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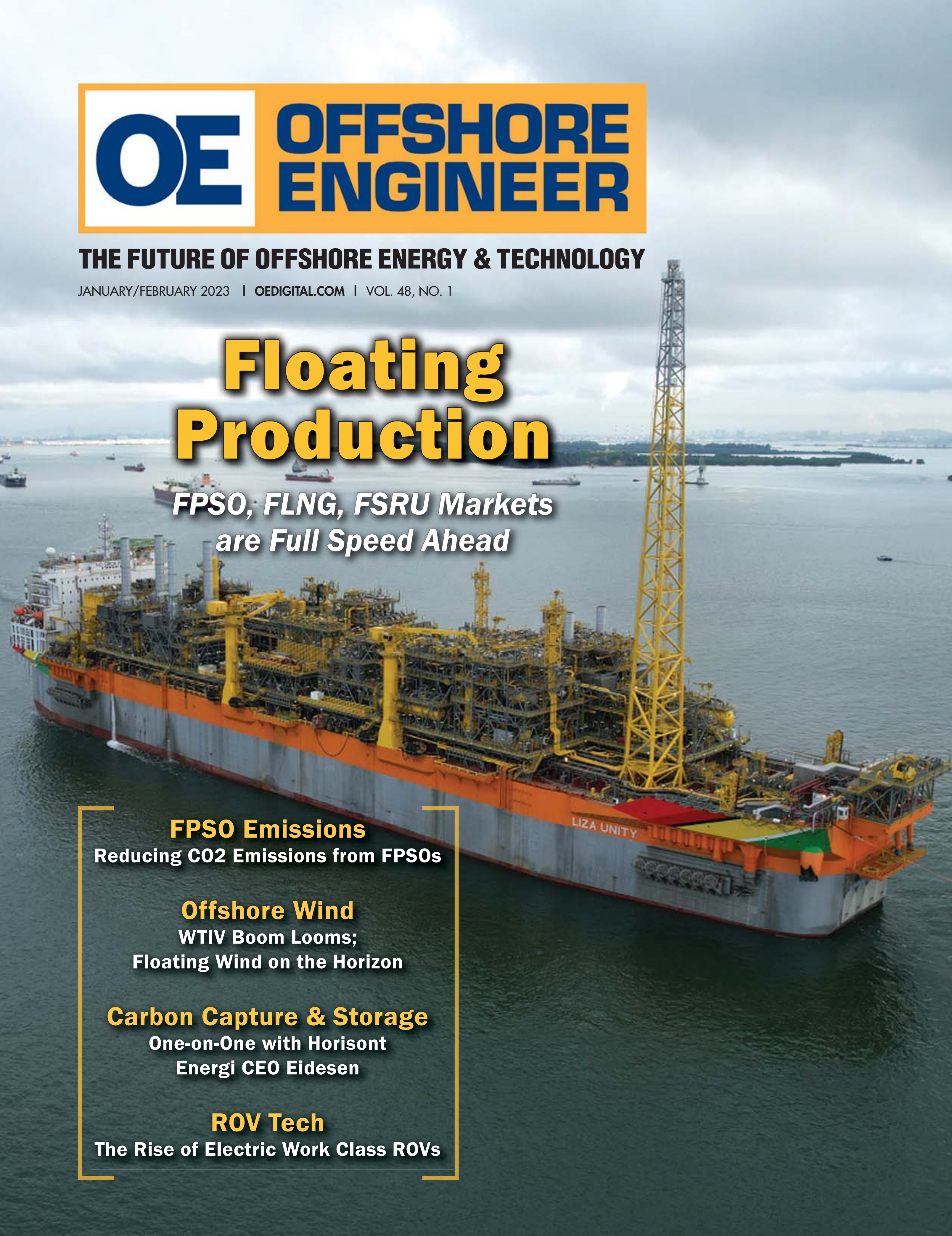
Floating Production

FPSO, FLNG, FSRU Markets are Full Speed Ahead



FPSO Emissions
Reducing CO2 Emissions from FPSOs

Offshore Wind
WTIV Boom Looms;
Floating Wind on the Horizon

Carbon Capture & Storage
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The Rise of Electric Work Class ROVs


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F E A T U R E S

Reducing CO2 emissions from FPSOs

Gas turbines used to be the obvious choice for powering FPSOs, not any more.

By Wendy Laursen

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Floating Production: Opportunities … & Challenges … Abound

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Bartolomej Tomić

Bernhard Schulte Offshore /Matthias Giebichenstein

NAUTICUS

AWASH IN CASH

Big Oil has 219,000,000,000 reasons to be happy. In 2022 Big Oil – BP, Chevron, Equinor, Exxon Mobil, Shell, and TotalEnergies – more than doubled its profits to $219 billion, blowing previous records out of the water during a year marked by volatility, punctuated by Russia's invasion of Ukraine and all of the economic and energy insecurity that ensued.

Awash in cash, oil companies have signaled a re-think on the speed of energy transition strategies, striking while the theoretical oil price iron is hot and making amends for a nearly seven-year run of stagnation and shrinkage.

None were clearer than Bernard Looney, Chief Executive, BP, who said: "We need lower carbon energy, but we also need secure energy, and we need affordable energy. And that's what governments and society around the world are asking for."

While ladling cash on investors courtesy of dividends and share buybacks is a priority, much of the recent windfall is making its way back into exploration and production, as the fleets of idled rigs and boats come back to life.

The floating production niche, which was moribund for several years, is roaring back, with IMA/WER projecting orders for 9 to 11 FPSOs, a few FLNGs and a handful of FSRUs, too. But while prospects are bright, a number of hurdles – from a dearth of qualified contractors to the energy transition to heightened environmental regulation – could conspire to mute the size and speed of the rebound.

And while oil is 'back', the offshore renewable sector still offers ample opportunity, as laid out by Phil Lewis, director of research, Intelatus in a pair of reports this month.

Up to $8B is forecast to be invested in new wind turbine and foundation installation vessels to meet offshore wind demand in the international segment; while $3B is forecast to be invested in new anchor handlers to meet floating wind demand.

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THE CASE FOR OSV NEWBUILDS

Is the market ready for newbuild orders again?

By Jesper Skjong, market analyst, Fearnley Offshore Supply

A decade ago, the offshore support vessel market saw newbuilds practically flying out of the docks as the industry seemed to know no bounds to its potential growth. Back then, "sky's the limit" and anyone saying otherwise was simply left behind as there were far more people eager to participate in the circus than realizing that it was getting out of hand.

When the offshore activity hit a proportionally hard stop towards the end of 2014 and into 2015, the PSV newbuild orderbook stood at a record-high number of 360 vessels, around 30% of the total fleet. Especially large-capacity vessels were ordered in droves, and while the total PSV fleet grew by around 50% between 2010 and 2015, the number of units with more than 4,000 DWT grew by 250% in that same period. And while these numbers are significant in themselves, the orderbook delivery schedule at the time had PSV fleet growth at more than 150 and 400% respectively in the same period!

In the years thereafter, the OSV market struggled with devastating oversupply, not just in light of the far weaker market activity in the years following 2015, but even compared to the peak vessel demand in 2014. Regardless, the shipyards continued building already ordered units, and close to 200 PSVs have been delivered in the wake of the market crash.

As a result, at the trough of the market, in 2017, as much as 40% of the total supply fleet was laid up around the world, with dayrates suppressed to levels accordingly.

Since then, however, less a Covid-19 induced detour, the market has recovered to a significant degree.

While there is admittedly still a rather large number of cold-stacked OSVs, the majority of these units are considered non-commercial due to their age, lay-up duration, and condition. Arguing to this effect is the fact that the market has been able to improve to the degree that it has while said vessels remain idle.

As the optimism in the OSV market continue to climb, addressing the elephant in the room become increasingly important. Newbuild orders has, perhaps unsurprisingly, been close to non-existing since the market deteriorated, leading to stagnated fleet growth and aging vessels.

Our market forecasts suggest strong cash flow earnings across most OSV segments, representing a change in most vessel owners' financial situation compared to recent years. It is likely that shipowners will prioritize the free cash flow for servicing existing debt obligations and potentially treat themselves with dividends or share repurchases initially, as the financial flexibility in recent years has been limited.

Now faced with these vastly improved prospects, it is crucial to understand what market conditions are required for newbuilds to become commercially justifiable. Furthermore, it is also vital to consider how other market elements come into play for this exercise, including cost developments such as newbuild cost, operational expenditure, cost of, or even availability of capital, and lead times.

Analyzing the AHTS, PSV, and CSV markets, we note distinct differences in the supply and expected demand per segment. But in addition to fleet balance, these vessel segments have also seen different developments in respect to the above-mentioned market elements. As such we expect that the newbuild activity will vary despite the OSV market having improved overall.

In our view, the AHTS market is the least likely segment to see newbuilding activity due to the current market balance. With still some way to go on the demand side for the utilization to reach a level that generates satisfactory strong cash flows, it is unlikely that vessels will be placed in the near-term. Furthermore, the newbuilding costs in this segment is also significantly up from the last cycle. Thus, with both current term dayrates and utilization falling short of the required levels to justify the required investments and other associated cost for this vessel type overall.

It should, however, be noted that there are very different use cases for large-, medium-, and small-capacity anchor handlers both historically but even to a larger degree going forward. As commercial-scale offshore floating wind is set to kick off from 2025 onwards, we expect an additional demand driver for the high-end AHTS fleet that can lead to significantly tighter market balance in favor of the vessel owners.

The PSV market, especially considering the high-capacity units, appears more attractive than the AHTS segment. In fact, the number of working PSV with a capacity exceeding 4,000 DWT has never been higher. This has led to term dayrates for this segment specifically improving dramatically in the last 18 months. However, when examining the newbuild potential in respect of the aforementioned cost parameters, we find that here as well the market conditions have not improved enough to warrant newbuild orders quite yet.

We also need to note the upcoming EU Emissions Trading System that will come into effect in the coming years, leading to high technological risk due to the uncertainty of fuel and cost of operations. Hence, this is expected to serve as a delaying element in the newbuilding process.

The subsea construction support vessel segment on the other hand looks more promising when reviewing the cost development of newbuilds, market balance, and subsequent dayrate trajectories. Moreover, considering Norwegian shipyards' position in this vessel class, where most high-end subsea construction vessels, and around half of all CSV tonnage were built herein, one could argue a favorable currency effect at present. Due to the relatively weak NOK when quoting the construction cost in USD, we find that in the current market environment allows for an interesting entry point at present compared to historical costs.

Furthermore, with a fleet growth that has almost come to a halt in recent years due to lack of deliveries and several high-end assets sold out of offshore, among them to government bodies recently, we note a significant tightness in the construction segment going forwards. Hence, the market balance in the CSV segment could possibly justify fleet additions in the years to come. The key limitation, however, remains available credit and high entry point, considering building assets in the 250-ton AHC crane segment would entail an investment cost significantly higher than that of the supply segment counterparts.

In summary, we currently see some way to go for the rates and overall utilization to justify OSV newbuild orders. Factors such as the pace of capacity deployment within offshore wind, banks stance on credit and emissions regulations will have an impact, leading to major complexity in the decision-making process towards actually placing newbuilds. That having been said, there are definitely justifiable cases within the industry in certain vessel segments, albeit far from the scale seen historically.

RIG SCRAPPING LOWEST IN YEARS AS RECOVERY INTENSIFIES

By Teresa Wilkie, Director of RigLogix - Westwood Global Energy Group

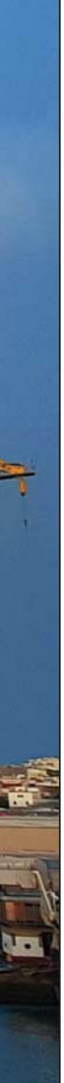
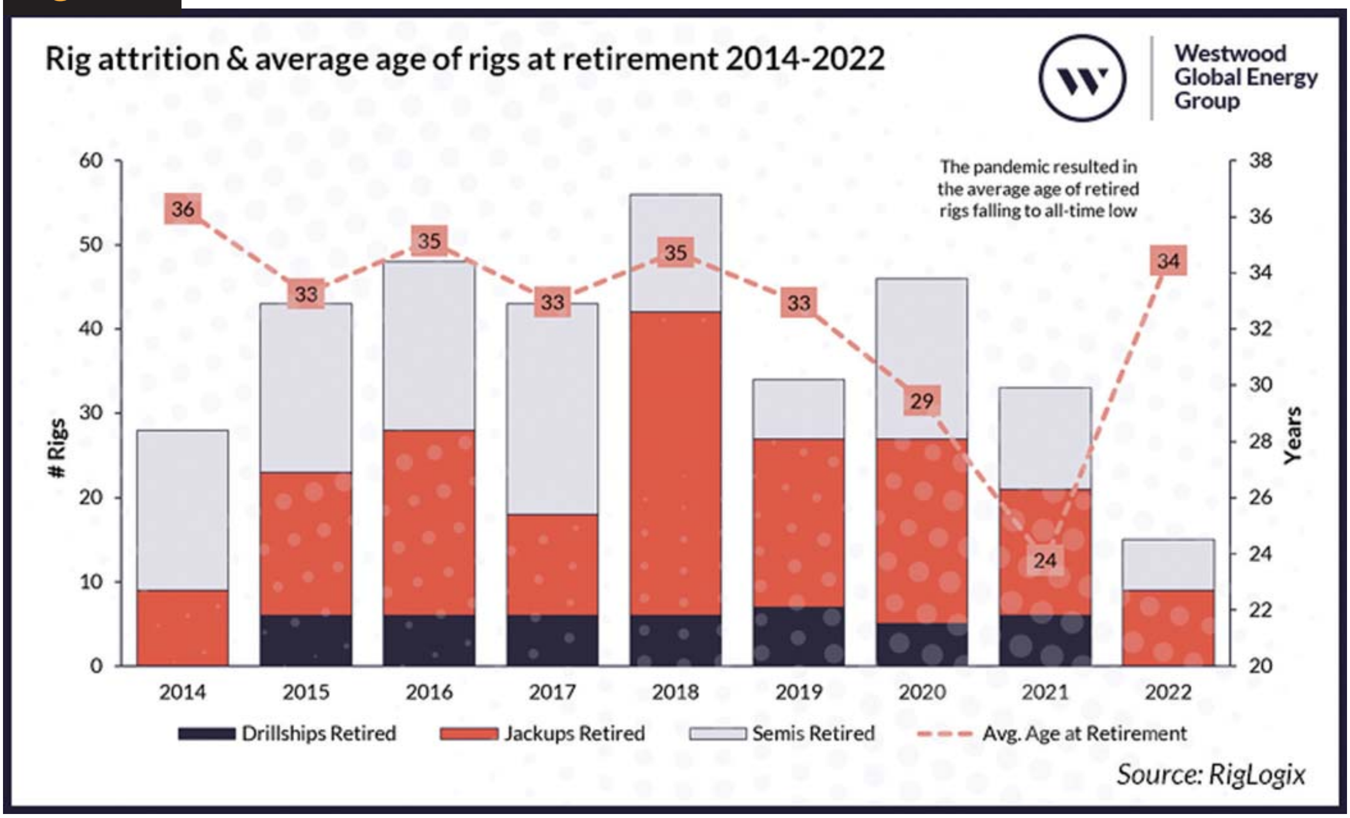


Figure 1



From 2014 to 2018, during the deepest period of the rig market downturn, there was a yearly average of 43 rigs – jackups, semisubmersibles (semis) and drillships – permanently removed from the active fleet, mostly through scrapping or conversion for non-drilling purposes. Demand during the same period was 8% lower (549 rigs versus 505) than the previous five-year average and it spurred rig owners to rethink the size and quality of their fleets. Then when commodity prices and rig demand began to show signs of improvement during 2019, a 21% drop in attrition was recorded compared to the 2014-2018 period. This was attributed to drilling contractors seeing the early signs of potentially putting assets, some of which had previously been circling the drain, back to work should demand and dayrates rise sufficiently.

Market upturn supressing attrition

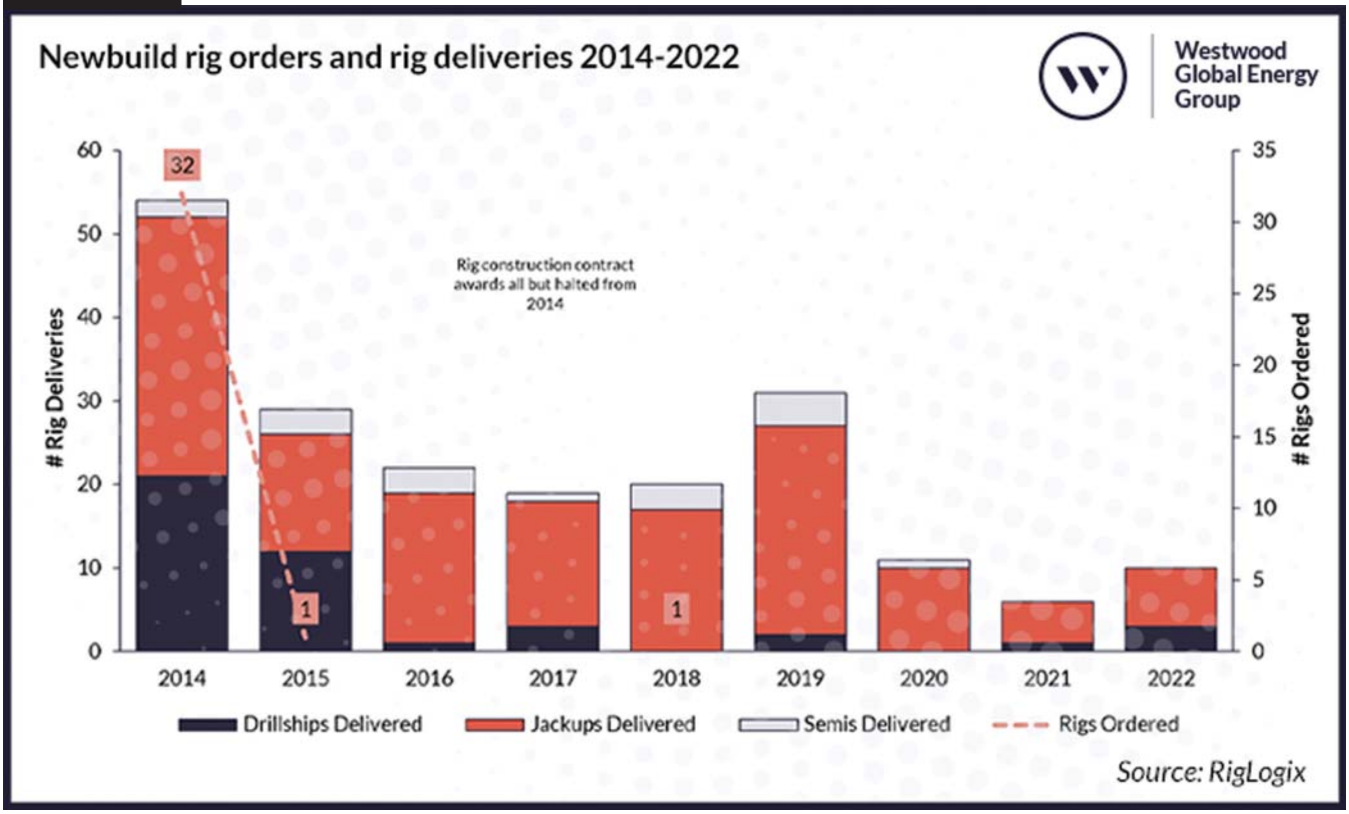
Of course, the 2019 market recovery was short lived when in 2020 the Coronavirus pandemic obliterated rig demand and with it came a 35% jump in rig attrition against the previous year. Between 2020 and 2021, the average age of rigs being retired fell to an all-time low, and during this time we saw drillships as young as eight years old being removed from the active fleet.

We are now once again amid a rig market upcycle that really took hold in the latter half of 2021, with higher demand and utilisation now being recorded in all three rig segments. And this is no doubt one of the main reasons behind the substantially lower level of attrition last year. No drillships were removed from the active fleet in 2022, while just nine jackups and six semis were retired, the majority of which were over 30 years old.

This indicates that rig owners are hanging on to vintage or cold-stacked tonnage, as is generally the case in a rising rig demand and dayrate market. However, the available supply of active (non-cold stacked) rigs, especially jackups and drillships, is shrinking fast and there has already been word that several rigs, which have been idle for multiple years, are being bid into tenders where rig owners do not have any active rigs to bid.

The price tag associated with putting such a rig back to work these days is not cheap, with some drillers estimating

Figure 2



this to be as much as $100 million for a drillship, which would often require a multi-year contract with a dayrate high enough to make a suitable return. In addition to this, it is understood that a driller may now have to wait as long as 18 months for a reactivation to be completed these days.

Reactivations favoured over newbuilds so far

As the supply/demand balance tightens, the reactivation of rigs has been on the rise with approximately 25 jackups, three semis and nine drillships brought back to life since 2021. However, the level of newbuilds being delivered from shipyards hasn't increased to the same level witnessed during the short-lived 2019 recovery period.

During 2019, 25 new jackups, four semis and two drillships were delivered from shipyards in the Far East or Singapore but 2022 brought with it just 10 deliveries in total, which is even less than the number delivered during 2020 (11 rigs).

Most of the remaining stranded newbuild rigs available, of which there are 22 jackups, 15 drillships and eight semis, are owned by the shipyards and drilling contractors continue to be very cautious when it comes to purchasing such a rig. However, 2023 could be the year the tide turns on this, especially if the level of demand continues to improve. In the last quarter of 2022, Transocean announced that it had signed a purchase agreement as part of a joint venture for the 7th generation ex-West Aquila drillship for $200 million from the Daewoo shipyard. Meanwhile, Saipem confirmed it had exercised its option to buy the 7th generation Santorini drillship (originally ordered by Ocean Rig), which it had been bare-boat chartering from Samsung Heavy Industries since 2021. Meanwhile, it's understood that various drilling contractors are eyeing the remaining drillships left in yards.

New rig orders unlikely in near term

As seen in Figure 2, the level of new rig construction contracts being awarded has all but stopped, with just two new rigs ordered since 2015. Sentiment from the industry is that there is little appetite for new rigs to be ordered following the harsh lessons learned from previous newbuild cycles as well as a lack of spare capital for such an expensive purchase. Therefore, it is unlikely that we will see a wave of new construction anytime soon and instead drilling contractors will look to their own idle fleets or already under-construction or stranded units to meet their client's needs if current supply runs out.

SUB-SAHARAN AFRICA FLNG

Uniquely Positioned to meet European LNG Demand

By Obo Idornigie, VP for Upstream Research, Welligence Energy Analytics

Even as investment into new energies increases, the global hunger for gas is growing. It's payday for producer countries, and companies are revisiting gas discoveries that have been classed as "stranded" for many years. The emergence of Floating LNG (FLNG) provides a means of monetizing these formerly unwanted finds. The shorter cycle times and lower capex can give FLNG technology an edge over traditionally much larger onshore liquefaction developments. One region where the FLNG solution is building real momentum is Sub-Saharan Africa (SSA).

After Golar's 2.4 MMtpa Hilli Episeyo vessel started up in Cameroon in 2018, Eni fired up the region's second FLNG vessel (the 3.4 MMtpa Coral Sul) last year in Mozambique. Several new projects are expected to start-up over the next few years, as gas resource holders pursue relatively short-cycle and low-cost access to global markets, particularly the hungry European market which lies in close, relative proximity. Our analysis of pro-posed projects highlights that the cost-stacks are well below expected European gas prices pre-2030, but at similar levels over 2030-2035 – quick start-ups are therefore vital to capture the opportunity.

Sub-Saharan Africa becoming a focal point for FLNG activity

Two new projects are expected online this year. Golar will provide the 2.45 MMtpa Gimi FLNG vessel to bp and phase one of its Greater Tortue Area (GTA) project in Mauritania/Senegal, while Eni acquired Exmar's 0.6 MMtpa Tango FLNG unit and will deploy it on its Nene Marine project in Congo-Brazzaville. Furthermore, first steel was cut at Wison Heavy Industry's yard in January for a second vessel (2.4 MMtpa), destined for the same Eni project (start-up in 2025).

- **New project sanctions in 2023:** It's not just European E&Ps looking at FLNG – ExxonMobil is carefully studying its options for Area 4 in Mozambique. While there is more than enough gas to support an onshore liquefaction plant, appetite to sanction such a development is uncertain due to the scale of investment required and long payback periods. We therefore believe the US Major is likely to go down the FLNG path, at least initially.

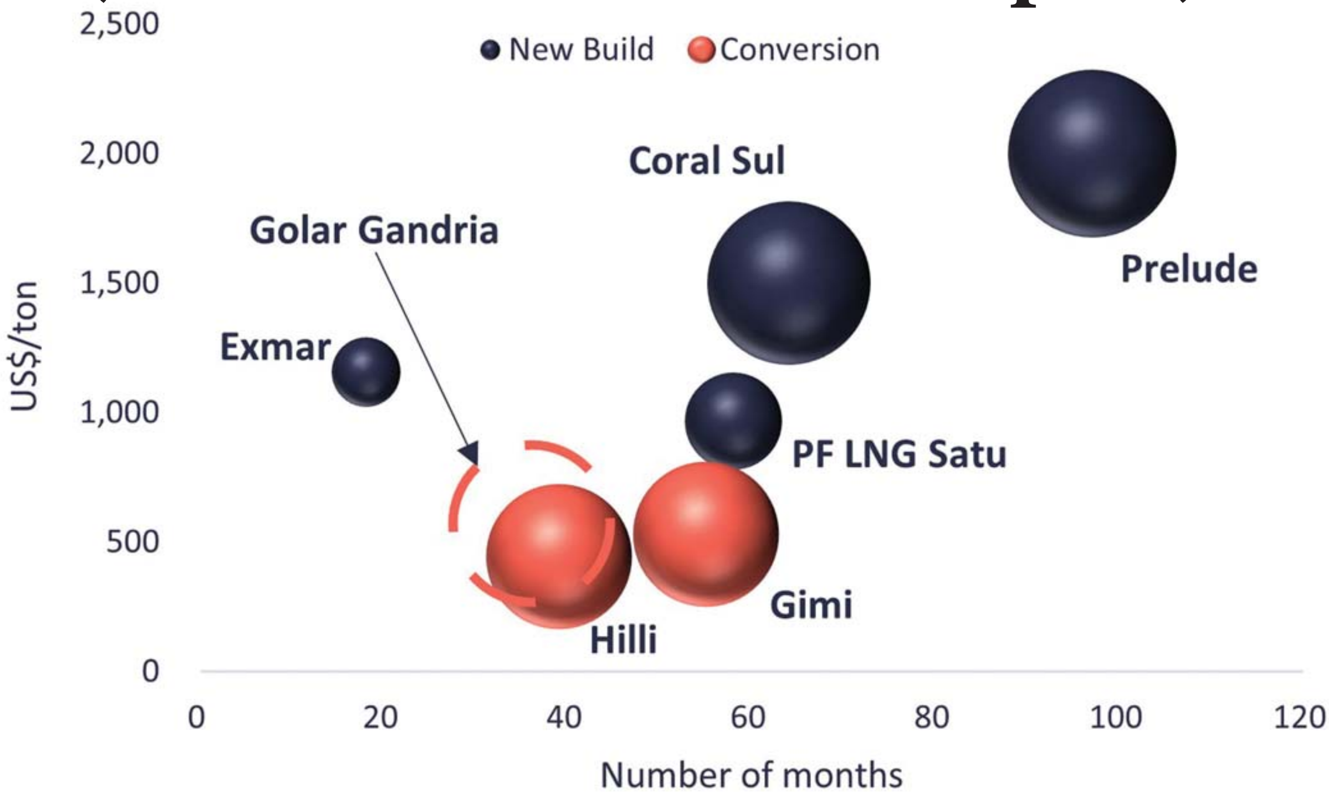
Another key project that may receive FID this year is phase two of bp's GTA in Mauritania/Senegal. Both this, and Area 4 in Mozambique, can comfortably support 20-year 3.5 MMtpa LNG supply contracts. Golar has earmarked the Gandria LNG carrier for conversion to a 3.5 MMtpa vessel. The project location is uncertain at this stage, but Golar is confident it will online by 2025.

Sub-Saharan Africa LNG/FLNG projects

- **The next big gas play – Tanzania:** The East African country, lying immediately north of Mozambique, is working to get its 30+ Tcf gas resource monetised, but we don't see any near-term rush from the likes of Equinor and Shell to build an onshore facility. They may prefer to go down the FLNG path.
- **Shallow-water gas in Nigeria and Gabon:** There are several stranded 2-3 Tcf gas discoveries across the two countries. These fields could utilise small FLNG vessels like the Hilli Episeyo. Alternatively, they could be candidates for New Fortress Energy's Fast LNG solution. One project

Sub-Saharan Africa LNG/FLNG projects

FLNG cost per ton vs. lead time (sanction to first LNG export)*



Source: Welligence Energy Analytics, Golar company presentation, Oxford Institue for Energy Studies

**Bubble size proportional to liquefaction capacity. Based on estimated LNG export start dates for Gimi, Exmar and Golar Gandria. The Exmar vessel is the former Tango LNG vessel and will be repurposed for operations in Congo-Brazzaville.*

that is progressing is driven by UTM, a small Nigerian independent. It has entered the FEED phase to locate a 1.2 MMtpa FLNG vessl on the mature, ExxonMobil-operated Yoho field, where the gas will be supplied via blowdown.

Europe's thirst for gas is a huge opportunity, supply chain constraints are a concern

Most FLNG projects in SSA are backed by European operators, looking to supply their home market. The region is expected to remain supply-constrained over the medium term given curtailments on piped gas imports from Russia. We estimate the full-breakeven cost for select pre-FID projects in SSA to access the European market is under US$8/MMbtu. With European LNG prices potentially averaging US$18/MMbtu out to 2030, now is a window of opportunity for suppliers to create enormous value.

The FLNG solution offers shorter cycle times and therefore access to this opportunity. But one concern for companies green-lighting new projects in the next 18 months is the tightening supply chain, particularly in the vessel construction yards. The shipyards in China have been beset with delays and are yet to recover from Covid-19 restrictions. Delays and cost inflation are therefore risks to companies' ambitions.

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WTIV BOOM LOOMS

Up to $8bn forecast to be invested in new wind turbine and foundation installation vessels to meet offshore wind demand in the international segment.

By Philip Lewis, Research Director of Intelatus Global Partners

Over the last few years, many statements have been made concerning growth in wind turbine and foundation installation demand. These statements have been followed, in some cases, by firm orders for high-specification vessels, mainly from established players. However, many of the announcements remain unconverted into shipyard orders.

We forecast that close to 30,000 increasingly large turbines and foundations will be installed in the international bottom-fixed segment between 2022 and 2035. At least 10 WFIVs and/or six additional WTIVs will be required to meet international demand in the forecast perform after the middle of the decade, inferring an investment of $4-8 billion.

Offshore wind activity was until recently centered in northwest Europe and China, driven by government subsidies provided to support energy transition targets. Going forward, new European markets will emerge off the coasts of the Baltic, Atlantic and Mediterranean. Activity will be seen in the wider Asian region including Taiwan, Japan, South Korea, Australia and India. The US will emerge as one of the largest bottom-fixed installation markets during the forecast period. Several of the new offshore wind markets are shaped by local content preferences impacting, to various degrees local ownership, registration and flagging, crewing and vessel build content.

As we can see from the following charts, 15 MW wind turbines will be trend for established markets with some new markets still deploying smaller turbines. The impact of a bigger turbine is a larger rotor diameter and that means the WTIV crane needs to lift to higher heights.

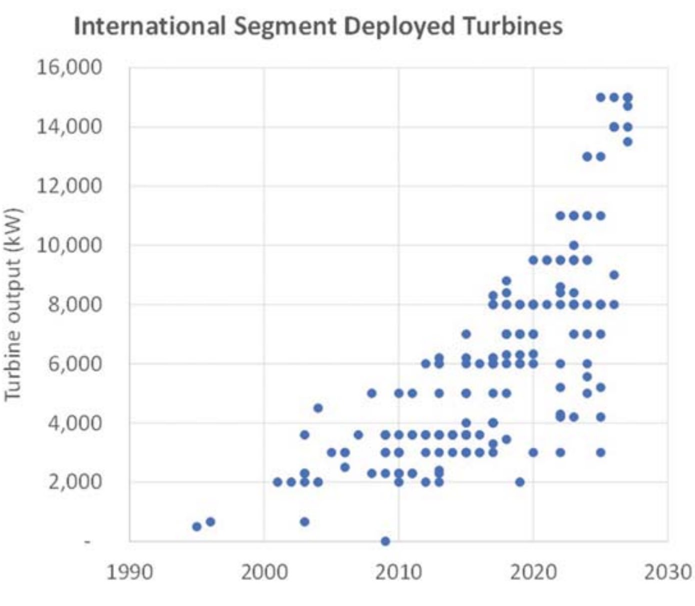
Wind turbine and foundation installation vessel demand is rapidly changing. Until recently this requirement has been largely satisfied by wind turbine installation vessels (WTIVs) and heavy lift vessels and semi-submersibles designed for the oil & gas and port/salvage market (HLCVs and HLSSs). Market requirements have now firmly shifted to purpose-built next generation WTIVs and WFIVs - foundation installation vessels capable of handling the largest bottom-fixed monopile and jacket foundations.

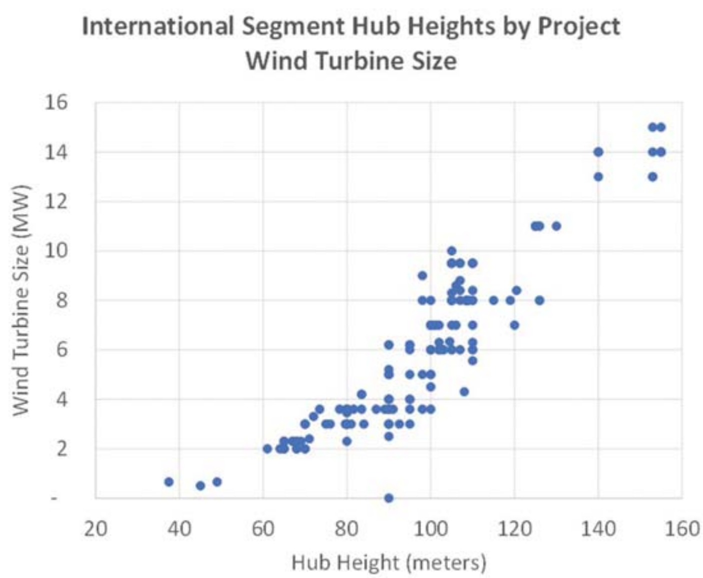
The foundation segment poses interesting installation challenges. With wind turbines getting larger, the loads on foundations are greater and they have to be bigger. Further, with bottom-fixed wind farms moving to the 40-60 meters water depth range as seen in the below chart, foundations will become significantly heavier – another key driver for installation vessel crane capacity.

As turbines and foundations become larger, a large number of exiting turbine and foundation vessels have become technically obsolete. This has resulted in the upgrading of existing vessels and new builds. The chart below shows how the existing and planned turbine and foundation fleet matches the evolving technical demand.

Additional turbine and foundation installation vessels will be required to meet international demand in the forecast period after the middle of the decade.

For more information about the Intelatus Global Partners, visit www.intelatus.com or contact Philip Lewis at +44 203-966-2492.





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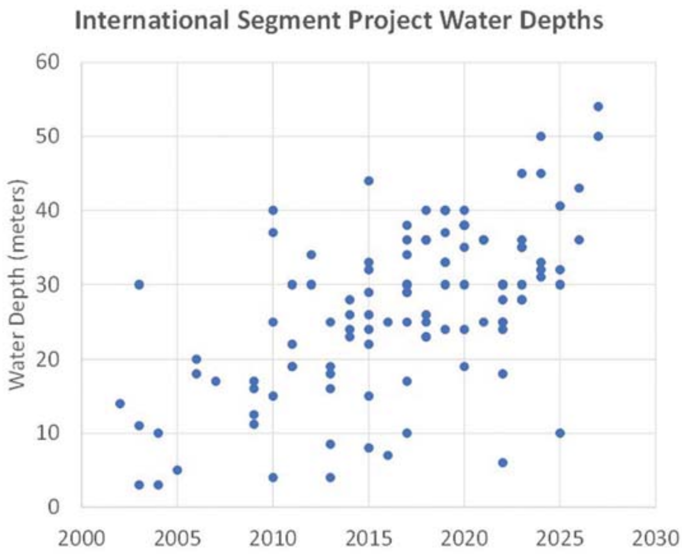

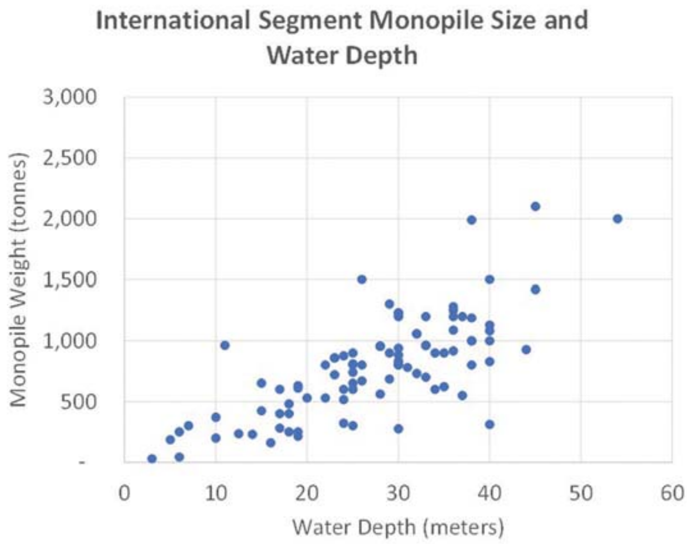

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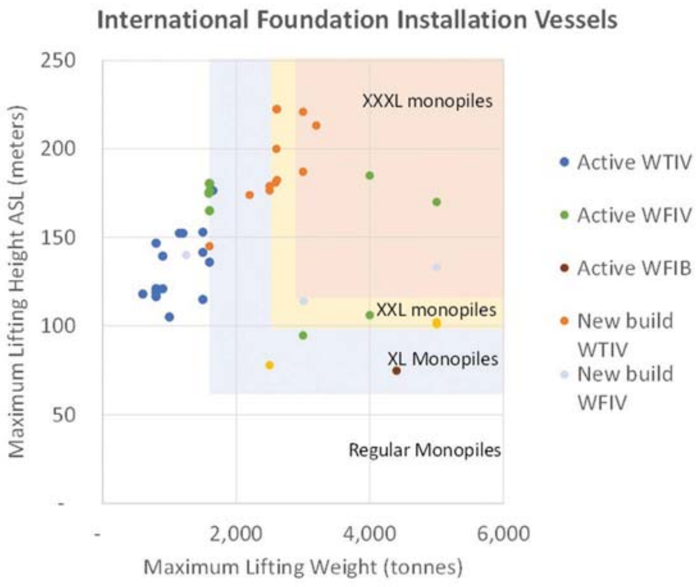

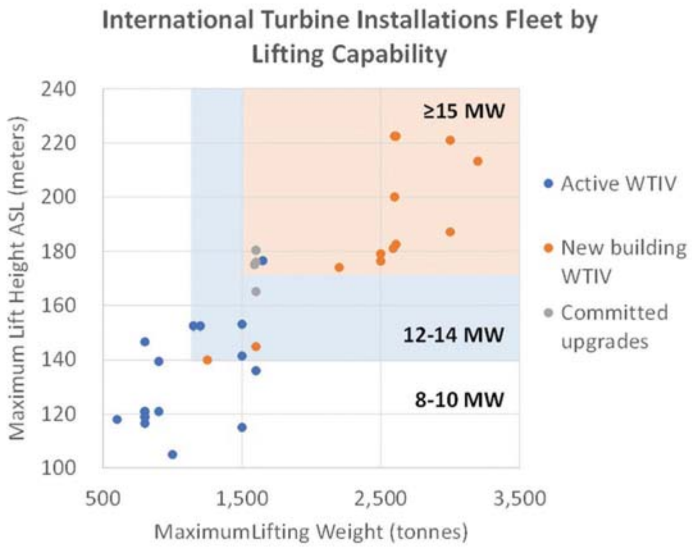

Courtesy Intelatus

FLOATING WIND

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D IS THE FUTURE

$3bn forecast to be invested in new anchor handlers to meet floating wind demand

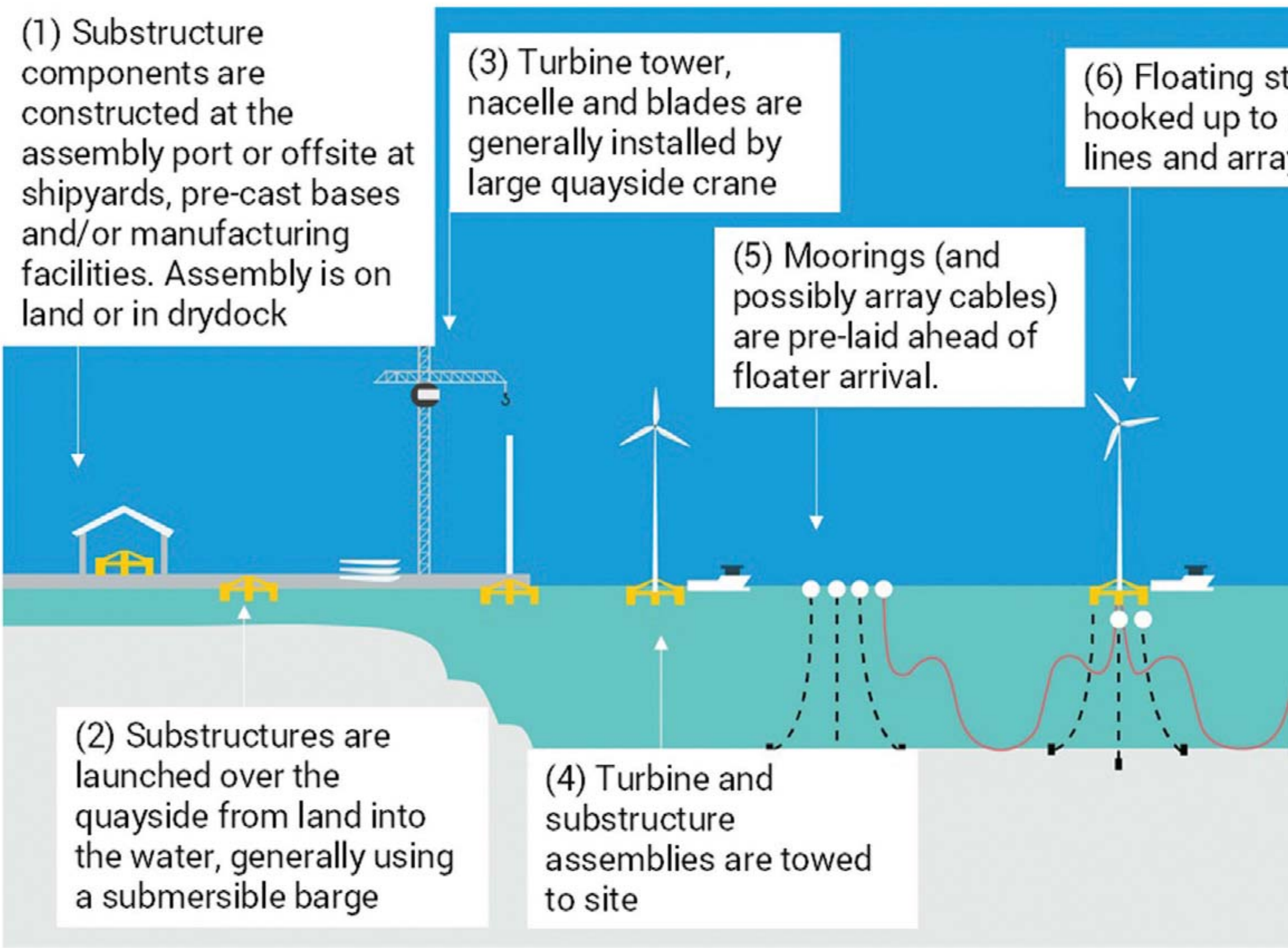
By Philip Lewis, Research Director of Intelatus Global Partners

Floating wind is an emerging technology. Currently being tested in small scale demonstration and pilot projects, global floating wind commissioned capacity at the end of 2022 was less than 200 MW. By 2030, close to 11 GW of commercial scale wind farms are planned to be commissioned in Europe and the Asia Pacific Region. 2030-2035 will see a period a high commissioning activity as the USA joins established European and Asia Pacific markets. Floating installed capacity is forecast to reach 63 GW by 2035. This translates to the installation of close to 4,000 floating turbines, over 16,000 anchors and close to 17,000 mooring lines.

Whereas floating wind projects will leverage experiences from the bottom-fixed industry, there will also be many differences, particularly in how floating turbines are constructed and installed, as shown in the graphic below. The differences drive demand for a different type of vessel than seen for bottom-fixed offshore wind projects.

For floating wind projects, we will see the largest anchor handlers and light subsea construction vessels deployed to pre-install mooring systems designed to maintain the position of the floating wind turbines, to tow the structures from port and to hook-up the floating turbines to pre-existing moorings. For example, our analysis identifies the optimal size of AHTS for mooring pre-lay as having a bollard pull of at least 250 tonnes and a clear back deck of over 800 square meters. The following chart identifies only 63 current optimal AHTSs with the ideal bollard pull and clear deck space combination for mooring pre-lay. The number of vessels of 15 years age or younger falls to only 12 by 2030, when commercial floating wind is forecast to take off at scale.

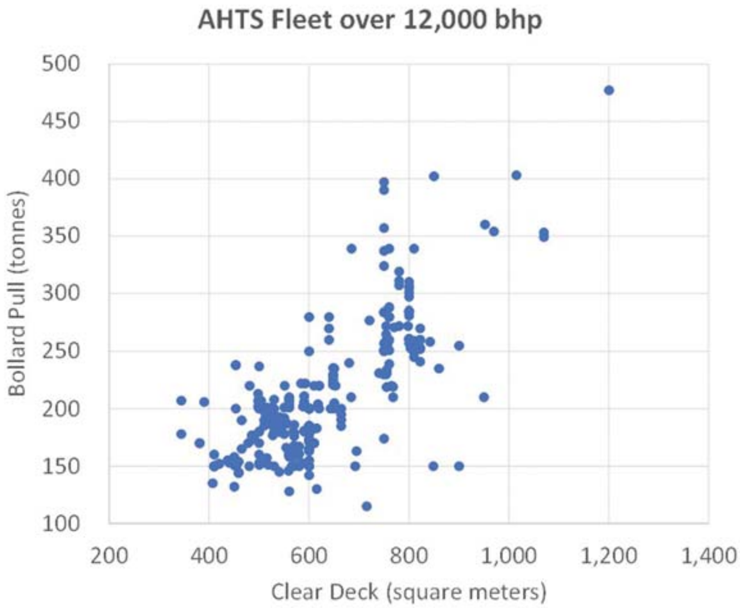
The large anchor handling segment has seen limited re-



Courtesy Intelatus

cent new building activity due to poor market conditions in the core oil and gas sector, with only five large anchor handlers delivered in the last five years. Oil and gas activity is currently picking up, reducing available supply. The challenge is accentuated by an aging fleet, much of which becomes technically uncompetitive by 2030. As a result, our forecast identifies a large anchor handler shortage of around 30 vessels after 2030.

Newbuilding prices for large anchor handlers were around $80-85 million in 2015/16, when large anchor handlers were last contracted. Since then, there has been limited activity to guide price estimates. However, a capital cost estimate of at least $100 million per vessel seems reasonable, meaning that potentially $3 billion will be invested in new built optimal anchor handlers to meet floating wind demand.



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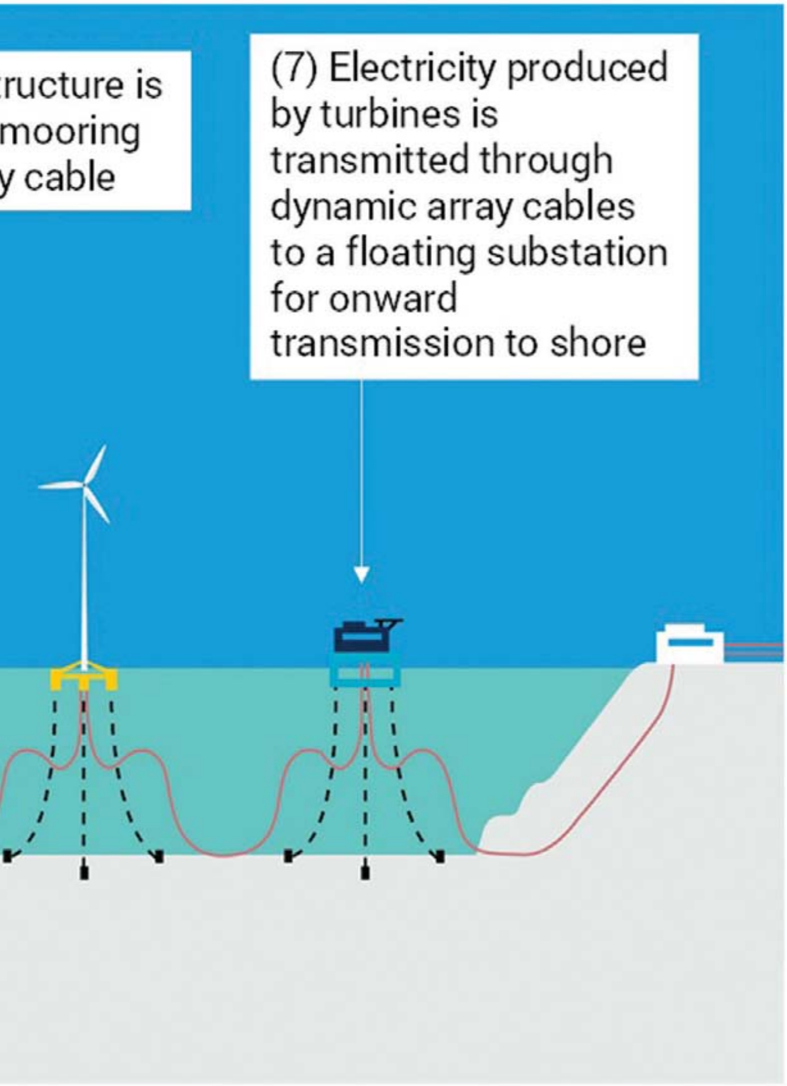

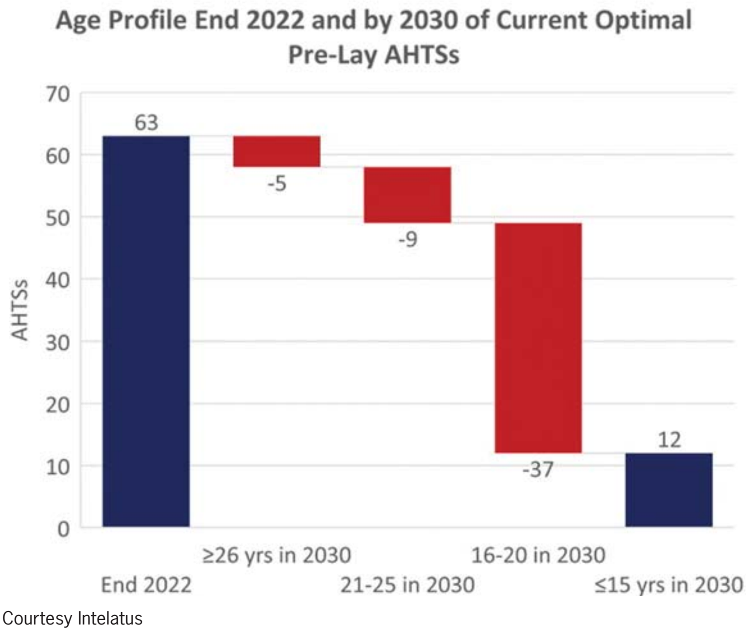

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BALTIC SEA PREPS FOR SURGE IN OFFSHORE WIND PROJECT ACTIVITY

By Tomasz Laskowicz, Researcher at Intelatus Global Partners

The Baltic Sea area offers the countries of the region (Poland, Estonia, Lithuania, Latvia, Finland, Sweden, Denmark and Germany) a large generation potential for offshore wind energy. The European Commission identifies the potential of the Baltic Sea for the installation of 93.5 GW of offshore wind farms, but this figure may be an underestimate. Developers plan to develop large-scale projects based on both bottom-fixed foundations and floating technologies, and countries are identifying new areas for offshore wind development. However, permitting processes take years, and the lengthy procedures coupled with inflation concerns create barriers to project development.

According to the Marienborg Declaration, 8 EU countries will develop 20 GW of offshore wind power in the Baltic Sea by 2030. There are currently only 15 wind farms operating in the Baltic, with a total capacity of 2.5 GW, and additionally two German projects with a total capacity of 700 MW are under construction. By 2024, around 720 wind turbines with a total capacity of 3.4 GW are likely to be operating in the Baltic.

The desire to realise ambitious target to achieve 20 GW of installed capacity in the Baltic by 2030 therefore means that the second half of the decade will be a busy one. There are currently more than 20 projects at various stages of development that could provide an additional 17 GW of installed capacity in the Baltic by 2030. These projects will mostly be based on large turbines of around 15 MW, meaning that between 2025 and 2030, around 1,100 to 1,300 turbines are forecast to be installed in the Baltic. However, almost all projects are currently in the process of environmental studies and permitting, which will allow the developers to make a final investment decision.

Of the seven Polish projects, with a total capacity of 5.9 GW, that have received support under the government's pricing support, none has yet obtained the necessary full construction permits. The projects are expected to be built before 2030, and some of them may possibly be grid connected as early as 2026. One of the most advanced projects in Poland is Baltic Power, developed by PKN Orlen and Northland Power, with a capacity of 1.2 GW. The project is the only one to have obtained a permit for the onshore part of the infrastructure, but the construction of the offshore part requires a separate permit. The time between bidding for the project and the start of the construction process reaches several years and exposes developers to the risk of negative changes in terms of price fluctuations, exchange rate risk (Poland is not part of the euro area), interest rate increases, which have a potential impact on investment returns. The projects under construction in Poland, with a total capacity of 5.9 GW, have most of the necessary environmental permits and could enter the construction phase in about two years. Polish developers have secured government guarantees for inflation indexation of the guaranteed off-take price, which was set at around €70/MWh in 2021. In Poland, preparations are also underway for the construction of port and supply chain infrastructure, with a decision taken to build a Vestas turbine factory and installation port in Świnoujście (western Baltic) and a tower factory in Gdańsk. The development of Polish projects with a capacity of around 16.5 GW, which may enter the realization phase, subject to the settlement of location proceedings, means the installation of around 1,000 turbines over the next 12 years.

Countries in the Baltic region are also taking up the challenge to launch their first offshore wind projects before 2030. Lithuania has announced one 700 MW auction and is reviewing an auction for a further 700 MW. The Elwind project, which is being developed by Latvia and Estonia, has received final site selection. In addition, Latvia intends to carry out a bidding process for a project of around 1 GW. The most advanced project underway in the Baltics is Saare Livii, which, in the first phase, is expected to reach 1.2 GW of installed capacity.

In Finland, offshore wind energy is expected to contribute to the 2035 climate neutrality target. Currently, the 42 MW Tahkoluoto is the only operational offshore wind farm in Finland, for which a 600 MW extension is planned. State-owned Metsähallitus is also developing a 1.3 GW wind farm in partnership with Vestas. OX2 is active in Finland and is building a portfolio of offshore projects also in Sweden, the developer announced in January that it had started studies on a 1.4 GW power plant project. The Sea-Sapphire joint venture is in the early stages of planning four floating wind projects off the coasts of Sweden and Finland, which could have an installed capacity in excess of 5 GW.

While Sweden aims to achieve climate neutrality by 2045, its efforts to date have not focused on offshore wind farms. While developers are proposing the development of numerous large-scale projects, including the 5.5 GW Aurora, many projects are in the early stages of development with no possibility of inauguration before 2032. At the beginning of February, OX2's 1.7 GW Galatea-Galene wind farm announced further project development approvals, which could result in construction starting as early as 2026.

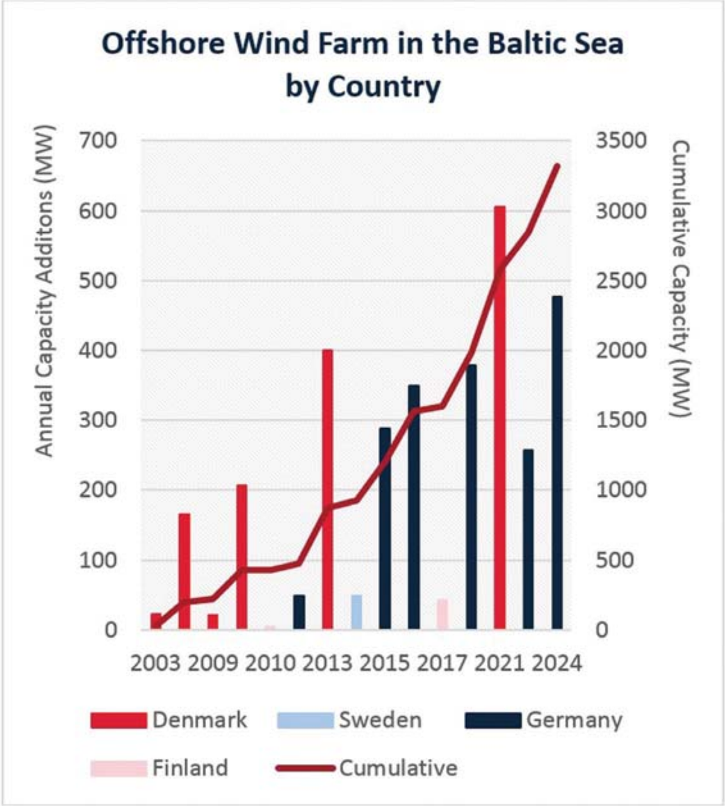
Denmark is continuing to investigate the feasibility of the Hesselø offshore wind farm, for which a tender of up to 1.2 GW is planned for 2024. Denmark is also announcing the construction of an offshore energy island on the island of Bornholm in the Baltic Sea to accommodate wind farms of up to 3 GW. The project is to be carried out in cooperation with Germany.

Germany aims to achieve 30 GW of installed capacity by 2030 and 40 GW by 2035, some of which will be realised in the Baltic Sea. In January this year, Germany announced auctions of areas with a total potential of 7 GW of installed capacity, including 1 GW in the Baltic Sea. Further auctions will be announced in March.

Following the outbreak of war in Ukraine, countries in the Baltic Sea region have increased their interest in offshore wind energy in the Baltic. A number of projects with high generation potential are reviewing an accelerated permitting process, thanks to the determination of governments. The countries of the region do not intend to stop at the ambition of installing 20 GW in the Baltic by 2030. Further auctions are already underway to enable further offshore wind development.

In Poland, awarding of locations has begun for so-called second-phase projects, whose total installed capacity could exceed 8 GW. Two of the 11 identified sites have been awarded to state-owned energy giant PGE, which is already developing three projects in the Polish Baltic Sea, including two in cooperation with Ørsted. Further awards for the Polish second phase of support are expected soon, with the government considering extending support in the second phase to as much as 12 GW (against 5 GW in the auctions already planned). The 12 GW would be subject to auctions held between 2025 and 2031. This would mean that the Polish government is prepared to raise the total target for installing offshore wind farms by 2040 from 11 GW to 17.9 GW.

The need to build a source of energy, independent of energy imports, is pushing the countries of the Baltic region towards ambitious targets for the construction of offshore wind. Crucial to the ability to meet the installation targets in a timely manner at this stage appears to be the procedure for environmental assessment and the issuing of construction permits. The second half of this decade will be a busy time in the Baltic Sea as projects that are in the planning phase today succeed in entering the implementation phase.



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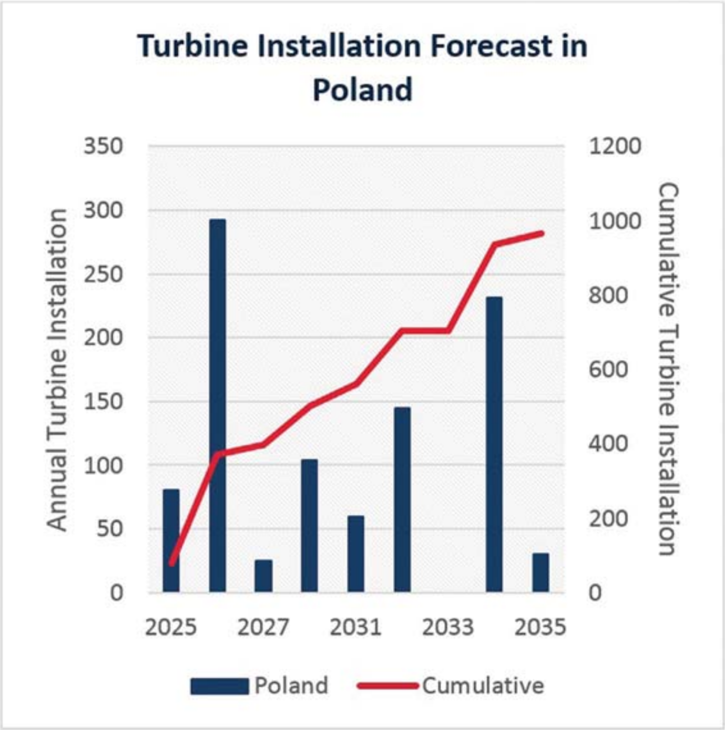

Courtesy Intelatus

FLOATING P
OPPORTUN
CHALLENGES

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RODUCTION:
NITIES ... &
S ... ABOUND

Nothing inspires confidence in the energy markets like a high price per barrel, and a rebound to the $80-$100 range following six years in the doldrums is welcome news for the floating production sector, which are deep water, long-term, and expensive projects. 2022 was a banner year for the Floating Production sector, and '23 is shaping up even better, with IMA/WER projecting orders for 9 to 11 FPSOs, a few FLNGs and a handful of FSRUs, too. But while prospects are bright, a number of hurdles – from a dearth of qualified contractors to the energy transition to heightened environmental regulation – could put the sector back on ice.

By Greg Trauthwein

Oil prices in excess of $80/barrel, and the expectation that they will hold firm or rise in the near future, has helped to drive a strong recovery in the deep water sector and brightened prospects for capital expenditure for floating production systems, an energy segment that was on life support only a few years ago.

While oil majors are still holding back on major increases in capital spending, "this is changing," said Jim McCaul, IMA/WER, who has analyzed the floating production business since 1995 and recently released *Annual Review and Five-Year Forecast of Orders for Floating Production System.*

"Oil prices have risen to levels that support investment in new facilities and capex budgets are slowly expanding. The profit opportunities are too great to pass up."

Most recently, Reuters reported that Exxon Mobil was preparing to approve its fifth oil production project in Guyana and is considering taking additional exploration acreage, according to a Reuters report on **OEDigital.com**. [**https://www.oedigital.com/news/502185-exxon-set-to-order-fifth-guyana-fpso-sizing-up-more-blocks**]

This comes as global inflation takes a heavy toll, with the latest development expected to cost about 27% more than the last, which is due both to inflation and the increased size of the project.

The company's proposed fifth development, at an oilfield called Uaru, would pump about 250,000 barrels of oil per day at peak, for a development that is estimated to cost about $12.68 billion, according to an estimate prepared for Guyana's EPA. Exxon has submitted a development plan for the oilfield, and an initial construction contract was awarded last fall to Japan's Modec. This will mark Modec's debut in Guyana.

Exxon and its partners Hess and CNOOC Ltd. inaugurated Guyana's production in 2019 and today deliver all the oil output in the country, from its 10,347 sq. m. Stabroek block, via two FPSOs, the Liza Destiny and Liza Unity, both supplied by SBM Offshore.

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Overall, orders for production floaters have returned to historic pace and a large backlog of deep water projects has developed. More than 200 projects in the planning stage are likely to require a floating production system for field development over the coming decade, according to the IMA/WER report, and the backlog includes about 60 projects requiring an FPSO within the next five years.

RIDING THE ROLLERCOASTER

Like the offshore oil and gas business itself, the market for floating production systems – projects that can easily exceed $10 billion, with the FPSO alone costing $2.5-$3 billion – has endured its fair share of high and lows over the past generation.

"I've watched this business grow from something like 60 FPSOs up to close to 200 today," said McCaul. "A lot of the [original] 60 are already gone, I've seen them come and go from the planning stage to the development stage to the installation stage to the decommissioning and scrapping stage. It's like old friends disappearing!"

McCaul said that the market had been in literal freefall since 2016 "when the Saudis decided to put all the American tight oil people out of business by driving the price of oil down and starving them from revenue. It didn't work, but the investment in the sector really began to fall off. Just as it was beginning to hum again, along came COVID and that knocked the business for a loop again."

Along the way, orders for floating production units have swung wildly, from up to 20 one year, down to zero the next.

"In 2021 we began to recover; '22 was a very good year [with orders for 11 FPSOs and FPUs combined]; '23 [and the foreseeable future] looks wonderful."

While the value of a single FPSO contract [$2.5-$3B] is astronomical in traditional commercial shipbuilding contract terms, McCaul noted that further growth in '22 was muted by a capacity problem – both in terms of human capital to effectively bid and manage a multi-billion, multi-year projects, plus a physical limitation in the num-

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ber of shipyards that have drydocks big enough to accommodate the units.

"There are only so many contractors that can take these orders, as first of all, the unit itself, the FPSO is complicated, and the new ones are very large," said McCaul, noting that when he started covering the market in the mid-1990s, 60,000 bpd output was typical, whereas the units coming online today are in the 250,000 bpd range.

This effectively raises the scale exponentially on revenue, but also on technical complexity.

"They [the oil majors] have difficulty getting people and companies to bid the contract. There's been a number of tenders that have been canceled because they haven't had enough bids. I think in 2022, the orders would've increased faster if capacity had been available."

… AND THEN THERE IS GAS …

The wildcard since Russia invaded Ukraine in early 2022 is gas, as Russia sought from the beginning to use energy security as a weapon across Europe, by curtailing and eventually shutting off the pipeline to the continent. Common logic suggested that an energy-starved Europe would cave on sanctions, particularly as the winter months came and energy prices soared.

But a funny thing happened: a warmer than usual winter (so far) conspired to help moderate gas prices, and Europe aggressively moved to bring LNG import facilities online to move its supplies from pipeline to ship delivery.

"The floating storage regasification unit (FSRU) business is booming, it's taking off like a bullet due to the Russian cut-off of pipeline gas to Europe," said McCaul. "[The Russian gas cut-off] threw Europe into crisis mode, and that crisis mode has European governance encouraging companies, if not to do it directly themselves, to have terminals where you can bring LNG into Europe. The whole slew of orders, since March 2022. They got them so quickly that it was unbelievable."

Citing a "tremendous increase in the need for LNG globally," McCaul expects many new FSRU orders globally in '23 and beyond. McCaul expects FSRU orders globally over the next few years to be very strong. All of the FSRUs that were being used temporarily for LNG transport were vacuumed up in Q2 after the Russian gas pipeline cutoff. "Supplying FSRUs is going to be a good business over the next five years. We see this as a tremendous market. But yard space for a newbuild FSRU will be a constraint. Yards are full of LNG carrier work and the queue for a new FSRU will be pretty long -- 2026+ to get delivery. But could be a great opportunity for LNG owners with older carriers that can be repurposed in a repair yard for terminal use."

O&G & ENERGY TRANSITION: IT'S COMPLICATED

As if the traditional market and geopolitical forces aren't detrimental enough to accurately predicting the speed, pace, and direction of oil and gas prices, enter a still rela-

© Elnur/AdobeStock

tively new force: energy transition.

The world, from governments to corporations to consumers, continues to push the envelope on the development and deployment of renewable energy, with the Wall Street Journal reporting recently that 10% of all motor vehicles sold in 2022 were electric.

That said, the world remains a solid generation or two away from a significant divorce from traditional fossil fuels, and as Russia's war in Ukraine has proven, energy security tops most countries' agendas.

"The transition, the talk of transition, the prospect of transition from fossil fuels does not exactly encourage companies to make the large investment in something that's going to be operating for 20-25 years," said McCaul.

"These projects, like the one that Exxon Mobil is doing Guyana, that's its fifth $12-13 billion project. It takes a bit of hope to invest in something that's going to cost $12 billion when everybody talks about getting rid of oil."

Ultimately though, it comes down to the balance sheet, and big oil lost a literal fortune and amassed considerable debt in the six years before 2021. Highly leveraged and unwilling – or unable– to reward shareholders with stock buybacks and dividends, fiscal discipline came into vogue, effectively muting investment in new tech and projects, said McCaul.

In step with the energy transition, legislators globally are ratcheting up pressure via environmental legislation which, at best, will increase the cost of the project; at worst, will delay, suspend or shut it down altogether.

This is happening right now in Australia, where the Barossa project is delayed. Late last year, the Australian court ruled against Santos, telling the company it had not consulted "all the indigenous people on the Tiwi Islands … for its environmental plan," Reuters reported.

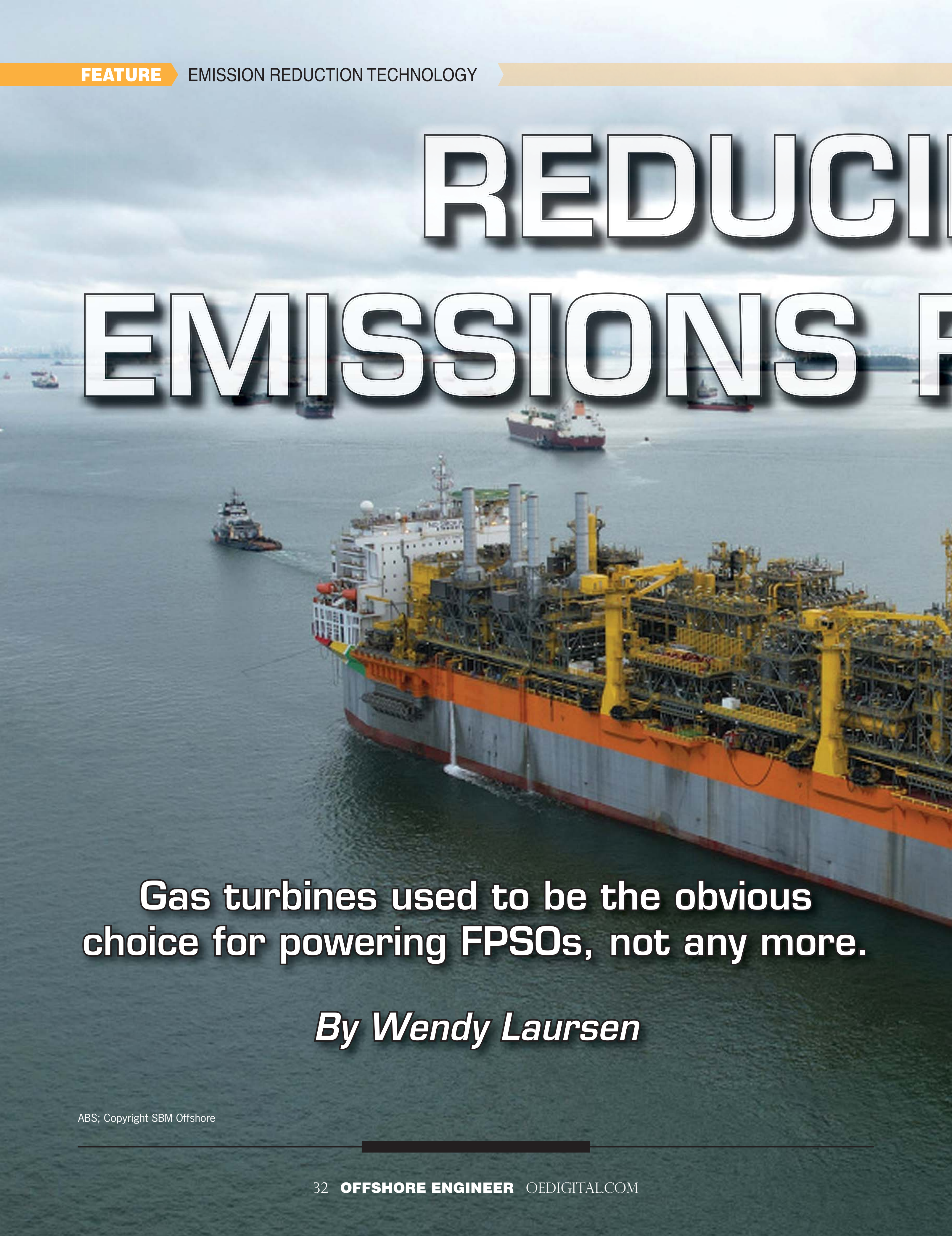
According to McCaul, delays like Barossa are unusual, for an offshore project to progress to this stage, then "out of the woodwork someone says it didn't pass all of the environmental tests. Then all of a sudden everything's back to zero," in terms of environmental approvals.

Regardless, Santos reported in December 2022 that it was applying for fresh approvals, and first gas remains on track for 1H '25.

All-in-all, McCaul is cautiously optimistic that, despite challenges, 2023 will end up being a solid year for floating production orders.

"We think maybe 15 could be ordered, but we don't think 15 will be ordered because [of the limiting factors on the contractor side]," McCaul summarized.

"Realistically, we're looking at about nine to 11 FPSOs and a couple of FPUs ordered in 2023," in addition to a few more FLNGs and a handful of new FSRUs if yard space is available."



REDUCI
EMISSIONS F

Gas turbines used to be the obvious choice for powering FPSOs, not any more.

By Wendy Laursen

ABS; Copyright SBM Offshore


NG CO2
FROM FPSOS
LIZA UNITY

Using gas turbines to power FPSOs has enabled the use of gas that would otherwise be flared, but they are inefficient by today's standards – having an energy conversion rate of around 25-30%, according to a 2022 ABS whitepaper.

ABS claimed an industry first in 2021 with the award of its Sustain-1 notation for an FPSO, ExxonMobil's Liza Unity, delivered by SBM Offshore, and it was a sign of things to come.

While combined cycle power generation offers a more efficient use of produced gas and heat generation than turbines, the industry's ambition to eliminate CO2 emissions has expanded attention to flare gas recovery, carbon capture from power generation, electrification, and digitalization.

There is no universal solution, says Mia Elg, R&D Manager at Deltamarin, a company that provides ship design, offshore engineering, and construction support for the marine and offshore industries. "For instance, there can be significant changes in oil and gas production during a field's lifetime. This influences power consumption and primary fuel availability. Production could be run using gas turbines burning the by-product gas, but the gas may not be available later. In this case, external fuel would be used, and each fuel requires different or very fuel-flexible machinery."

Gas turbines represent approximately 80% of CO2 emissions from offshore activities, and replacing them with electricity from renewable sources is receiving increased attention. Using shore power is an option for near-shore, and energy from offshore wind farms is an option for remote locations. Still, as Marie-Francoise Renard, Offshore Sales and Marketing Director, Bureau Veritas, says, this second option relies on weather and electricity storage solutions.

Alan Waters, Senior Manager Front End Brownfield UK at Aker Solutions, was involved in the evaluation of carbon capture versus electrification for an FPSO project last year. He says managing process heat is important. Many gas turbine power systems have waste heat recovery installed, and that heat source needs to be replaced. While there are promising technologies such as high voltage electrode boilers, the electrical demand would actually be higher if the power system is electrified.

The principal challenge for electrifying existing FPSOs is the need for high voltage slip rings on already congested turrets, or taking power from an over-the-side balcony; these can have fundamental constructability challenges.

"The power taken onboard needs to be stepped down to interface with the rest of the systems onboard, so a single transformer, or multiple smaller ones, will need to be installed. Here the economies of scale and available real estate start being problematic.

Often, the switchboard that they have to be interfaced with have limited cubicles and cabinets. These may have to be extended as well."

There are no technical showstoppers for system design but rather constructability challenges that influence the business case, he says. "We need to look at schemes, such as the use of a single power source across multiple fields, to support the business case challenges."

For Waters, subsea power systems rather than topside solutions, as Aker Solutions has already successfully demonstrated at Equinor's Åsgard field in the North Sea, or floating substations as developed for Chevron's Jansz-Io project in Western Australia, are technology game changers.

Compressors and water injection pumps are often the biggest topside power consumers, says

Christopher Bowles, Head of Sales Upstream Industries at MAN Energy Solutions, who also sees the value of subsea compression. He explains that MAN's subsea compressors at Åsgard are 11.5MW, but topside, the same function would require about 50MW.

MAN continues to boost the efficiency through improved impeller design and welcomes electrification. A recent delivery of electrically-powered compressor trains will include vapor recovery units to reduce the volume of gas flared.

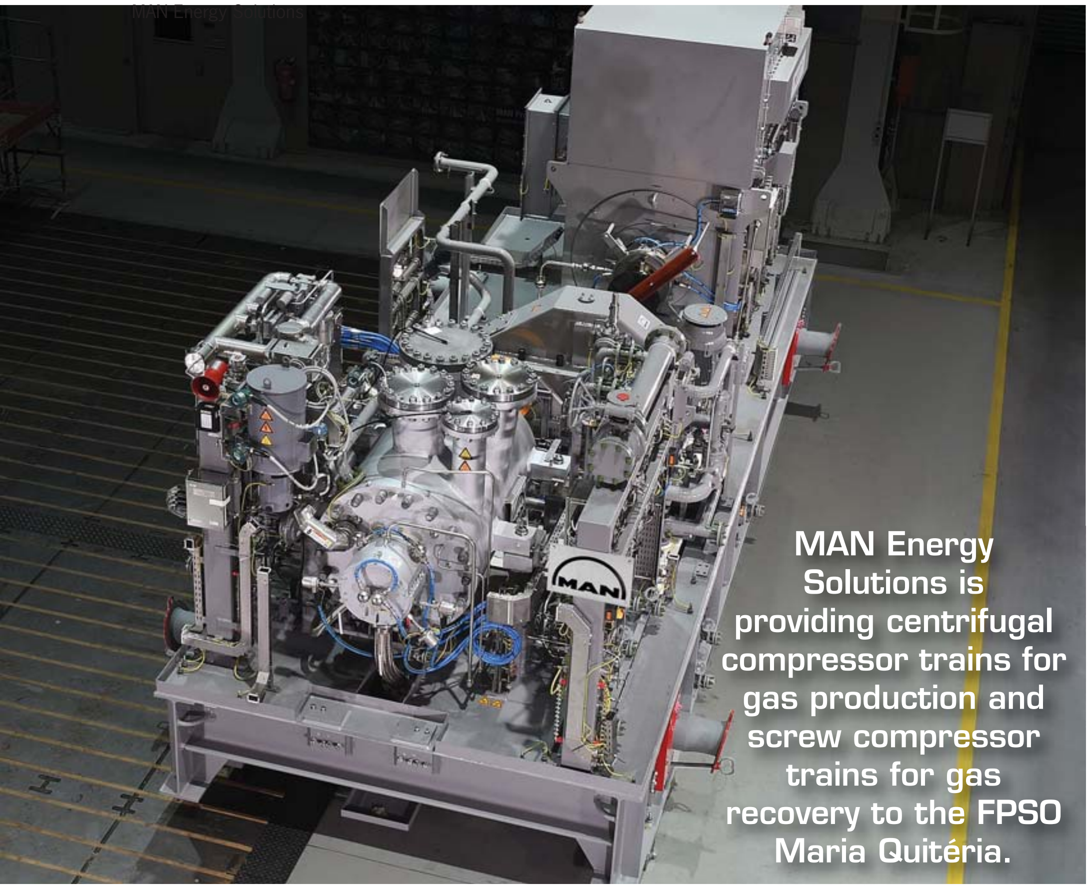
"The Electrical Module provides all the distributed energy to power the entire FPSO, in addition to housing equipment that controls the processes onboard the vessel, and that gives us an opportunity to help optimize power,

Aker Carbon Capture

DNV qualified Aker Carbon Capture's modular CO2 capture system in 2022.

FPSO Liza Unity

ABS; Copyright SBM Offshore



MAN Energy Solutions

MAN Energy Solutions is providing centrifugal compressor trains for gas production and screw compressor trains for gas recovery to the FPSO Maria Quitéria.

energy, and processes at a collaborative, system level."

He says measures like closed bus operation in the power network can support higher levels of efficiency and availability, as can energy storage and autonomous control systems.

Dave Waddington of GE Power Conversion is seeing increased adoption of electric motors in the compressor train. The company was recently awarded a contract to supply their FPSO Electrical Module for energy distribution on a deepwater FPSO.

Chris Ayres, Chief Customer Officer at OPEX, an ERM Group company, says digital technologies can deliver reductions of up to 7.5% in CO2 emissions. Bumi Armada recently selected OPEX's artificial intelligence (AI) technology to reduce CO2 emissions from the Armada Kraken FPSO.

"FPSOs have huge amounts of up-to-the-minute data coming from equipment and processes, all of which can be used to generate an operational emissions model that allows teams to focus on the root causes of emissions day to day."

A typical configuration which produces a fully customized, asset specific emissions model and up-to-the-minute AI-powered dynamic emissions target can be installed in eight weeks.

Digitalization addresses many aspects of an FPSO's operation, says Greg Trostel, Industry Development Manager, Rockwell Automation.

Examples include the use of digital technologies to: operate more closely to control limits, employ a predictive asset management strategy to avoid process upsets, predict and analyze flared emissions, and connect everything to everyone.

He says the industry should take a fresh look at its projects. "We have seen examples in the past of great design features being cut from projects to meet budgetary approval hurdles. This focus on the CAPEX portion of the project (typically 2-4 years and one-third of the total project cost), while important, needs to be balanced with more attention on the operations of the vessel (up to 25 years and two-thirds of the total project cost)."

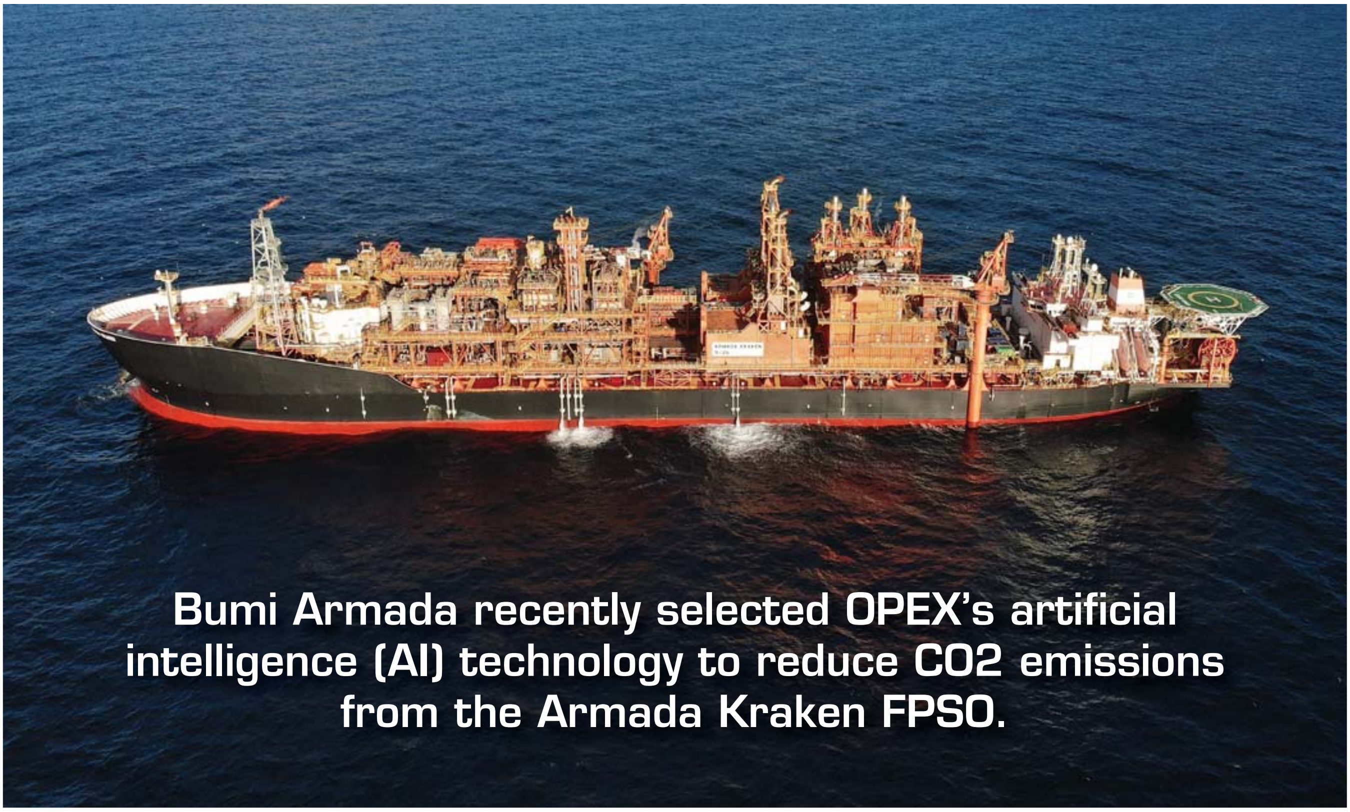
BW Offshore says case studies have shown that it's possible to integrate power generation carbon capture into a new FPSO-based field at an overall capture cost that is lower than the CO2 emission tax rate, and DNV-qualified Aker Carbon Capture's modular CO2 capture system in 2022.

SBM Offshore aims to have a near-zero emissions FPSO available by 2025, and the Mero field consortium in Brazil is developing subsea separation technology. With these developments, the industry pushes further forward on emissions reduction.


GE

GE Power Conversion's e-House electrical distribution module.


MAN Energy Solutions


Bumi Armada recently selected OPEX's artificial intelligence (AI) technology to reduce CO_2 emissions from the Armada Kraken FPSO.

OPEX

Horisont Energi:

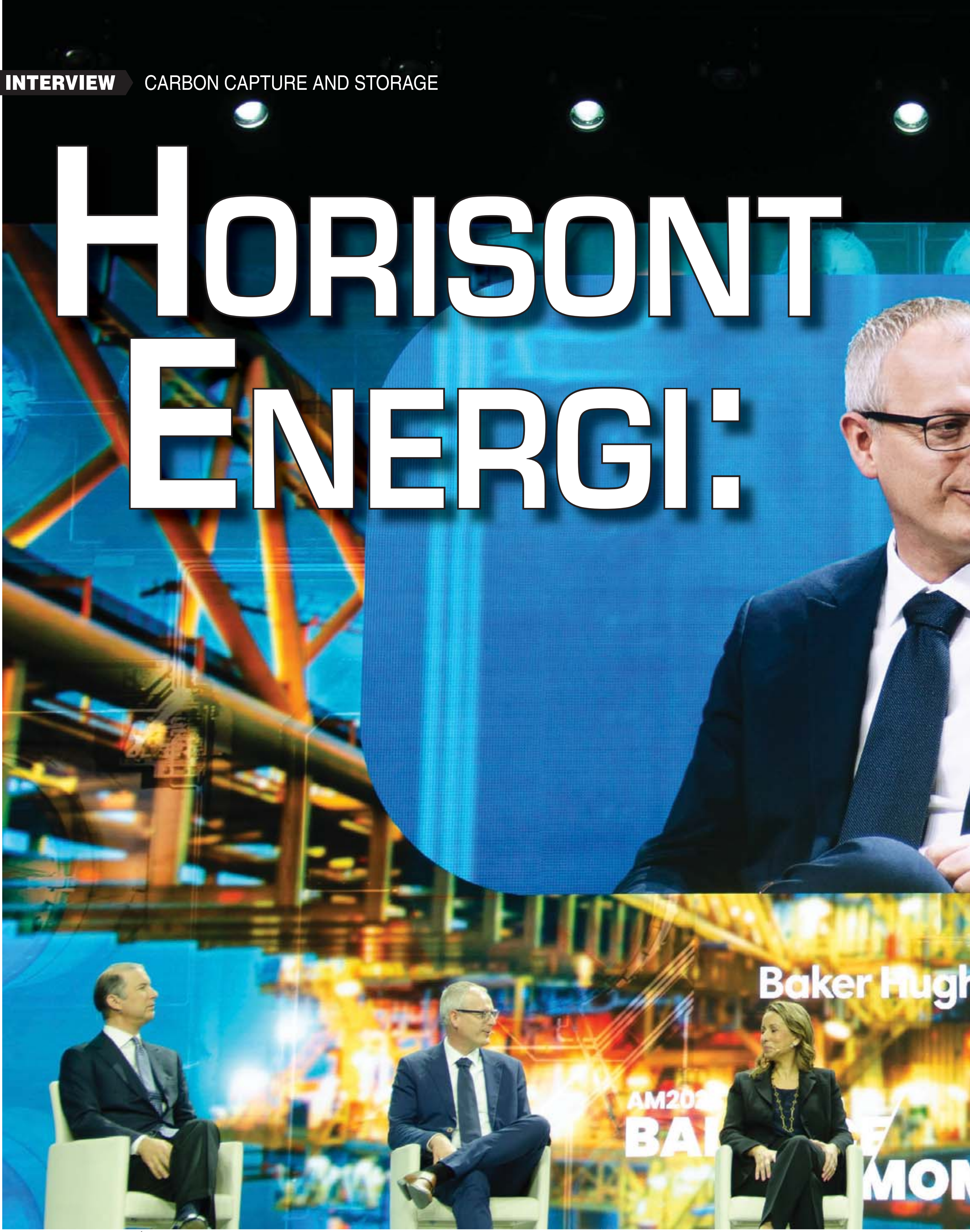
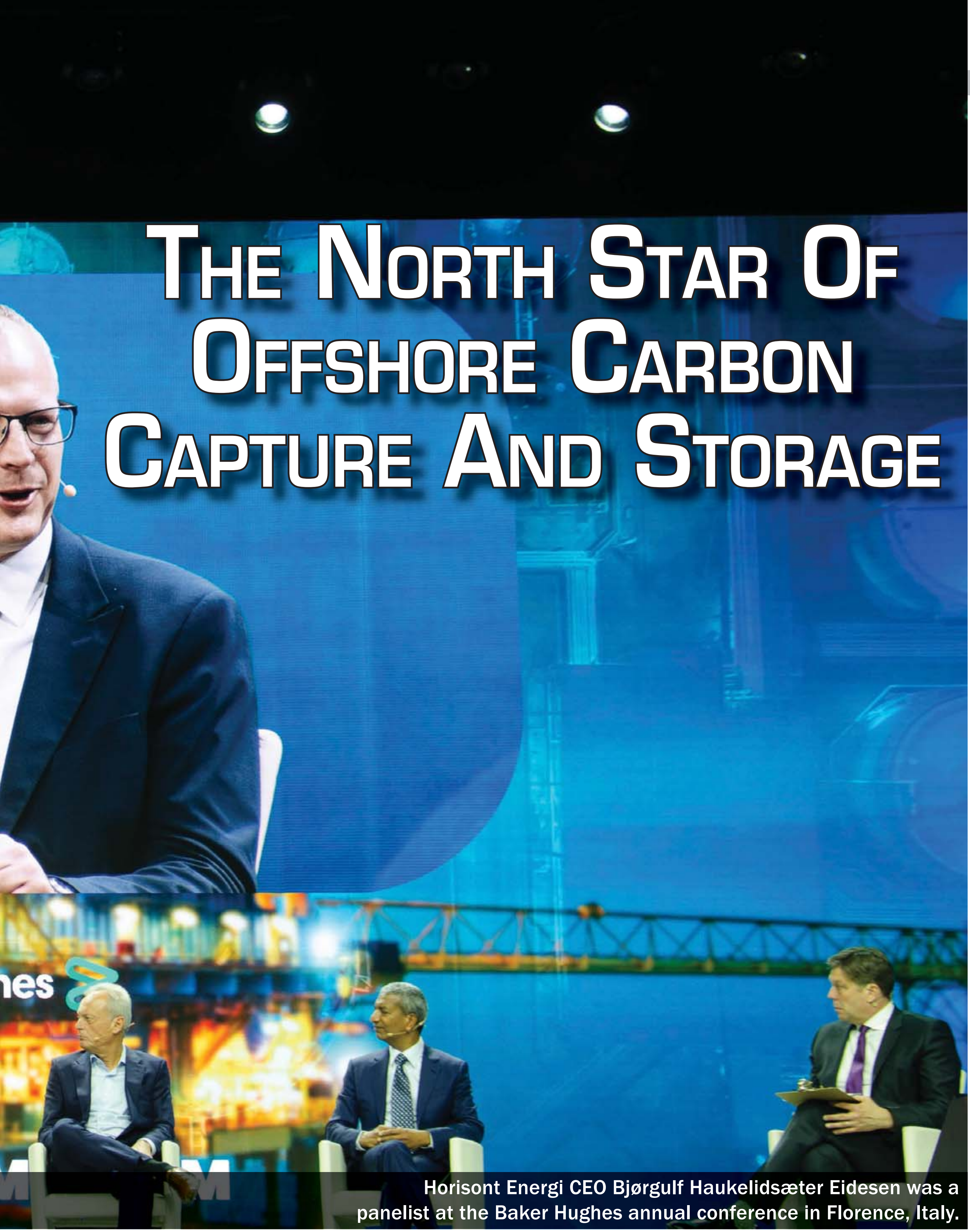


Photo by Bartolomej Tomić

The North Star Of Offshore Carbon Capture And Storage



Horisont Energi CEO Bjørgulf Haukelidsæter Eidesen was a panelist at the Baker Hughes annual conference in Florence, Italy.

Carbon capture and storage has been described as one of the critical technologies for slowing down global warming, and one company in Norway is set to act as the "North Star" and lead the way in this effort.

By Bartolomej Tomic, Managing Editor

Bjørgulf Haukelidsæter Eidesen established Horisont Energi in 2019, as he wanted to make something climate-positive at a large scale. The company discovered the Polaris reservoir in the Barent Sea, off northern Norway. It plans to use the offshore storage as a part of a larger Barents Blue project, which envisions converting gas on the Norwegian continental shelf into CO2-emission-free blue ammonia and storing the resulting CO2 under the seabed.

The plan had attracted the Norwegian majors Equinor and Vår Energi as potential gas suppliers for the project, with collaboration deals signed in 2021.

Apart from the Polaris Project, Horisont Energi is also working on another pure-play CO2 storage project in Norway, the Errai, in the North Sea. [**NOTE**: *Horisont Energi and Neptune have yet to obtain the rights to the Errai offshore site, but Eidesen remains confident it will get the deal done.*]

OE caught up with Eidesen on January 30, 2023, in Florence, Italy, on the sidelines of the Baker Hughes Annual Meeting.

In the conference's opening remarks, Baker Hughes CEO Lorenzo Simonelli said: "As we look at the future, there is no future where hydrocarbons don't play a role in the energy mix for the decades to come. Let's focus on [reducing] emissions, and not on the fuel source."

This, Eidesen believes, is an area where Horisont Energy can help.

In discussing Polaris, Eidesen said that the Norwegian Petroleum Directorate had scanned the entire shelf to determine which types and formations could be fit for CO2 storage. "We looked at their work and identified the Polaris structure," Eidesen says. He says that the Polaris is a " very nice structure," with all the things one could be looking for from a potential CO2 storage reservoir, including a nice cap rock, to ensure containment. The conservative estimate for the CO2 storage capacity of Polaris is "about 100 million tons," the equivalent to twice Norway's annual greenhouse gas emissions, "but could be much bigger," according to Eidesen. In order to verify the true capacity, the company needs to start filling the reservoir with CO2. The plan is to build the ammonia production plant on the coast in Norway's north near the Polaris reservoir and pump the CO2 into it via a pipeline.

Aquifers

Eidesen said that Polaris is an aquifer and not a depleted oil and gas reservoir. "Generally, in Norway, we say that potentially 30% to 40% of the carbon storage capacity of Europe is in the Norwegian continental shelf. It's a pretty large shelf." He said most of that storage capacity is in aquifers.

"Oil and gas fields, when, at some point, are all emptied, will represent maybe 3 to 5 billion tons of CO2 storage capacity. But the total estimated capacity by the Norwegian Petroleum Directorate is about 80 billion tons," Eidesen said.

He said that Polaris has been estimated to have "about 100 million tons of CO2 storage capacity ... but we expect it to be much bigger than that. "To prove that the reservoir is bigger, the company needs to start filling it up

Did you know?

Both projects - Polaris and Errai - are named after a "North Star." The current North Star is called Polaris, and the Errai will succeed the Polaris as the Earth's northern pole star in a couple of thousand years.

with CO_2, and with that the plan is to build a plant on the coast in Norway's north near the offshore reservoir and pump the CO_2 via a pipeline into the reservoir.

Once the project comes closer to reality, the plan is to have separate entities for ammonia production and for CO_2 storage, with the company expected to receive income streams from both.

The company is hoping that some of the Norwegian offshore gas fields in the vicinity of the future ammonia plant in Finnmark, in northern Norway, could provide feedstock for the plant.

Specifically, the plan is for the onshore facility to convert natural gas from the Barents South region to carbon-neutral blue ammonia (99% CO_2 capture rate), dubbed an easily transportable hydrogen carrier.

The produced blue ammonia can then be used directly as ammonia, but can also be converted to hydrogen at the destination. Horisont has said that the plant is planned to have a production capacity of 3000 tons of ammonia per day “making it one of the largest ammonia plants in the world.“

Vår Energi & Equinor Pull Out; Fertiberia is 'In'

Back in December 2021, announcing the pact with Vår Energi and Equinor for the Polaris CO_2 storage development, Horisont Energi said that an investment decision for Polaris and the Barents Blue project was expected to be reached around year-end 2022.

However, on the morning on February 1, 2023, a day after our interview with Eidesen in Italy, Equinor and Vår Energi issued press releases announcing their withdrawal from the project. Simultaneously, Horisont Energi issued a statement welcoming a new partner to the project: Spanish ammonia producer Fertiberia.

While some described the withdrawal of Vår Energi and Equinor as a setback for the project, Equinor said it was still “positive“ about finding ways to get gas from Hammerfest LNG to the Barents Blue project.

Vår Energi, which had planned to export gas resources discovered in Alke and Goliat fields, west of Hammerfest, via a tie-in to the Barents Blue project, said it would seek other solutions, as “development of the proven resources in the region, including Goliat, Alke and Lupa, will require an export solution with greater capacity than what we deem realistic within the scope of the [Barents Blue] project.“

In a statement announcing the partnership changes, Eidesen praised Vår Energi and Equinor for having been “instrumental in maturing the project in the development phase ending January 31.“

Horisont Energi also said it would invite new partners into the Polaris CO_2 storage license, including a qualified operator. “A new license group will bring the project forward to a submission of plan for development. The changes in the license group will be coordinated with relevant authorities," the company said on February 1.

Why pay to store CO2?

In the current political climate, multiple industries face escalating costs for carbon emissions, so securing CO_2 storage at fixed costs is a hedge.

“In the current European industrial system, you have a mechanism for pricing CO_2 emissions,“ said Eidesen. “We have the Emission Trading System (ETS) which imposes a fee for emitting CO_2,“ a price which currently has been between 80 and 100 euros per ton of CO_2.

Eidesen said the price is forecast to be between 150- 170 euros per ton of CO_2 in 2030. “So you can say this represents a financial risk to emitters of CO_2, that they cannot control what the cost will be.“

According to Eidesen, storing CO_2 in, say, Errai, puts a cap on how high the price can go, providing some degree of financial certainty.

In addition to cost, Eidesen said there are other drivers. “Other customers are motivated by the fact that they want to deliver carbon-neutral products to their customers. Their customers demand decarbonized value chains. They can get more value for the product if it's decarbonized.“

In November 2022, Horisont Energi also signed a letter of intent with E.ON, for the latter to store more than one million of CO_2 a year from its European customer sites. This would take effect starting from 2027, with gradual increase. Horisont Energi will provide services on CO_2 marine transport and long-term storage.

Horisont Energi plans to store four to eight million tons of CO_2 annually in the first development phase of the Errai project, potentially storing more in later phases.

Asked about the Errai capacity, Eidesen said “We have estimated the P90 to 185 million tons of storage capacity. So it's bigger than Polaris in the respective case for the P90.“

Horisont Energi in January signed an option agreement with Haugaland Næringspark to locate the land- based CO_2 terminal for the Errai carbon capture and storage project to Gismarvik in Rogaland, where Haugaland Næringspark has one of Norway’s largest industrial areas. The CO_2 terminal will receive CO_2 from European and Norwegian customers, including the planned CO_2 terminal in the Port of Rotterdam.

Photo by Bartolomej Tomić

We have the Emission Trading System (ETS) which imposes a fee for emitting CO2 [a price which currently has been between 80 and 100 euros per ton of CO2. The price is forecast to be between 150-170 euros per ton of CO2 in 2030.] This represents a financial risk to emitters of CO2.

Horisont Energi CEO
Bjørgulf Haukelidsæter Eidesen,
in discussing the business case for CO2 storage.

RETROFITS COULD OFFSHORE WIND

Bernhard Schulte Offshore /Matthias Giebichenstein

ACCELERATE U.S.
DEVELOPMENT

The US Administration's strategy to fast-track offshore wind development is exciting for overseas shipbuilders and service providers in the field. Joint ventures meeting Jones Act requirements will support accelerating development. Some question, however, whether ambitious 2030 targets can actually be achieved.

By Paul Bartlett

Ulstein group is a front runner. The Norwegian-based company has already provided the design for a rock installation vessel now under construction for a joint venture between Houston-based Great Lakes Dredge & Dock (GLDD) and Netherlands based Van Oord. Now being built at Philly Shipyard and due for delivery in first half of 2024, the ship will be the first Jones Act-compliant offshore wind support vessel to be built in the US. It will be deployed on the Empire I and II wind farms off the coast of New York.

Lars Ståle Skoge is Commercial Director at Ulstein Design & Solutions AS. "There is a great potential for European companies like Ulstein to contribute to develop the offshore wind market in the US, and get a quick start based on the learnings from the European offshore wind industry," he told Offshore Engineer.

His Rotterdam-based colleague, Nick Wessels, outlines the company's strategy of diversification. Ulstein is offering a wide range of offshore wind designs for different tasks, he reveals, but it is also offering scope to upgrade existing vessels.

"We have several designs available that are suitable for US operations," he explains. "These include feeder jack-up installation vessels, feeder transport units to ship foundations and turbine components to jack-up vessels, and heavy-lift foundation installation ships." The designs can all be customized to meet specific clients' requirements.

Head start

It is no secret that Ulstein is in discussion with various offshore wind companies in the US but company executives cannot reveal more details. Wessels says that the selection of an Ulstein design by GLDD provides a head start. The US company required a Jones Act compliant, dynamically positioned vessel that could be constructed in a US shipyard to undertake scour protection on offshore wind foundations.

There are specific requirements for vessels to be deployed in the US. Apart from the Jones Act itself, ships designed for US deployments must also meet US Coast Guard requirements. And, depending on customer and shipyard, designing in imperial units may be a significant plus point, Wessels reveals.

"Typically, we see that build time in the US is longer than in Europe, for example, and we constantly evaluate the possibilities and the best project approach," he explains. "Our Dutch design office typically works on one-off designs that are fully tailored to client specific requirements. We prefer to work with the shipowner for the concept and basic design as they know what they want to do with the vessel in terms of operation.

"It allows the shipowner to tender with several shipyards," he continues. "After that, we are happy to support either the selected shipyard in the actual building of the vessel if so desired or to keep supporting the shipowner's newbuilding team."

The opportunity to upgrade or convert existing offshore vessels could provide a fast track. Ulstein has completed a number of conversion projects including the two PX121 platform supply vessels, Esvagt Leah and Esvagt Heidi. Both ships, originally built at Ulstein Verft, returned there in 2021 to be upgraded with more environmentally friendly power systems and converted into emergency response

Martin Sundgot Hansen
sales manager
aftermarket Ulstein Verft

Photo courtesy Ulstein Verft

Representatives from Olympic and Ulstein Verft in the Ulstein Verft dock hall

Photo courtesy Per Eide Studio/Ulstein

and rescue vessels.

Another more extensive upgrade is currently in progress in Ulsteinvik. The shipyard is currently engaged in the upgrading of the Service Operation Vessel (SOV), Windea Leibniz, built in 2017, which features a TWIN X-STERN. This unique Ulstein hull form provides the vessel, managed by Bernhard Schulte Offshore, with significantly better seakeeping qualities, widening the weather window.

The SOV has already worked successfully for Siemens Gamesa on the Sandbank and DanTysk wind farms in the German North Sea. But her operational window will now be significantly increased by a series of modifications. These include the recently completed installation of an adjustable pedestal for the gangway and a 50% increase in single cabins for charterers, providing accommodation for 60 persons. This will mean a change in the vessel's status from SOV to Construction SOV (CSOV).

In another upgrade, early in 2022, Norway's Norside Wind AS opted to convert the platform supply vessel, Farland, into a walk-to-work vessel for the offshore wind sector. The vessel, of Ulstein PX121 design, has been equipped with a motion-compensated gangway, an Access & Cargo Tower, a new accommodation module, and a battery package. The converted vessel will now operate under the name Norside Cetus.

Illustrations courtesy Ulstein

All images courtesy Nauticus

AQUANAUTS, HYDRONAUTS, ROLL OUT!

*Houston-based Nauticus Robotics' first production Aquanauts and Hydronauts will head into the wild and closer to full commercialization this year, with testing planned in Norway and in the Gulf of Mexico. Elaine Maslin caught up with founder and **CEO Nicolaus Radford** on what's been a busy few years for the tech start-up.*

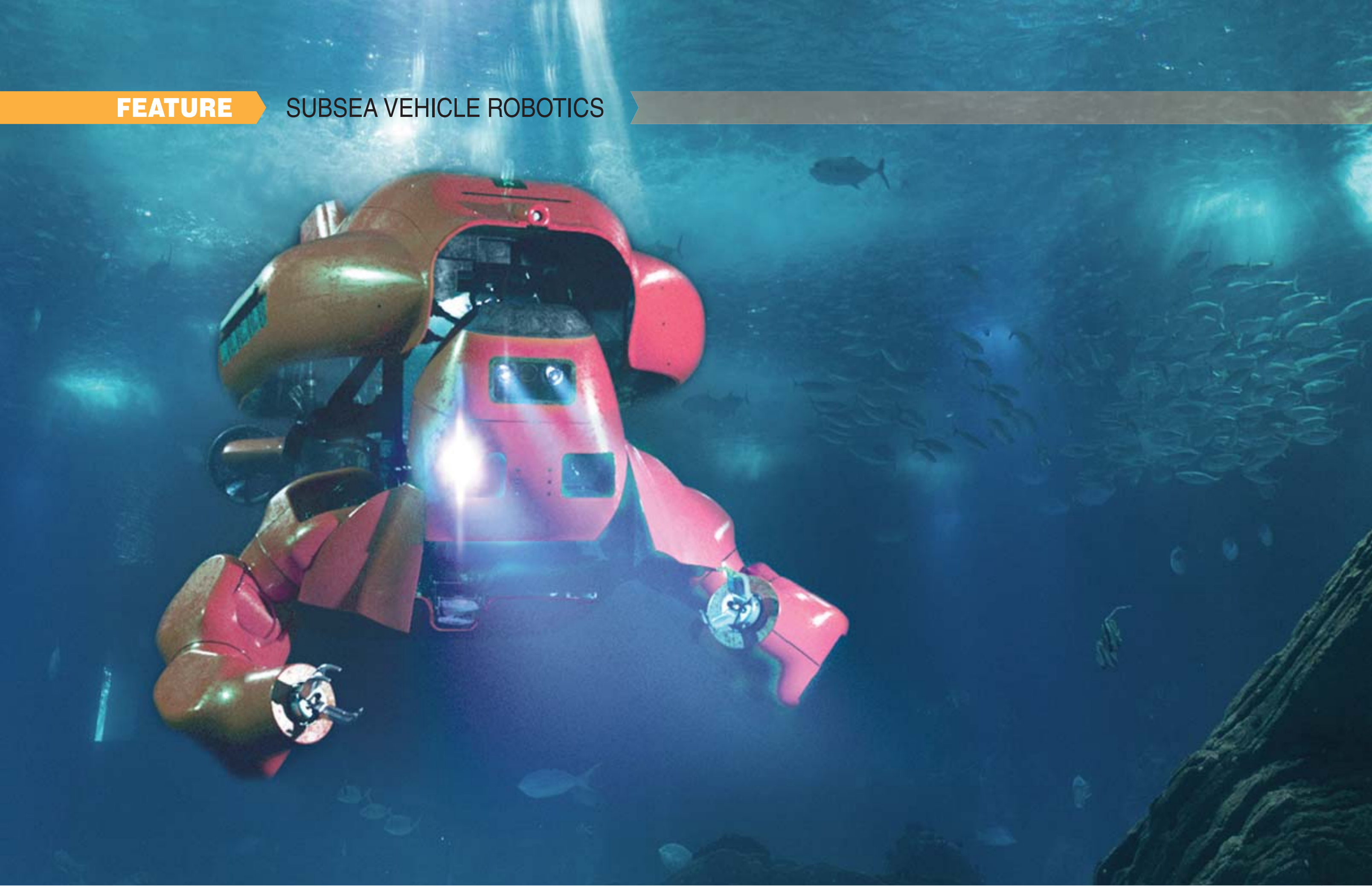
It's been a relatively fast journey for Nauticus. Set up in 2014 (as Houston Mechatronics Inc), the company has been a bit of an outsider in the offshore industry, against incumbents offering (for the most part) more traditional looking underwater robotic systems.

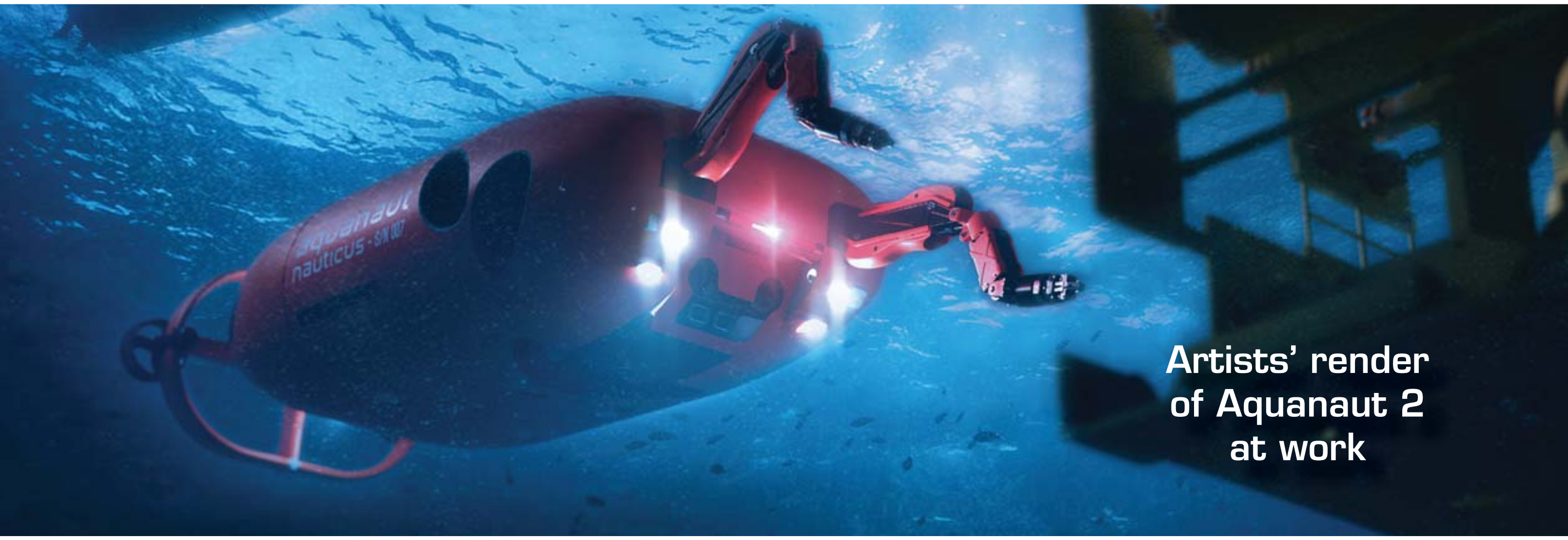
However, the third quarter of 2022 saw the company (whose investors include Schlumberger (SLB) and Transocean) complete a business combination with CleanTech Acquisition Corp., netting it nearly $60 million to fund its first fleet of ocean robots; list on the Nasdaq exchange; agree a trial with energy giant Shell; win a contract with the U.S. Defense Innovation Unit; and agree a defense related partnership with tech giant Leidos.

It now has three of its second-generation Aquanauts in build in Vancouver, which will be used on trials in the Gulf of Mexico and offshore Norway, and two Hydronaut uncrewed surface vessels (USVs), which will act as launch and recovery systems and surface gateways to Aquanauts, in-build in the UK.

CEO Nicolaus (Nic) Radford, who set up the firm in his living room eight years ago, doesn't hold back his ambition. Innovation has been "mind numbingly slow" in the offshore industry, he says. Part of Nauticus' ambition is to "put an adrenaline shot" into it, by taking robotics technology developed for space flight into the ocean.

"My dream is to have a network of Aquanauts and Hydronauts out there working, a whole Navy of them, being





Artists' render of Aquanaut 2 at work

My dream is to have a network of Aquanauts and Hydronauts out there working, a whole Navy of them, being controlled by control centers around the world, out there 24/7 doing their thing. That's the core of the business. There's an ocean of opportunity.

Nicolaus Radford, Founder and CEO, Nauticus Robotics

controlled by control centers around the world, out there 24/7 doing their thing. That's the core of the business. There's an ocean of opportunity to take advantage of," he says, from fisheries to countering global security threats, which have heightened recently, with increased underwater surveillance to protect critical infrastructure, such as pipelines and communications cables.

"I'm fired up as you can as you can possibly get about this industry and I think there's so many different facets to move into," he says. "Frankly, it's huge. It's enormous, it's completely front and center right now. It's the epicenter for all of our resources, right? Food, minerals, energy."

That adds up to an estimated $2.5 trillion marine economy, of which some $30 million could be addressable the types of ocean robotics it's building, according to Nauticus.

Born in Illinois, Radford graduated with a Bachelor of Science in electrical and computer engineering then joined NASA's Johnson Space Centre and pretty much went straight into robotics, including DARPA sponsored programs, before moving to Houston, working with United Space Alliance and then Oceaneering Space Systems as a contractor to NASA, again in robotics.

"At NASA I learned a ton of stuff, but uncovered this idea that there was meaningful change to be made in the ocean domain," he says. "I had had some exposure to the ocean world before and remember the first time I saw an ROV I was like, OK, that's cute, but we can do so much better. Then you realize they don't want to do any better."

Artists' render of Hydronaut

A part of the problem is incentives and the ability to disrupt. "Some of the big incumbent players have very successful businesses, but it ties them to certain incentive structures," he says. "When you're paid by the hour, you do not want fewer hours. So, Schlumberger (who he'd worked with at NASA) sort of challenged me, what would you do about this? I said we need to create a hybrid vehicle. We need to be able to have an AUV turn into an ROV, because we actually don't need an umbilical. It was a flash in the pan idea, and so you know we garnered some investment."

Radford had also been working with Transocean on some drilling software and they were interested in the idea too; so they had their first investors. Since then, US government contracts, from the Navy, especially, have been a strong driver. It's meant that, over the past four years, Nauticus has developed and tested a significant amount of technology – most of which they've not been able to publicize, says Radford.

"My proudest moment was when we did a fully autonomous demonstration and I was taken to the side by our customer and they basically said 'that was the most advanced stuff they'd ever seen'. We essentially had an autonomous mission that occurred over about 20 minutes of action where the robot was able to pick up a tool, assess it, figure out a way to operate it, figure out a way where that tool could be operated on. We just put the robot in the water, we hit the on switch and sat watching with cups of coffee and it worked. We were almost crying! It was incredible." That was two years ago in a test tank environment – they've not been able to share the video, he says.

Since then, testing has been in the real-world, including Lake Travis in Austin, but also coastal areas. "We have some milestones coming up which will stress that (capability proven two years ago) probably by a factor of 10," says Radford. The Aquanauts are also getting closer to commercial work. Three (second generation) production Aquanauts are in build at International Submarine Engineering in Vancouver. A couple of them are due to head to the Tau Autonomy Center in Norway to qualify "certain actions" for a couple customers. One will be doing some pilot work in the Gulf of Mexico in mid-2023.

They'll go out with a lot of autonomous capability under their belts, says Radford. "That work (with the US Navy) has meant being able to build up thousands of kilometers and hours of dive time on their autonomy software," says Radford. It's also meant building a commercial and defense variants of Aquanaut. "Those two platforms are in the water every single day, diving, collecting data, building out behaviors, to deploy to the production systems, so we don't have to wait till they come up the assembly line to build out their usable action. It's a library we've been building for years now."

The offshore pilot with Shell, planned for mid-2023, will focus specifically on testing Aquanaut's ability to deploy a robotic tool, for carrying out inspections on pipelines. Currently, this tool can only otherwise be placed with an ROV, for which a fully crewed ROV vessel is needed, which "would be overkill" for the work it's doing. Part of the qualification work for this tool deployment includes supervised autonomy and tool control using Nauticus' acoustic communication networking technology.

This is wrapped in with wider over the horizon communications – terrestrial and underwater – to support the ability to operate without an umbilical. While satellite communications are there, the rollout of the likes of Starlink will provide more inexpensive ways to transmit more data to the surface, says Radford. For through-water communications, Nauticus has been working with Schlumberger, from whom Nauticus has licensed use of an underwater modem previously tested from a DriX USV to receive video from an AUV. It's also been work with Singapore-based Subnero.

Subnero has been developing software defined underwater acoustic modems for communications, networking, navigation and monitoring, which it calls Wireless Networked Communications (WNC). Recent testing with Nauticus has included the ability of their WNC to dynamically adapt to provide the best performance in a given environment.

Concurrently, Nauticus is building, through Diverse Marine in Cowes, UK, an 18 m, aluminum-hulled, SMART-Gyro (from Golden Arrow) stabilized USVs called Hydronaut, which will act as a transport, recharge and communication gateway for Aquanaut. Nauticus has an agreement with Diverse to build 20 Hydronauts, with the first two initially scheduled for completion in Q1 and Q2 2023. The rest are expected to include Jones Act compliant builds via Diverse Marine's USA-based shipyard partners.

Saab Seaeye eWROV
©Saab Seaeye

THE RISE OF ELECTRIC WORK CLASS ROVs

In this article, we look closely at the latest developments in the work class ROV space. Based on what we've gathered, the future is increasingly electric.

By Bartolomej Tomic, Managing Editor

©Saab Seaeye

Seaeye eM1-7 manipulator

Saab Seaeye eWROV

If you're a regular Offshore Engineer/OEDigital.com reader, Saab Seaeye is a company requiring no introduction. Saab Seaeye's vision of an all-electric future for underwater robotics led it to pioneer a wide range of systems that include powerful work robots such as the Seaeye Panther, Seaeye Leopard, and now its new, full-size work class vehicle, the Seaeye eWROV, along with an all-electric work-class electric manipulator.

"As the world's largest manufacturer of electric underwater vehicles, Saab Seaeye sees a future where electric robotics perform all tasks in the underwater domain, including those currently undertaken by hydraulic systems," Saab Seaeye told Offshore Engineer.

"It was the Seaeye Panther and Leopard that opened the market for electric work systems that could carry out a significant amount of tasks traditionally undertaken by hydraulic systems, yet offer greater precision and reliability - and are an environmentally responsible alternative," the company said.

According to the comapny, compared to a hydraulic ROV, the 3000-meter rated Leopard is typically 50% more efficient, 30% more compact, and 50% lighter, boasting unrivalled power-to-weight ratio.

"Indeed, it is the most powerful electric robot of its size in the world," the company says.

According to Saab Seaeye, operators of Panther and Leopard benefit from smaller umbilical cables and handling systems, smaller deck load requirements, smaller deck footprint, smaller vessel requirements and smaller transportation and mobilization needs, reducing operating costs considerably.

"They are easier to operate and maintain, more agile and responsive, acoustically quieter and more eco-friendly. The success of all Seaeye work systems sees them deployed globally for a wide range of work tasks, that can include survey, IMR, construction, drill support and decommissioning," Saab Seaeye said.

Saab Seaeye has recently developed a new system; the powerful electric work class Seaeye eWROV with an overall power and performance that exceeds that of a typical 250 HP vehicle.

In addition to what the company says are "significant advantages of electric over hydraulic the new Seaeye eWROV offers other key benefits.

Saab Seaeye says that the eWROV has been designed for onshore control for resident or unmanned vessel operations and will play an important role in future autonomous vessel fleets that will empower progress towards a sustainable future.

Designed to remain at sea for long durations eWROV can operate in either manual mode or supervised autonomous mode with human oversight and incorporates upgrading capability for increasing levels of autonomy and automation as technology evolves over time, Saab Seaeye explains.

The also stresses that electrification improves reliability and increases the mean time between failures (MTBF) thereby increasing levels of persistence and ultimately lower through-life operating costs.

"At the core of Saab Seaeye's future-flexible robotics vision is their intelligent distributed control architecture that enables easier adoption of evolving technologies," the company says.

During operation, the vehicles provide the operator and pilot clear and enhanced information while independently

©Saipem

©Saipem

managing each device on the vehicle, including auto redundancy to keep the vehicle working even with multiple equipment damage.

Also, Saab Seaeye says eWROV has been designed with eco-responsibility in mind, with a significant reduction in carbon emissions.

Its greater efficiency and a need for less energy, results in a significant decrease in CO2 emissions overall which, combined with an electric system that has minimal oil volume, makes eWROV a significantly environmentally friendly option," the company said.

Furthermore, the eWROV is fitted with two Seaeye eM1-7 seven-function all-electric work class manipulators.

The company says the manipulators are as powerful as a hydraulic equivalent, but more reliable and dexterous with millimeter precision and "extremely accurate" force and position feedback with each joint having its own intelligent microprocessor for intuitive and precise arm control.

Saab Seaeye said that the future would see significant growth in onshore controlled operations with vehicles de-

Images: ©SMD

Quantum WROV operated by Oceanica offshore

Quantum WROV over SMD workshop test tank

Atom WROV and LARS in SMD workshop

Quantum EV

ployed from subsea docking stations, or lightly manned, or unmanned vessels, where reliability and reduced maintenance will require all-electric robots for long-term deployment underwater.

"This requires increasingly intelligent robotic systems offering ever higher levels of operational capability, reliability and maintainability.

Saipem's Hydrones

Italian company Saipem is known mostly for its large offshore construction and decommissioning vessels, pipelayers, drilling rig services, as well as for the construction of offshore production facilities. But it also develops ROVs and subsea drones.

In 2017, Saipem resolved to invest into a new generation of subsea robotics solutions and developed a program to enable new ROVs for subsea inspection and intervention.

Come late 2021, the first intervention drone, named Hydrone-R, was fully qualified and ready to go on a ten-years contract for a major operator offshore Norway.

Saipem is not resting on its laurels and is working on the next frontier of all-electric WROV, called Hydrone-W which combines high power, high efficiency, and unique capabilities as to station keeping and manipulation. This is planned to be commercialized late this year.

Hydrone-W is an all-electric Work Class ROV capable of working as a subsea resident vehicle tethered to a subsea base as well as in traditional ROV mode.

It is designed to be fully remotely controlled from the topside offshore or from an onshore control center. The Hydrone-W may also support the subsea construction activities carrying out tasks relating to construction, pre-commissioning, and commissioning of underwater infrastructures.

Hydrone-W is a 180 kW ROV said to be able to perform under the most difficult conditions. This ROV is also said to be equipped with a "revolutionary" propulsion and power management system to reduce energy consumption during operations.

It can be configured according to customers' requirements with bespoke accessory instruments and functions.

Main Characteristics: All-electric WROV (Work-Class Remotely Operated Vehicle), 3,000 mwd rated, full DP, 175 kW, heavy-duty, capable of interfacing & handling 2-tonne skids.

In 2019 the company secured a 10-year contract with Equinor for the use of Hydrone-R and Hydrone-W in the Njord Field development.

The scope of work encompasses ROV and UID services to support drilling activities, as well as the entire plan of inspections and interventions on the Njord subsea assets (such as Pipeline End Manifolds (PLEMs), flowlines, umbilicals, and riser bases, etc.).

Control of Hydrone-R and Hydrone-W will be ensured from both the floating platform Njord-A, which recently returned to its offshore location after an onshore revamp, and from shore via Sonsub's proprietary remote-control technologies.

Hydrones are designed, created, and developed by Sonsub, Saipem's subsea technology and equipment development center. Worth noting, Sonsub is understood to be working on the qualification of new materials and components in order to extend operability down to 6,000-m water depth.

SMD – Quantum EV and Atom EV ROVs

SMD is a subsea technology company that has been developing work-class ROVs for over three decades.

For 2023, the company's latest products are the electric Quantum EV and Atom EV ROVs which are more compact than previous generations, help reduce CO_2 emissions, and can even operate autonomously when equipped for that.

According to SMD, Quantum EV is a 270hp heavy construction vehicle with a high payload and powerful thrust output. Atom EV is a 130hp light construction vehicle suited to shallow-water, high-current work in offshore renewables.

"Both vehicles are more compact than previous generations, so they will fit on smaller vessels or uncrewed surface vessels to help reduce CO_2 and cut client costs," SMD said. SMD says the new electric vehicle range is bristling with new tech, and tech with a purpose, at that. The ROVs feature a new DC power transmission system that is said to be far more efficient and environmentally friendly than previous generations. Further, the ROVs employ advanced flight control computers to help do operations faster and maintain control in arduous conditions – such as high currents, SMD explains.

The flight control system can also link to other SMART systems unlocking autonomous functionality. They use unique electric propulsion technology that offers extreme performance in fast-moving water but not at the expense of fine control. "All this adds up to a range that can work where current generation vehicles can't, that opens up the operating weather window and delivers higher quality results. All while being more environmentally friendly," SMD says.

Looking to the future of work class ROVs, SMD said: "Work Class ROVs are a multipurpose tool. And as with any tool there is always a focus on how well it does the job, its reliability, and its dependability. But the offshore energy mix is changing. And we are also seeing changes to the way people work (and go to sea) with much more emphasis on work-life balance and the environment. So the robotic tools that construct and maintain energy infrastructure need to evolve.

"In the future, the tools we today call Work Class ROVs will need to be suitable for uncrewed vessel and resident work, we may see less cabled connections to the surface and onboard power systems, we will probably see AI start performing tasks, with a move from person in loop to person on loop – command to control. It will be easier and faster to undertake tasks and see the results - with real-time information at the fingertips of stakeholders anywhere in the world."

SIMOPS & Platform De

Well-Safe Solutions

k The Schooner ecommissioning

A summary of the operational benefits of SIMOPS – as seen during the Schooner platform decommissioning campaign.

By Drew Duncan, Senior Well Abandonment Engineer, Well-Safe Solutions

Simultaneous Operations (SIMOPS) are multiple activities carried out at the same time in a single location, often in close proximity to one another. The risks of SIMOPS working on a live marine asset, often in a small workspace, requires careful mitigation so that personnel and assets are kept safe.

The Schooner platform, operated by Norwegian operator DNO, is located in the Southern Basin of the UKCS. A twelve-slot Normally Unmanned Installation (NUI), 10 of the 12 slots have wells still open to the reservoir. One slot has a previously abandoned well and the last remains empty.

In typical scenarios, wells are abandoned sequentially, with wireline-based intervention carried out to install barriers and remove any hydrocarbons present in the wellbore (stage AB0). The tubing is then removed with the BOP installed, with abandonment barriers set in place (stages AB1 and AB2). Conductor cutting and recovery is then generally performed as a batch operation as part of stage AB3.

Digital Slickline Operations

Well-Safe Solutions proposed a program of SIMOPS batch digital slickline operations to significantly improve operational efficiency and reduce the total cost of abandonment. This enabled eight of the 11 wells to be entered and abandoned to AB0 status, with two digital slickline units operated at the same time. One unit worked from the drill floor through a high-pressure wireline riser, while the second carried out operations from the Schooner platform's weather deck.

Due to the tight space constraints of the weather deck, Well-Safe's engineering team led the design, fabrication and installation of moveable beams installed below the drill floor, which supported the lubricator above multiple well slots and maximized the length of lubricator available for maximum toolstring length.

An unusual challenge in this scope was the discovery that one of the wells contained 14,000 ft. of slickline above a toolstring; present since 2006 when previous attempts at fishing had been unsuccessful. Peak mobilized their heavy-duty fishing system, with approximately 11,575 ft. of wire successfully removed over 24 runs. This successfully cleared the tubing and allowed access for the deep-set plug.

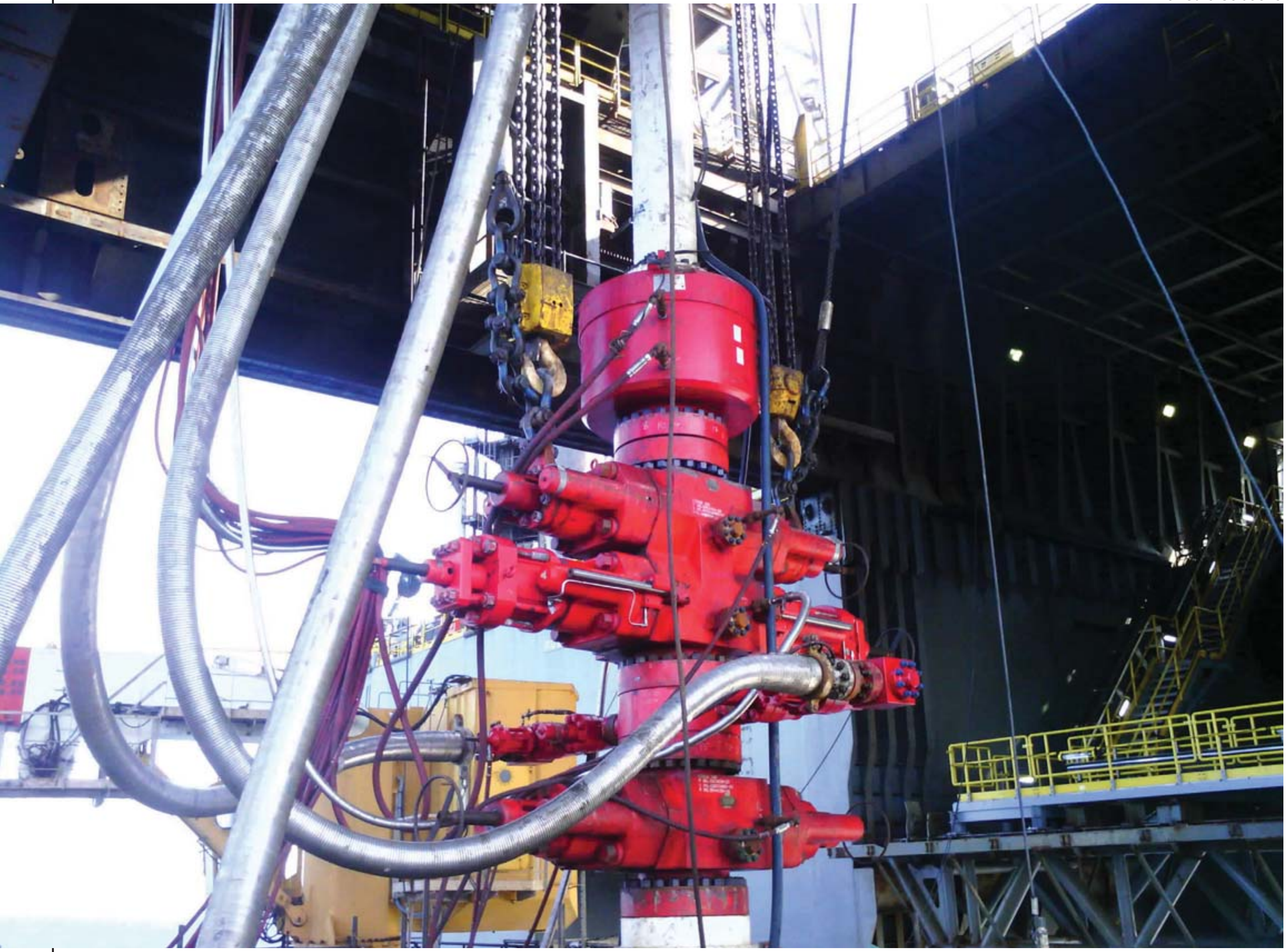
As we weren't sure exactly how long it would take for the execution of fishing operations, our digital slickline SIMOPS enabled three other wells to be entered, abandoned and suspended concurrently. This not only delivered a considerable time saving for the client, but crucially was able to be carried out with no detriment to operational safety.

A key tenet of Well-Safe Solutions' offering is its dedication to collaborative working, enabling lessons learned to be shared throughout the industry. Our drive to reduce the cost of decommissioning for our client led to the use of several specialist technologies.

Two digital slickline units were used to support SIMOPS, using industry-leading digital slickline services. This method enabled execution to be streamlined by combining two services into one cable conveyance. Real-time services including performing mechanical jarring, explosive and non-explosive plug-setting and utilizing tubing cutters.

In addition, this technology enabled a higher level of operational efficiency through reduced equipment handling, as there was no longer a requirement for additional rig-ups between conventional slickline and e-line (or wireline) equipment. Wellbore data was also enhanced by the digital slickline system's ability to provide real-time toolstring pressure and temperature data.

Pressure wave valves provided by Oilenco enabled an additional run to be removed from the scope, following deployment of the blow-out preventer (BOP) and pres-



Well-Safe Solutions

sure-cycling of the valve. These intelligent practices further reinforced the time savings achieved by the SIMOPS carried out earlier in the project.

Every Little Bit Helps

The use of SIMOPS was not the only optimization measure used on the project. With operational efficiency one of the central goals of the scope, Well-Safe Solutions was able to halve the time the BOP was off the well, by 'hopping' it between wells. This avoided the removal of choke and kill hoses along with the bell nipple, which is normally a time-consuming process. This procedure enabled the high-pressure riser to be removed, the rig to be skidded to its new location, the tree to be removed, and the high-pressure riser to be reinstalled – all while the BOP remained suspended, increasing the value of savings for the client.

For NUIs such as the Schooner platform, day trips using helicopters for limited-duration work campaigns are the norm. Lack of daylight, as well as instances of poor weather, can create considerable difficulties in enabling access to and egress from the platform. Air-gapping operations, where surface well barriers are proved and flowlines are removed, were originally planned to be carried out ahead of the drilling rig's arrival to the platform by way of a helicopter or walk-to-work campaign. Well-Safe proposed to DNO that this operation could be safely carried out as SIMOPS, with the air-gapping carried out simultaneously to the concurrent batch digital slickline activities.

SIMOPS methods enable Well-Safe Solutions to realize significant cost savings to benefit the client and the wider decommissioning industry, with no detriment to operational or personal safety.

MacGregor

DIGITAL TWIN

With equipment installed on the equivalent of every other ship at sea, MacGregor's marine and offshore ambitions to exploit digital twin technology at scale are as achievable as they are understandable.

Like many of the digital terms entering the marine and offshore lexicon, gains associated with the 'digital twin' have quickly become slippery due to multiple interpretations. But a technology with deep consequences for design, operations and maintenance cannot be allowed to slide into the shallows of the maritime buzzword, say Dennis Mol, Vice President Technology & Sustainability, and Bhavik Thakker, Director Digital Solutions, MacGregor.

This is one reason MacGregor recently formalised the Digital Twin part of its digital services offering. Another is that the group has already proved a front-runner in securing safety, productivity and sustainability gains by developing real-time digital processes to support the marine cargo and offshore load handling equipment it delivers.

"Rather than talking up potentials, we have evolved a set of cases to demonstrate the purpose of using a digital twin in different scenarios, and the benefits of calculating, simulating and analysing what is feasible for equipment based on data from the operating environment," says Thakker.

MacGregor's conclusion is that digital twin technology has value for marine and offshore customers at every stage of its product and service offering: from the product concept stage, to design and engineering verification, testing and sea trials, training, operations and maintenance.

Alternative Realities

"Data that is 'engineering-level' accurate allows a digital twin to simulate the real time dynamics of an actual vessel in its environment," explains Mol. "This creates analytical power that goes beyond theoretical modelling. A designer can evaluate the impact of an integrated equipment configuration at the pre-development stage, for example, and work to refine control systems in advance to benefit the whole."

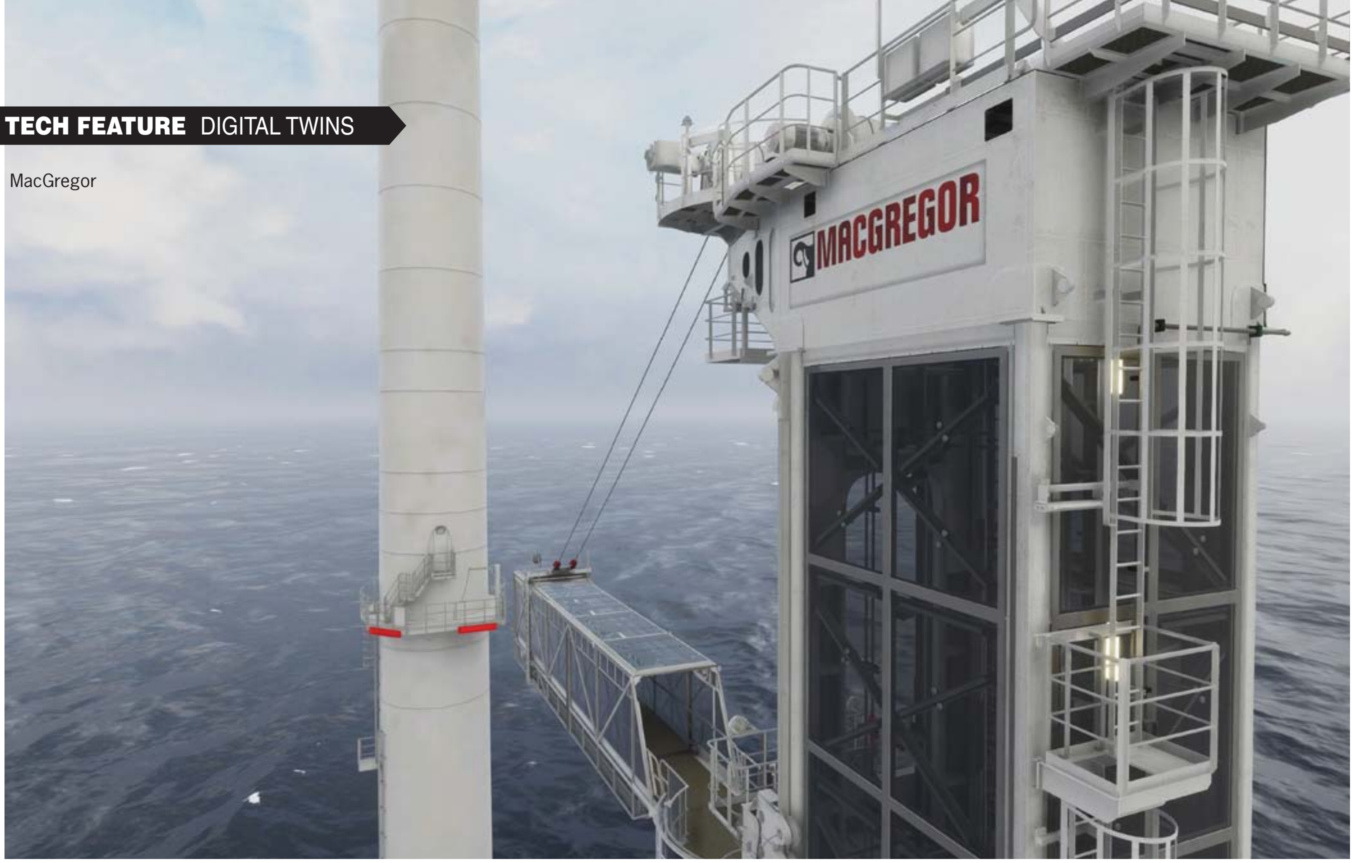
Allowing the user to try-out a new design is empowering for the customer and invaluable for the engineer – both as a way of exploring and predicting behaviour, and as a tool to get things right the first time and avoid cost overruns. For MacGregor, the benefits of using the digital twin are available from a product's conception to the end of its operational life, Mol stresses.

"Working with accurate specifications and real data, we can use the digital twin for FEED studies and rapid prototyping in the idea development phase, and present the customer with interactive 'almost-real' experiences," adds Thakker. "Later in the process, the technique allows us to optimise the general arrangement, choose the right equipment combinations, develop realistic structural analysis, verify the design, and simulate and analyse work processes."

Behind Every Good Twin – A Better Twin

"MacGregor has already used a digital twin in key product developments," says Mol. "Its in-house developed 'C-how' simulation technology has been deployed to de-risk the engineering phase, verify the design in different on-deck scenarios and optimize operability."

In one case, a shipyard used a digital twin to simulate control responsiveness of a MacGregor davit system during boat launch and recovery, in order to verify the maximum wave height limit. In another example, using the



MacGregor

technique in the product test phase enabled dynamic vessel motion modelling so that an owner could verify that a gangway designed for the bow of a vessel would operate safely at greater wave heights.

For operational purposes, one MacGregor customer made use of a digital twin to maximize the weather window within which subsea equipment could operate, while another developed new subsea crane operating guidelines after an incident involving a mis-timed change in mode.

Data-Driven Lessons

Thakker explains that, once the equipment is built, a digital twin also proves invaluable for verifying safety, optimising control procedures and automation sequences, and for detecting failure root causes.

"The data analytics capabilities can be used for predictive maintenance planning and to anticipate failure and repair needs for critical equipment well in advance," he says.

But the usefulness of the digital twin for worldwide maritime industries is not limited to machinery. "The experience of using the digital twin also takes training using simulation to a new level," adds Thakker.

"In fact, the best point of delivery for the data-driven lessons that enhance equipment efficiency is to the people using it. Training needs to be delivered in the most effective way, and e-learning, scenario-based simulations, analytics and immersive augmented reality-based methods create a powerful mix to get the message across on standards to office-based and shipboard personnel alike."

A digital twin-level of simulation accuracy makes high-fidelity training more affordable, based on MacGregor's heritage and continuing role as a global supplier of handling equipment.

In a fast-changing scenario, MacGregor is already trialling the use of the digital twin technique for an augmented reality-based pilot covering air compressor maintenance sequencing, says Thakker, but his preference is to focus on gains already won.

"Getting that real-time feel and having the ability to simulate how equipment actually responds in an emergency situation results in a much steeper learning curve for the user," he says. "If an incident has occurred in the past, we can just play it back using a rich visual format, see how the guys respond and then train them on what they could have done better or patterns to look out for."

MacGregor is on the verge of delivering a new portable simulation-based offshore active heave compensation crane training package which uses digital twin capability to an offshore support vessel operator, he discloses, based on a rental and software licensing agreement.

"Our experiences with digital twin technology have allowed us to mature and formalize our approach across the entire scope of our activities - from design and engineering to testing, verification, training, operational support and maintenance," adds Thakker. "And the more we learn, the clearer the benefits for our customers become."

BY THE NUMBERS

RIGS

Worldwide

Rig Type	Available	Contracted	Total	Utilization
Drillship	7	70	77	91%
Jackup	216	270	486	56%
Semisub	27	50	77	65%

Africa

Rig Type	Available	Contracted	Total	Utilization
Drillship	1	14	15	93%
Jackup	19	12	31	39%
Semisub	1	4	5	80%

Asia

Rig Type	Available	Contracted	Total	Utilization
Drillship	4	5	9	56%
Jackup	91	70	161	43%
Semisub	17	6	23	26%

Europe

Rig Type	Available	Contracted	Total	Utilization
Drillship		4	4	100%
Jackup	12	31	43	72%
Semisub	7	18	25	72%

Latin America & the Caribbean

Rig Type	Available	Contracted	Total	Utilization
Drillship	2	24	26	92%
Jackup	3	4	7	57%
Semisub		12	12	100%

Middle East

Rig Type	Available	Contracted	Total	Utilization
Jackup	53	119	172	69%
Drillship		1	1	100%

North America

Rig Type	Available	Contracted	Total	Utilization
Drillship		22	22	100%
Jackup	29	25	54	46%
Semisub	2	3	5	60%

Oceania

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

Russia & Caspian

Rig Type	Available	Contracted	Total	Utilization
Jackup	8	2	10	20%
Semisub		3	3	100%

Global Average Dayrates

Floaters		Jackups	
Ultradeep water	369.5	High-spec	141.1
Deepwater	287.7	Premium	103.5
Midwater	200.6	Standard	101.8

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 February 2023
Source: Wood Mackenzie Offshore Rig Tracker

DISCOVERIES & RESERVES

Offshore New Discoveries

Water Depth	2018	2019	2020	2021	2022	2023
Deepwater	16	20	13	13	20	
Shallow water	56	86	42	55	27	1
Ultra-deepwater	18	18	9	7	16	
Grand Total	**90**	**124**	**64**	**75**	**63**	**1**

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	577	47,450	22,857
Shallow water	3,234	423,351	142,943
Ultra-deepwater	338	44,345	28,479
Grand Total	**4,149**	**515,146**	**194,279**

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	580	19,171	12,070
Asia	800	15,010	6,973
Europe	775	12,797	12,395
Latin America and the Caribbean	189	6,435	39,707
Middle East	133	77,702	146,489
North America	466	2,797	12,742
Oceania	89	11,701	1,173
Russia and the Caspian	61	17,226	13,823
Grand Total	**3,093**	**162,840**	**245,372**

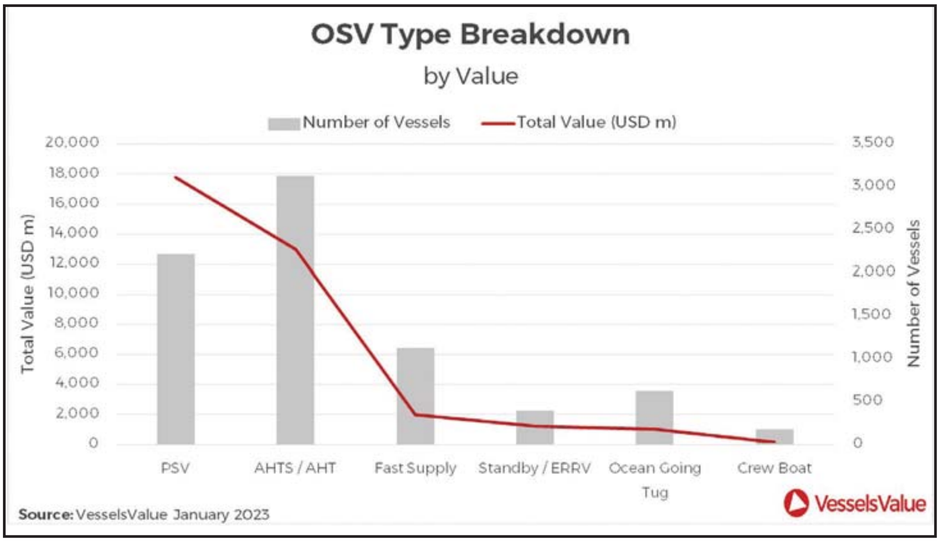
Source: Wood Mackenzie Lens Direct

Onstream and under development.

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

SECTOR IN FOCUS

OSV MARKET



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