers and purchasers are looking to incorporate additional sensing capabilities into their networks, such as permanent reservoir monitoring and downhole applications to name a few in the oil and gas sector.

OE: Can you talk about the technical aspects of subsea fiber optic cables? How do these cables differ in diameter, capacity, length, material, cost etc.? How is this technology evolving?

Much like standard telecommunication systems, offshore energy cable systems typically consist of a backbone or trunk section that connects major onshore sites to the offshore assets. This backbone cable typically consists of the same type of cable, repeater, and branching unit products found in standard telecommunication projects, which provides the benefit of using off-the-shelf products in place of bespoke, specialized products. Moreover, existing cable protection products such as URADUCT and mattressing are used extensively to protect both the optical cable and the offshore energy assets that the cable crosses.

Beyond the backbone, however, are where the specialized products come into play. In order to facilitate connections to floating production platforms, specially designed umbilical and riser cables are required. These umbilicals are typically large enough to encompass multiple standard subsea telecommunication cables and thus average between 80-120mm or greater in outer diameter, depending on the application. These umbilicals are designed with similar strength steel wire members, and polyurethane and armor layers, compared to the optical cable that they house, and can also support a wider range of applications, including power cable, electrical monitoring, and hydraulic and injection hoses. Umbilicals provide connectivity between subsea assets and offshore assets, such as floating oil platforms, via a specially designed catenary or free-hanging section of cable. This catenary is suspended in the water column using buoyancy and ballast modules affixed

to the umbilical cable.

Evolution in optical umbilical products is expected to follow similar design trends as standard optical cable regarding increased fiber count and a potential shift towards cheaper power conducting materials, though not much detail in that regard has been shared lately. As a specialty product, these umbilical cables are often sold a premium and can generally be expected to cost more than commercial subsea cable products.

OE: What are some of the main benefits for oil and gas operators who chose to go the subsea fiber optic cable route?

The main benefit of fiber optic cables for oil and gas applications is the advantage of direct fiber connectivity between onshore sites and offshore facilities and assets. Having direct, high-capacity traffic connectivity to floating oil platforms provides all the benefits of reliable communication that any standard telecommunication system would likewise provide. Considering the harsh operating environment and remoteness of these production platforms out in the ocean, a stable and reliable line of communication and data flow are critical.

Additional benefits of fiber optic cables unique to oil and gas include increased automation and controls, along with the ability to process high volumes of data generated through emerging fiber optic technologies such as downhole sensing and permanent reservoirs monitoring. Fiber optic cables also help to create a safer operating environment with a more connected workforce and more flexibility and reliability compared to satellite connections that can be severely impacted by weather and other natural events.

OE: Are there any distinct differences between commercial subsea fiber optic projects and those in the offshore oil and gas industry?

As mentioned previously, the oil and gas industry often presents unique design constraints that require specialized products to overcome. Specific requirements include OADM traffic flexibility to/from multiple offshore production platforms, while simultaneously restricting the use of powered equipment on the cable segments leading to these platforms.

Other differences in oil and gas projects include a particular attention to installation operations and health and safety. It is not uncommon for an entire project to be put on hold due to a crew member on a vessel not wearing the correct PPE, and vessels and their crew often have strict requirements for training and approach protocols when entering the "exclusion zone" surrounding the floating production platforms. Additionally, cable installation operations often have requirements not typically found in commercial subsea fiber optic projects, including live touchdown monitoring and cable protection when crossing pipeline assets, strategic placement of cable between pipeline anodes and electrical constraints, and unique shipboard representative accommodations.

Lastly, a major difference in oil and gas projects comes from the subsea technology products needed to facilitate connectivity to the floating platforms. Since many aspects of oil and gas are dynamic and consist of moveable production facilities, the optical network must be flexible enough to support new connections to offshore assets. The Subsea Umbilical Termination Assembly (SUTA) and other similar products are unique to the oil and gas industry which adopt highly specialized components to allow for such flexibility. SUTAs utilize wet-mate connector technology and advanced fiber termination assemblies to allow for direct connections to be made undersea via an ROV. These SUTAs connect the offshore assets via umbilicals to the fiber optic backbone, allowing for multiple connections to existing and future oil and gas assets without the need to install additional fiber optic backbone cable or recover and splice into pre-installed branching units or OADM units.

OE: You were recently awarded a contract to support Brazilian oil giant Petrobras' Malha Óptica project. Can you tell us about the project in general and what it aims to achieve?

Currently under construction, the 1,200 km Malha Óptica makes use of a traditional, two-fiber pair (2FP) repeatered trunk and branch architecture with 13 power-switched branching units (PSBU). The network will initially connect 13 floating production and storage offload-

ing (FPSO) units to the trunk via branching units with OADM technology to deliver 200 Gb/s of bi-directional communications to each cable landing stations (CLS) – one located at Praia Grande, state of São Paulo and the other at Praia da Macumba, state of Rio de Janeiro.

Petrobras is highly motivated in increasing capacity and security in the transmission of real-time data from offshore platforms. This increase in capacity opens up a range of possibilities, such as live video support from suppliers via video transmission, adoption of digital technologies on a large scale, and real-time remote monitoring of production facilities.

OE: What exactly is your scope in the project, and what do you believe was the key factor that contributed to the company winning the contract?

Pioneer has been hired by a consortium between ZMAX Blue Marine Telecom and Planova Planejamento e Construções, both Brazilian companies, which is responsible for the integration of the Malha Óptica system. Pioneer has been hired to help bridge the "language" gap between oil and gas and commercial telecoms. Our role in this project is to provide expertise, experience, and advise on all aspects related to oil and gas telecom equipment, marine survey, and installation activities. Since we started working on the project in April 2022, we have taken on an active role coordinating various subcontractors, providing our expertise in installation planning and procedures, supporting on-site factory acceptance testing, and assisting with other roles as needed to help move the project forward.

We believe that there were a few key factors that contributed to our winning the contract. Our general knowledge of the project based on years of planning by Petrobras, coupled with decades of installation and planning experience in oil and gas were likely distinguishing factors. We also had more general experience working in Brazil on telecom projects through the past two decades.

OE: It's now been several months since the contract was awarded. Can you give us an update on the status of the project?

As of January 2023, the entirety of the trunk cable, repeaters, branching units, and branch cable has been manufactured, with system assembly and test (SAT) ongoing.

Manufacture and integration of the SUTAs and umbilicals will be completed during the second quarter of 2023, the same as installation begins for the trunk.

The 13 initial FPSO umbilical connections are scheduled to occur throughout 2023, and the entire Malha Óptica is on schedule to be completed by late 2023.

OE: What makes the Malha Óptica project unique compared to other subsea telecom projects Pioneer Consulting has worked on?

In addition to the various nuances described above, Malha Óptica is unique in its somewhat "disaggregated" approach to design and implementation.

Many aspects of this project are being handled by separate manufacturers and installers, each with expertise relative to the oil and gas sector. The ZMAX-Planova consortium is acting as the integrator, pulling all of this expertise together to deliver a completed network for Petrobras.

Of course, this approach creates unique challenges in the coordination of materials, equipment, and subcomponents between suppliers and installers.

Although Pioneer is very familiar with a disaggregated approach to system construction for commercial telecom systems (for example having just completed the CrossChannel Fibre system using this approach), this level of disaggregation is unique because the disaggregated scopes are much larger than they would be for a commercial system.

Of course, this approach is quite common in the oil and gas industry, but not so much in commercial telecoms, at least at this scale.

OE: Finally, are there any drawbacks to using subsea fiber optic cables in the offshore industry? How is the cable's structural integrity, cybersecurity, and data safety en-

sured? And what can operators expect in terms of maintenance costs?"

Drawbacks to using fiber optic cables in the oil and gas industry are similar to the drawbacks of using fiber optics for commercial use, which include challenges in installation and repair operations, potential issues in permitting and regulatory hurdles, and the high cost of developing these types of systems. The oil and gas industry introduces additional challenges during installation, and repair operations due to the restrictions associated with nearby offshore energy assets, and, occasionally, the need for specialty equipment can drive up the development costs.

Cable structural integrity is ensured through typical cable protection requirements, which are aligned with the International Cable Protection Committee's (ICPC) recommendations.

Cable structural integrity is ensured through typical cable protection requirements, which are aligned with the International Cable Protection Committee's (ICPC) recommendations.

Leveraging existing transmission equipment, and network management services, the offshore energy sector sees all the same benefits in cybersecurity and data safety as the commercial sector. One unique aspect of these types of oil and gas networks is that they are generally private. Malha Óptica will be 100% owned by Petrobras, so they're able to decide if and how the data may be connected outside to public networks. At that point, security is the same as any other communications system.

Regarding maintenance costs, offshore operators experience similar costs as commercial operators. There is no difference in terms of ongoing operational costs. However, depending on proximity to offshore assets, if cable repairs are required, they may require more precise and specialized operations compared with commercial telecom systems.

This is to ensure the integrity of the abundant infrastructure deployed on the seabed. But, as mentioned earlier, what might be seen as a more challenging operation for the commercial telecom industry is seen as "business as usual" in the offshore oil and gas industry.

As Director of Client Solutions at Pioneer Consulting, **Austin Shields** has 8 years of submarine cable experience in both mechanical and electrical engineering. With a background ranging from network design and architecture, testing and verification, design, manufacturing, and qualification, to full-scale project management of undersea fiber optic cable systems, Shields brings a wealth of experience to clients. Shields holds a Master of Science in Electrical Engineering (Signal Processing) from New Jersey Institute of Technology, Bachelor of Science in Mechanical Engineering from Rutgers University, School of Engineering and Bachelor of Science in Applied Physics from Stockton University.

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CCS, Hydrogen Challenges a Focus at SPE OFFSHORE EUROPE 2023

Energy industry leaders are to set out how the sector can overcome challenges posed by the implementation of carbon capture storage (CCS) and the use of hydrogen at SPE Offshore Europe 2023 (OE23).

A series of technical papers and panel sessions on the topics will be on offer to help the industry as it transitions towards net zero. The theme of the conference at this year's 50th anniversary OE23, which will be held at P&J Live, Aberdeen from 5-8 September 2023, is: 'Securing sustainable and equitable energy for the next 50 years and beyond.'

A paper by Petronas will discuss the possibility of repurposing existing hydrocarbon pipelines for CO2 transportation. EBN B.V. will set out how project design and operational philosophy hurdles were tackled on two large-scale CCS projects in the Netherlands.

Another paper by EBN B.V. will analyze the storing of CO2 in a depleted gas field in the Netherlands. The Boston Consulting Group will detail how combining extensive research of limestone and steel industry with CO2 storage physics can enable the acceleration of mineralization in the reservoir from approximately 100 years to two years, rapidly accelerating the permanent CO2 storage process.

Hydrogen challenges are also set to take up a headline position on the OE23 agenda. Producing, transporting, storing and using low-carbon hydrogen safely and cost-effectively will be essential to enable the UK's net zero commitment to be met. However, numerous technical challenges need to be overcome to enable hydrogen to be deployed at scale.

Environmental Resources Management will present the results of industrial trials commissioned by the UK

"CCS and hydrogen projects and challenges will feature highly across the panel and technical sessions as stakeholders and decision makers convene to discuss, debate and make progress on the opportunities and hurdles that the energy transition presents."

– Kamel Ben-Naceur, SPE Offshore Europe Conference Chairman 2023

Government, Scottish Government and Scottish Ports to investigate the technical and commercial feasibility of exporting hydrogen from offshore wind in the North Sea by using liquid organic hydrogen carriers (LOHC) to industrial European demand centers.

A paper by Kent plc will present recent modelling work carried out supporting a Dutch North Sea operator to understand the change in risk on their production platform due to the newly produced hydrogen passing through it.

The University of Aberdeen has mapped the hydrogen storage capacities of UK offshore hydrocarbon fields and explored potential synergies with offshore wind. Its findings estimate a total hydrogen storage capacity of 3454 TWh within 96 fields investigated, significantly exceeding the determined 120 TWh seasonal domestic storage demand. The paper notes that "this methodology can be applied to any region where petrophysical field data and offshore wind data are available, to provide a high-level assessment of the techno-economic potential of hydrogen storage for coupling with offshore wind generated green hydrogen."

Kamel Ben-Naceur, SPE Offshore Europe Conference Chairman 2023, said: "CCS and hydrogen projects and challenges will feature highly across the panel and technical sessions as stakeholders and decision makers convene to discuss, debate and make progress on the opportunities and hurdles that the energy transition presents."

Hydrogen technology and know-how will also be showcased on the exhibition floor in the Hydrogen Hub, sponsored by ABB.

- **The full conference program can be found at:** ***www.offshore-europe.co.uk***

UTC

SUBSEA TECH SET FOR UTC 2023

Global subsea energy leaders will convene in Bergen, Norway at the Underwater Technology Conference (UTC) in mid-June to meet, greet and exchange ideas on the crucial underwater technology topics. Stig Instanes, TechnipFMC and Rune Vesterkjær, Aker Solutions, helped to shape a vibrant and diverse program, and they recently discussed the technical highlights and networking opportunities in store for visitors to UTC '23.

By Greg Trauthwein

"In Norway and Europe you have a lot of incentives and focus on how we can have a more sustainable energy production. But for it to be sustainable, it's important that we address the topics that we have of the trilemma; where you have energy security, energy affordability and energy sustainability, and see that it's also a profitable business."

– Rune Vesterkjær, Vice President, Subsea Energy Transition & Low Carbon Solutions, Aker Solutions

The scenic west coast of Norway is the place for the Underwater Technology Conference (UTC) 2023, scheduled for June 13-15, 2023, Grieghallen in Bergen, Norway.

UTC 2023 is estimated to attract 500 to 800 attendees and nearly 40 technical papers. But what the UTC lacks in size it compensates for in stature, as the event regularly attracts a broad array of leading executives from global companies working in the offshore energy and subsea space, including a dozen keynote speakers from key operators like Petrobras, Equinor and Shell, as well as the main suppliers in the subsea space.

"Many of us have been around for a lot of conferences over the years, and I would say that UTC is one of the few conferences where you see that the operators are taking a big part of the conference, both as presenters but also as regular delegates," said Stig Instanes, BD & Sales Manager, TechnipFMC, who serves as the Board Chairman of the Underwater Technology Foundation. "There is a very high probability that you'll meet your end client, the operator, at UTC."

"Networking is the main thing," said Rune Vesterkjær, VP – Subsea Energy Transition & Low Carbon Solutions, Aker Solutions, who serves as UTC's Program Committee Chair, agrees. UTC allows those who have developed the technology to meet and collaborate with colleagues and clients; "this is the magic happening, where you find even better solutions and you discuss other areas of application."

As the world emerges from the effects of the Covid shutdown, Vesterkjær argues that the social aspects of business are more important than ever, particularly to connect the younger people in the industry with the senior members of the industry, so each can gain from the others insight, experience and expertise.

The UTC Conference Program

While the UTC maintains its strong commitment to traditional oil and gas, it too sees the writing on the wall regarding energy transition, and the conference program is a repository of knowledge and insight on how companies

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– Stig Instanes,
Business Development Manager, TechnipFMC; Board Chairman of the Underwater Technology Foundation

in the space can leverage their own experience to broaden – not replace – their work in discovering a and recovering fossil fuels. "We still have a lot to do when it comes to traditional oil and gas subsea developments, and that will be covered," said Instanes. But increasingly, too, there is a push to leverage traditional offshore oil and gas subsea technologies for 'new' energy and systems, from floating wind to hydrogen to carbon capture and storage. "More and more we see that carbon capture and storage is relevant for subsea. I think all of us in the supply chain are ramping up for that, and there are quite a few technical presentations on that theme" together with the other emerging technologies.

"This conference is dedicated to underwater technology within the energy space, and right now there is an energy crunch," said Instanes. "This year's topic, securing global energy, is highly relevant for all of us."

With energy security and the environment competing as the prime topics, Instanes said "we need to harvest energy in the ocean space if we are going to succeed with this energy transformation. We are now looking into how traditional oil and gas underwater technology can enable renewable technology within the ocean space."

"The technical program is always what's been the key to the UTC," said Vesterkjær. "Learning what's been going on in the industry, learning about breakthroughs and the projects."

UTC attracts participants from around the world, and Vesterkjær sees this as a positive, allowing all to learn from the experiences, triumphs and failures from colleagues half a world away.

"In Norway and Europe you have a lot of incentives and focus on how we can have a more sustainable energy production," said Vesterkjær. "But for it to be sustainable, it's important that we address the topics that we have of the trilemma; where you have energy security, energy affordability and energy sustainability, and see that it's also a profitable business."

By its very nature, the subsea sector must invent, engineer and deliver products and systems that are robust and reliable, traditionally focused on the offshore oil and gas sector. The solutions that exist are not exclusively for oil and gas production, but also for methods of installation;

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methods to handle the high pressures; and understanding how to minimize impact on the surrounding environment. As energy evolves to include renewables, as well as budding industries like carbon capture and storage, Vesterkjær sees UTC as the platform to bring together the traditional industry with the new player to share information and help devise new energy solutions and businesses.

"I think our focus on robustness, reliability, and our proven technology is a good example of what we can achieve as a subsea industry," said Vesterkjær, "to see how we can help out on the other [emerging] industries to come.

In total there will be 36 technical papers, all focused on the trilemma: energy security, energy affordability and energy sustainability. The presentations will meld traditional oil and gas with renewable and 'clean' energy topics: offshore wind, hydrogen, wave energy, carbon capture and storage, as well as decarbonization topics in regards to subsea processing, including electrification on the sea bed.

Vesterkjær was also keen to point out that eight of the 15 keynote speakers – 53% – are female keynote speakers, but regardless of gender all are "highly skilled, eager and talented people who will give us their insights."

In addition to the traditional conference highlights, there will also be a field trip on the first day of the event – so dubbed day zero of the UTC – to OneSubsea's facilities in Bergen and also to Aker Solutions' facilities at Ågotnes.

The full conference and keynote program can be found online at *https://www.utc.no/agenda/*.

What	**Underwater Technology Conference 2023**
When	**July 13-15, 2023**
Where	**Bergen, Norway**
Web	**https://www.utc.no/**
Agenda	**https://www.utc.no/agenda/**

Images courtesy: UTC

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RIGS

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Rig Type	Available	Contracted	Total	Utilization
Drillship	4	77	81	95%
Jackup	225	264	489	54%
Semisub	27	50	77	65%

Africa

Rig Type	Available	Contracted	Total	Utilization
Drillship	1	15	16	94%
Jackup	16	13	29	45%
Semisub	1	3	4	75%

Asia

Rig Type	Available	Contracted	Total	Utilization
Drillship	3	5	8	63%
Jackup	95	65	160	41%
Semisub	17	5	22	23%

Europe

Rig Type	Available	Contracted	Total	Utilization
Drillship		8	8	100%
Jackup	14	31	45	69%
Semisub	6	22	28	79%

Latin America & the Caribbean

Rig Type	Available	Contracted	Total	Utilization
Drillship		24	24	100%
Jackup	3	3	6	50%
Semisub		12	12	100%

Middle East

Rig Type	Available	Contracted	Total	Utilization
Jackup	61	120	181	66%
Drillship				

North America

Rig Type	Available	Contracted	Total	Utilization
Drillship		25	25	100%
Jackup	26	24	50	48%
Semisub	2	2	4	50%

Oceania

Rig Type	Available	Contracted	Total	Utilization
Drillship				
Jackup	1	2	3	67%
Semisub		4	4	100%

Russia & Caspian

Rig Type	Available	Contracted	Total	Utilization
Jackup	8	2	10	20%
Semisub	1	2	3	67%

Global Average Dayrates

Floaters		Jackups	
Ultradeep water	424.5	High-spec	140.3
Deepwater	325.0	Premium	160.0
Midwater	391.9	Standard	98.8

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 June 2023
Source: Wood Mackenzie Offshore Rig Tracker

DISCOVERIES & RESERVES

Offshore New Discoveries

Water Depth	2018	2019	2020	2021	2022	2023
Deepwater	16	20	14	13	22	1
Shallow water	56	86	42	56	29	16
Ultra-deepwater	18	18	11	7	16	4
Grand Total	**90**	**124**	**67**	**76**	**67**	**21**

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	578	50,073	23,072
Shallow water	3,241	422,065	142,965
Ultra-deepwater	341	47,055	28,895
Grand Total	**4,160**	**519,192**	**194,932**

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	575	19,118	11,948
Asia	810	15,290	7,010
Europe	772	12,808	12,203
Latin America and the Caribbean	191	6,898	40,442
Middle East	134	79,428	146,972
North America	467	2,880	13,052
Oceania	89	11,679	1,174
Russia and the Caspian	60	17,500	13,370
Grand Total	**3,098**	**165,601**	**246,170**

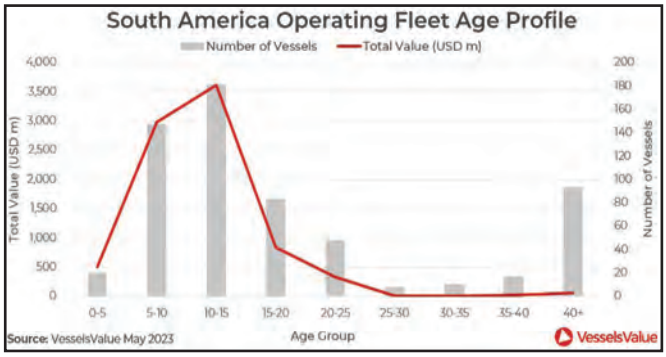
Onstream and under development.

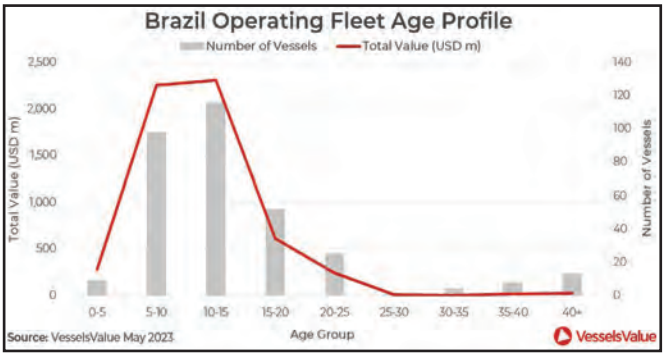
The portion of commercially recoverable 2P reserves yet to be recovered from the reservoir.

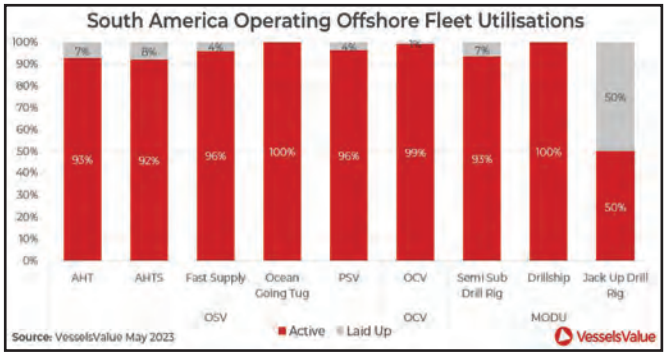
Source: Wood Mackenzie Lens Direct

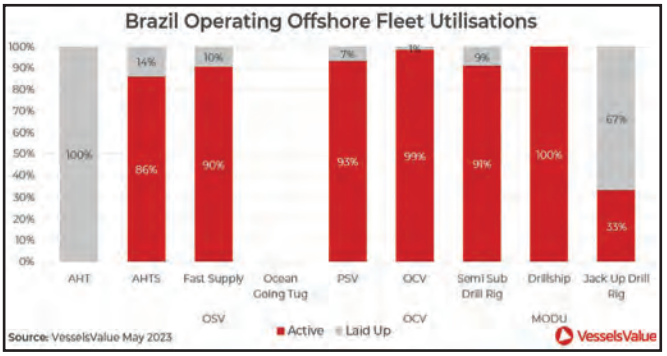
SECTOR IN FOCUS

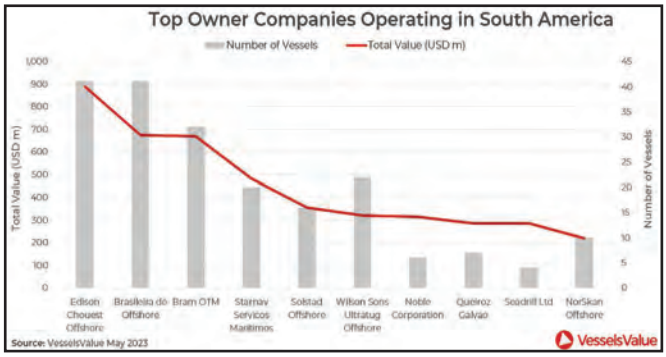
SOUTH AMERICA

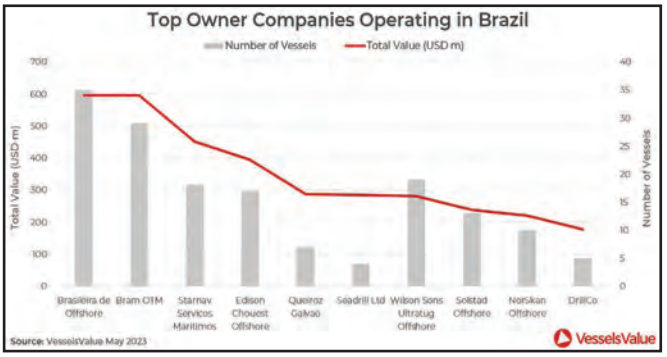


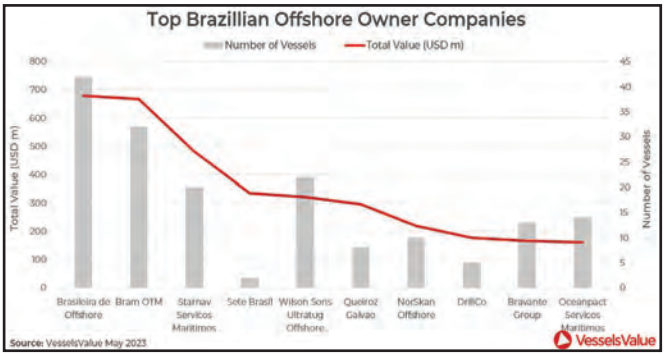












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24-7 OPERATIONS

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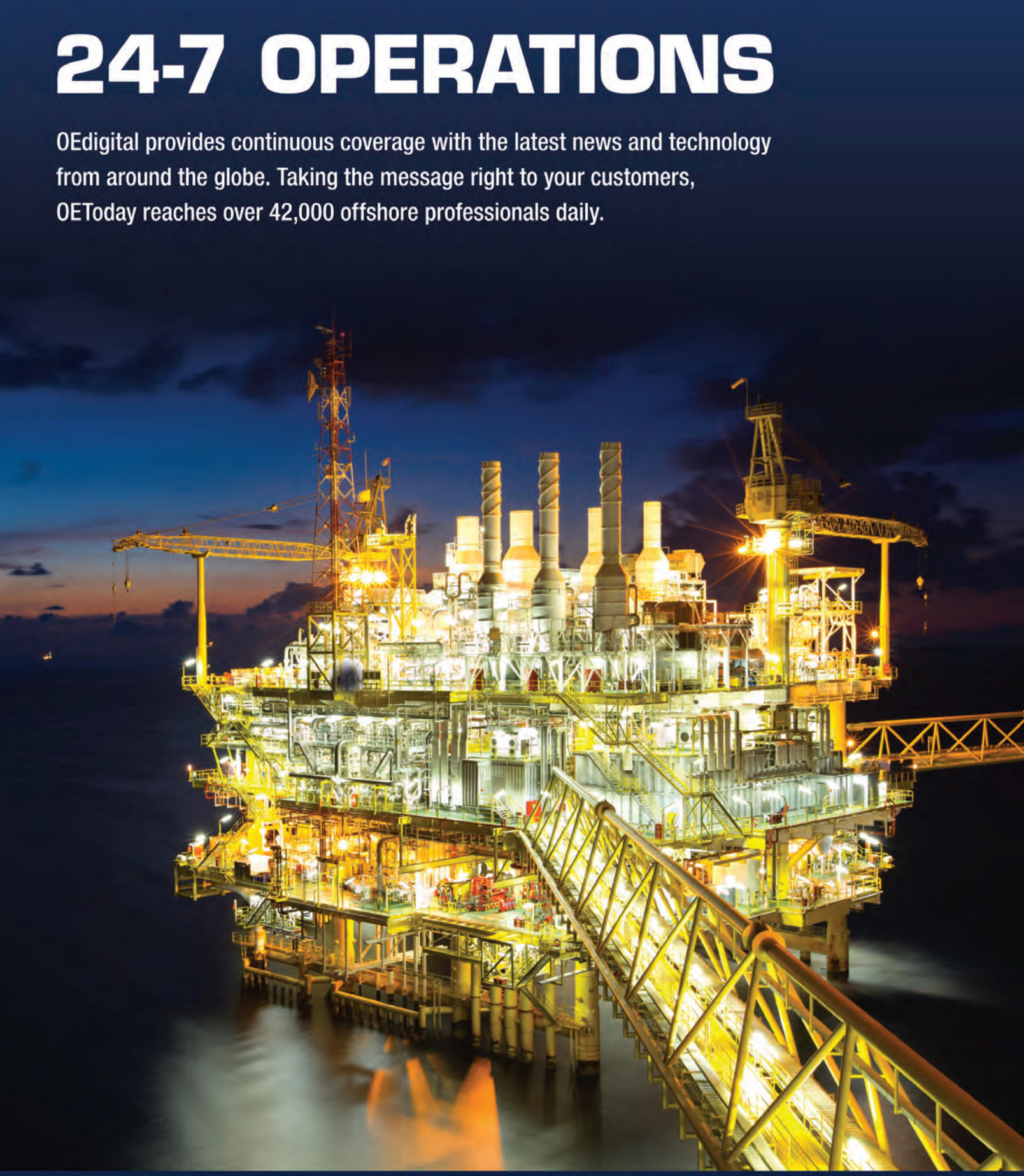

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