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NOVEMBER/DECEMBER 2022 | OEDIGITAL.COM | VOL. 47, NO. 6

2023 Market Forecast

"Old" Energy + "New" Energy ...
What's in Store in '23?

Subsea Power

Renewable Energy to Power Subsea Infrastructure

Going Deep

Deepwater Atlas, World's First Eighth-Gen Ultra-Deepwater Drillship

NOVEMBER/DECEMBER 2022
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FEATURES

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2023 MARKET FORECAST

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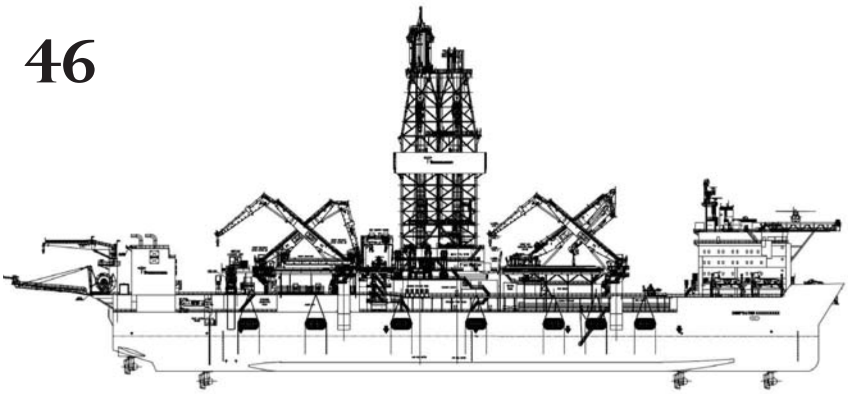

Image: Transocean

DEPARTMENTS

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BY THE NUMBERS

RIGS

Worldwide

Rig Type	*Available*	*Contracted*	*Total*	*Utilization*
Drillship	9	69	78	88%
Jackup	206	278	484	57%
Semisub	23	54	77	70%

Africa

Rig Type	*Available*	*Contracted*	*Total*	*Utilization*
Drillship	1	12	13	92%
Jackup	17	14	31	45%
Semisub		5	5	100%

Asia

Rig Type	*Available*	*Contracted*	*Total*	*Utilization*
Drillship	5	5	10	50%
Jackup	89	72	161	45%
Semisub	11	11	22	50%

Europe

Rig Type	*Available*	*Contracted*	*Total*	*Utilization*
Drillship	1	6	7	86%
Jackup	8	35	43	81%
Semisub	8	17	25	68%

Latin America & the Caribbean

Rig Type	*Available*	*Contracted*	*Total*	*Utilization*
Drillship	2	23	25	92%
Jackup	3	4	7	57%
Semisub		12	12	100%

Middle East

Rig Type	*Available*	*Contracted*	*Total*	*Utilization*
Jackup	52	118	170	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	1	4	5	80%

Russia & Caspian

Rig Type	*Available*	*Contracted*	*Total*	*Utilization*
Jackup	7	3	10	30%
Semisub	1	2	3	67%

Global Average Dayrates

Floaters		*Jackups*	
Ultradeep water	355.7	High-spec	143.7
Deepwater	287.7	Premium	101.9
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 December 2022
Source: Wood Mackenzie Offshore Rig Tracker

DISCOVERIES & RESERVES

Offshore New Discoveries

Water Depth	***2017***	***2018***	***2019***	***2020***	***2021***	***2022***
Deepwater	15	16	20	13	13	15
Shallow water	77	56	85	42	55	21
Ultra-deepwater	12	18	18	9	7	13
Grand Total	**104**	**90**	**123**	**64**	**75**	**49**

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	575	47,414	23,182
Shallow water	3,257	423,329	143,709
Ultra-deepwater	335	43,387	27,842
Grand Total	**4,167**	**514,130**	**194,734**

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	577	19,176	12,090
Asia	837	15,124	6,685
Europe	750	11,600	11,723
Latin America and the Caribbean	193	6,566	41,073
Middle East	133	73,973	145,395
North America	467	2,731	12,819
Oceania	89	11,701	1,173
Russia and the Caspian	61	17,236	13,829
Grand Total	**3,107**	**158,107**	**244,787**

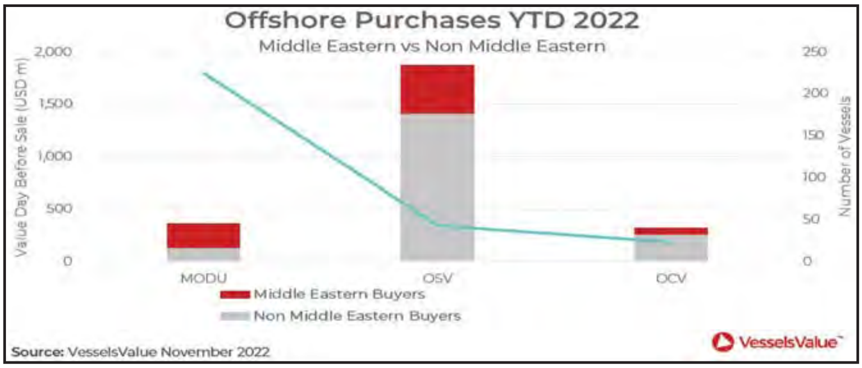
Onstream and under development.

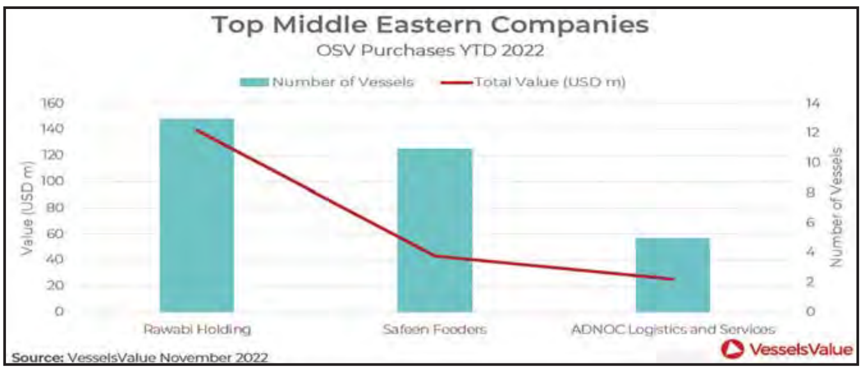
The portion of commercially recoverable 2P reserves yet to be recovered from the reservoir.

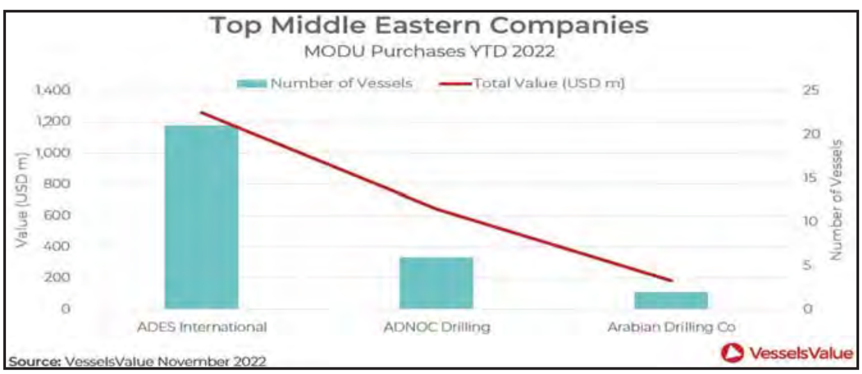
Source: Wood Mackenzie Lens Direct

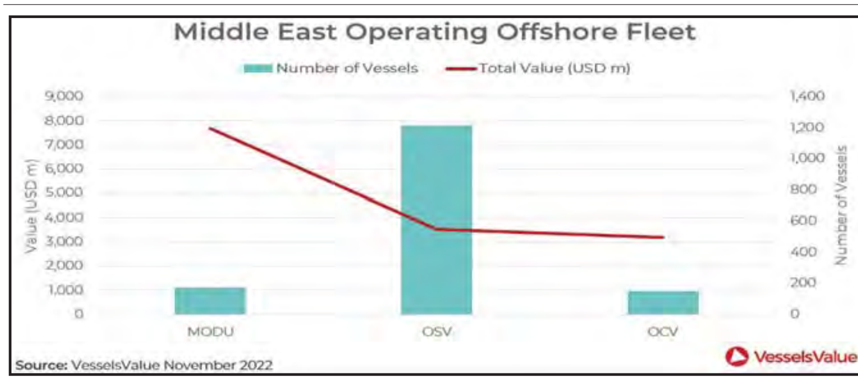
SECTOR IN FOCUS
MIDDLE EAST

Data & Statistics powered by VesselsValue









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Teresa Wilkie is the Director of RigLogix within Westwood Global Energy Group, leading a team of experienced offshore rig market analysts. She has over a decade of knowledge as an analyst in the oil and gas industry brining expertise from her time at IHS-Markit (formerly ODS-Petrodata) and Esgian (formerly Bassoe Offshore).


Maslin


Montgomery


Price


Skjong


Stoichevski


Wilkie

STRIKING A BALANCE

The year 2022 ends much the way it began: a healthy dose of geopolitical conflict and a healthier dose of global inflation, topped with energy security concerns across Europe and a keen focus on subsea security. Then of course there is the ongoing energy transition discussion and action. The move away from carbon-based energy sources is real and ongoing, but despite bold proclamations from 'experts' that the transformation can be fast-tracked, the reality is that we are generations away from ditching fossil fuels as a primary source of energy … long after I've vacated this chair (and this earth!).

To help add depth and breadth to the discussion, in this edition we've arranged for a broad spectrum of industry insiders to provide numeric insight and analysis to the offshore energy markets that look promising in 2023 and beyond.

Starting us off is Teresa Wilkie, Director of RigLogix - Westwood Global Energy Group, who offers a trio of 2023 rig market predictions that should leave most readers smiling: more reactivations, more mergers and acquisitions and $500,000 dayrates, courtesy of the sustained E&P upcycle, with jack-ups, drillships, and semi-submersibles (semi) all recording increases in demand, marketed utilization, and dayrates.

Next up is Matt Hale from Rystad, who says that offshore oilfield services spending will keep rising – up to 20% – in 2023, led by Brazil. You can read his report, and you can here his words, too, as Hale was recently interviewed by OE's Bartolomej Tomic for **OE TV**.

In considering the global offshore exploration outlook, Ruaraidh Montgomery, Head of Global Research at Welligence Energy Analytics, writes that Welligence expects global offshore exploration drilling activity in 2023 to remain relatively steady year-on-year, with the majors driving much of the activity in their core regions. Two areas with big impact potential - the Atlantic Basin and the Eastern Mediterranean - will draw much of the exploration investment.

Finally, Philip Lewis and Tomasz Laskowicz from Intelatus Global Partners provide insights via a trio of articles on the new and emerging frontier of Offshore Wind, particularly here in the U.S. as well as the embryonic industry in the Baltics. Phil and his team are a wealth of knowledge and insight on offshore wind globally, with details on 'when and where' assets are likely to be built plus up to the moment exclusives on the deals driving this business forward.

As always, a sincere bit of thanks to you for your interest and support of ***Offshore Engineer*** in 2022, with best wishes for a healthy and prosperous 2023.

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Check out the 2023 Media Kit via the QR Code Below

Reactivations, M&As & $500,000 dayrates ...

WESTWOOD'S TOP THREE 2023 RIG MARKET PREDICTIONS

The offshore drilling rig market has blossomed this year off the back of the sustained E&P upcycle, with jack-ups, drillships, and semi-submersibles (semi) all recording increases in demand, marketed utilization, and dayrates.

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

The drillship market is close to sold out at 94% marketed utilization, with leading-edge dayrates now hitting the mid-$400,000 range in both the US Gulf of Mexico and Brazil. The tightness within the market has already led to nine drillships being reactivated (2021-present) from cold stack and even a few stranded newbuilds finally landing their first drilling gigs.

Similarly, for jack-ups, urgency for capacity from National Oil Companies (NOCs), especially in the Middle East, has transformed the supply/demand balance within this market and, like the drillship fleet, has led to long-idled newbuilds finding work and 25 rig reactivations since 2021. As a result, rig owners have also realized substantial dayrate increases.

The semi fleet has had a slower recovery, largely due to lackluster demand from the North Sea. Nevertheless, rig owners have seen increases in utilization, and dayrates and marketed utilization now sits at 80%.

Extra capacity will be required

With the rig market recovery well underway, Westwood anticipates continued momentum in 2023.

The tightness in drillship and jackup capacity will be amplified next year as the demand outlook for these rigs is strong. Westwood's RigLogix records a total of approximately 40 years of unfulfilled floating rig (semi and drillship) requirements and around 93 years of jackup requirements that have a start date in 2023.

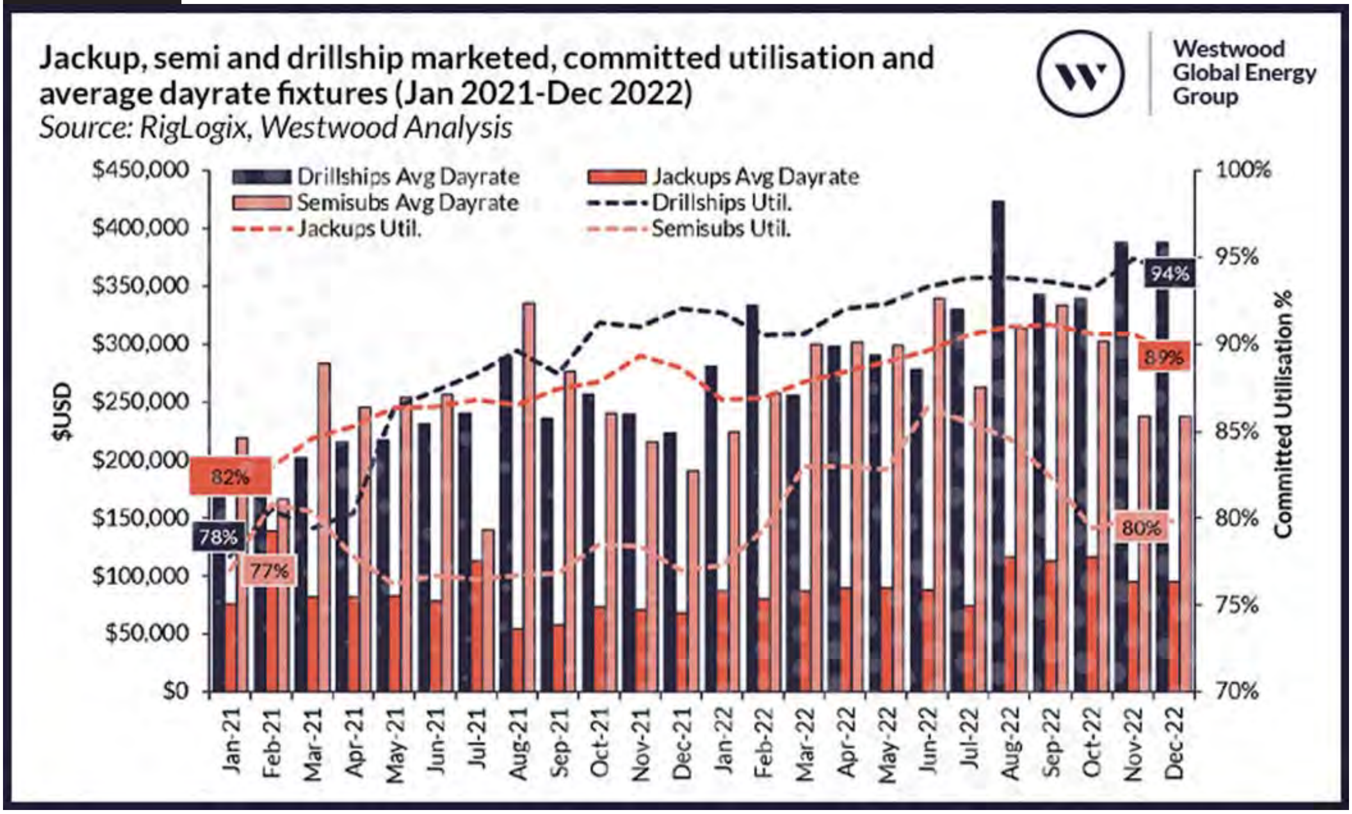
This high demand is expected to not only soak up the remaining active available supply in the market, but also additional newbuild units as well as cold-stacked tonnage that will require reactivation (see Figure 2).

However, commissioning a newbuild/stranded asset or reactivating an idle one is not a cheap or quick process. It is understood that pricing for a drillship reactivation is now $100 million or more and is likely to take 1-2 years to complete. This challenge may lead to some operators considering chartering a semi instead of a drillship where possible.

Dayrates will move higher still

This rising demand, coupled with a shrinking supply of

Figure 1



Source: RigLogix, Westwood Analysis

ready supply and the soaring economics behind reactivation, brings us to our next prediction: dayrates will continue to rise next year.

As shown in Figure 1, dayrates have already been moving north, and rumors suggest that we could see a $500,000 drillship fixture next year, which would be the first since the 2012-2014 period. Meanwhile, jack-up rates are also expected to continue their upward trajectory, driven by continued high demand from NOCs, and Westwood anticipates seeing further fixtures for non-harsh environment units within the recently recorded $130,000-$140,000 range.

Westwood's Offshore Rig Dayrate Forecast Report also shows that even the historically low rates for jack-ups in regions such as India will also rise in 2023.

Further upward movement for semi rates is even expected next year in both the harsh and non-harsh environment fleets.

The UK semi market is already showing signs of some tightening, and the Norwegian 6th generation segment is also expected to become busier in the second half of 2023. Several units have mobilized out of the region in 2022, and the lower supply will contribute to further tightening and dayrate increases.

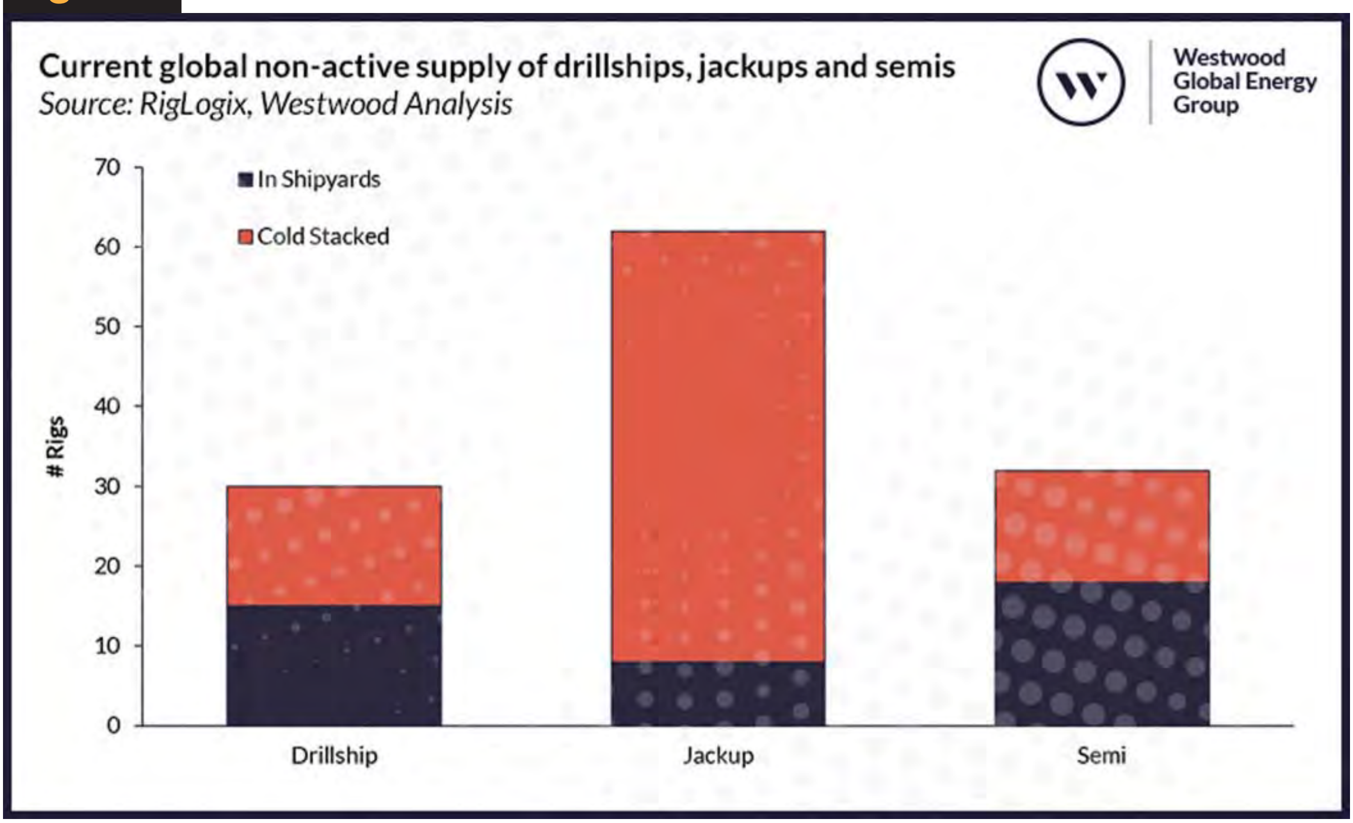
More consolidation on the cards

One of the biggest talking points of 2022 was the merger of Noble Corporation and Maersk Drilling – a sizeable combination and a key example of what the industry has been promoting for many years.

With rig market fundamentals improving and drilling contractors streamlining their fleets in the past few years, it seems to be the prime time for further merger and acquisition (M&A) activity.

Rumors continue to circulate of ongoing talks regarding certain rig owners. However, time will tell if and when these discussions lead to further M&A activity. Despite rig market improvement, it is widely recognized that there is still too much rig owner fragmentation, and further consolidation will be required to provide a smaller pool of players with larger market shares in the future.

Figure 2



Source: RigLogix, Westwood Analysis

OFFSHORE OILFIELD SERVICES SPENDING TO KEEP RISING IN 2023

Offshore E&P capex will shake off the pandemic-induced declines and rebound by 20% in 2022, reaching a total $165B spent on exploration, wells, and facilities.

OETV
Watch the video @ https://youtu.be/3reajS83pWI

By Matt Hale, a Lead Analyst at Rystad Energy, based in Houston, Texas

Offshore exploration and production (E&P) capital expenditures (capex) will shake off the pandemic-induced declines of the past two years and rebound by 20% in 2022, reaching a total $165 billion spent on exploration, wells, and facilities (Figure 1). This is slightly less than half the all-time high for offshore E&P investment of $332 billion in 2014, set at a time when the average Brent crude oil price had stayed above $100 per barrel for a fourth consecutive year. Following several years of lower crude prices and demand uncertainty, crude has jumped again this year to average over $100 per barrel.

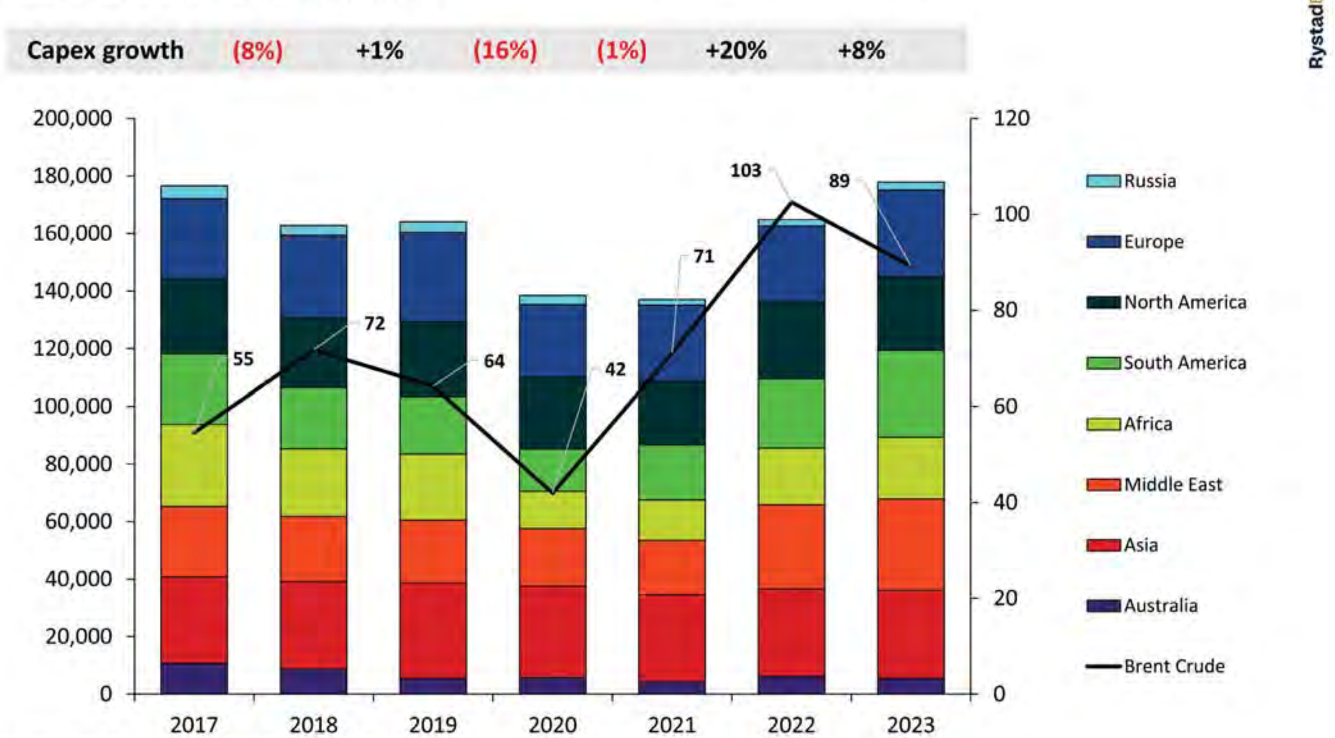
While Brent prices have cooled from a peak of $128 earlier this year, demand is expected outstrip supply beginning in December this year and lasting through the end of 2023, translating into an average price of $89 per barrel next year. This is largely driven by the EU embargo on Russian oil which takes effect on 5 December, constraining Russian exports by limiting the fleet of tankers to deliver crude to "friendly" countries including India and mainland China. In addition, natural gas takeaway capacity and capital discipline in an environment of high service price inflation are expected to limit the growth of US oil production. With this outlook for crude prices, offshore E&P operators are expected to continue investing in production, lifting capex by another 8% to $178 billion next year.

Since the offshore spending peak in 2014, operators have shifted their capital projects toward short-cycle investments, including shale and other tight resource plays in North America, which quickly boost short-term production, similar to infill drilling in proven geologic areas. In a sustained high commodity price environment, operators now feel more confident deploying capital into long-cycle offshore developments, like we saw in the last offshore investment cycle. These investments can take the form of seismic and FEED activity as well as more concrete investments in new wells and offshore facilities.

In the offshore drilling arena, state-owned producers including Saudi Aramco, ADNOC, QatarEnergy, and Petrobras are taking a lead in well construction, aided by international majors and other operators. One particular region of increased activity is the Middle East (Figure 2), where

Figure 1: Offshore E&P capital expenditure by continent, 2017 to 2023

Million USD (left), USD per barrel (right)



Source: Rystad Energy ServiceDemandCube – Oil & Gas

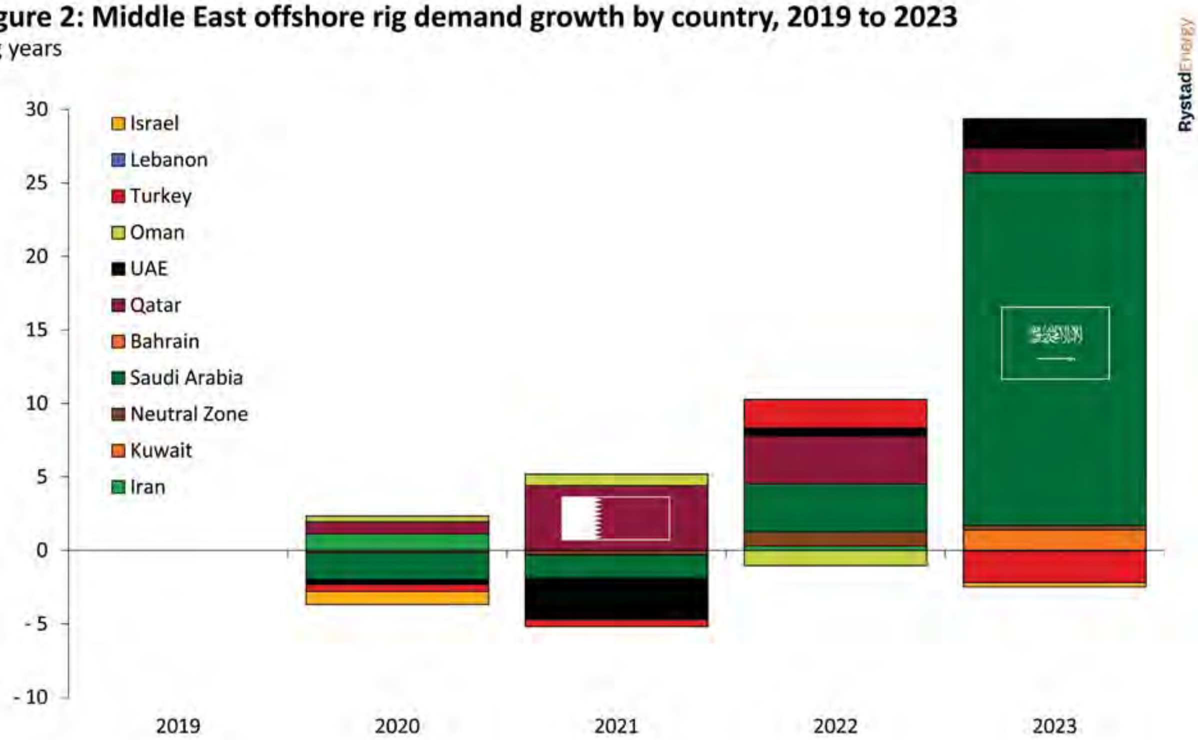
Saudi-backed driller ADES and UAE-supported ADNOC Drilling have spent the past couple years expanding their fleets, acquiring dozens of new and used jackup rigs to drill in the shallow waters of the Persian Gulf. Zooming in on Middle East rig demand, we see that the vast majority of year-on-year growth will come from Saudi Arabia, adding 24 rig years on top of 2022 levels. The entire region is expected to grow by 23% from a base of 118 rig years for this year, already 10% higher than 2021. In terms of rig years, the Middle East is by far the biggest growth region in 2023, followed by South America and West Africa which are projected to add 7.3 and 3.3 offshore rig years, respectively.

Growth in South America will be concentrated in the deepwater areas of Brazil and Guyana, led by Petrobras and ExxonMobil, with shelf activity only accounting for a small minority of the capital spending. Rather than shallow-water platforms, these developments will require massive floating production, storage and offloading (FPSO) vessels and complex subsea production systems. Based on standardized hull, topside, and mooring designs by SBM Offshore and MODEC, the largest newbuild FPSOs feature up to 2.3 million barrels of storage and 50,000 tonnes of topsides. Globally, seven FPSO projects have been awarded this year, with an additional 15 to be awarded in 2023 and another 12 in 2024 (Figure 3).

Brazil has been the dominant FPSO market over the past several years with just over one-third of FPSO awards over the 2017 to 2024 period. In addition to four projects in Brazil, next year will see three awards in the UK, two in Guyana, and two in Angola. In South America, subsea capex is expected to exceed $10 billion as these operators build out the infrastructure needed to support massive offshore oil fields such as Buzios, Bacalhau, and Jubarte in Brazil and Yellowtail, Payara, and Pacora in Guyana.

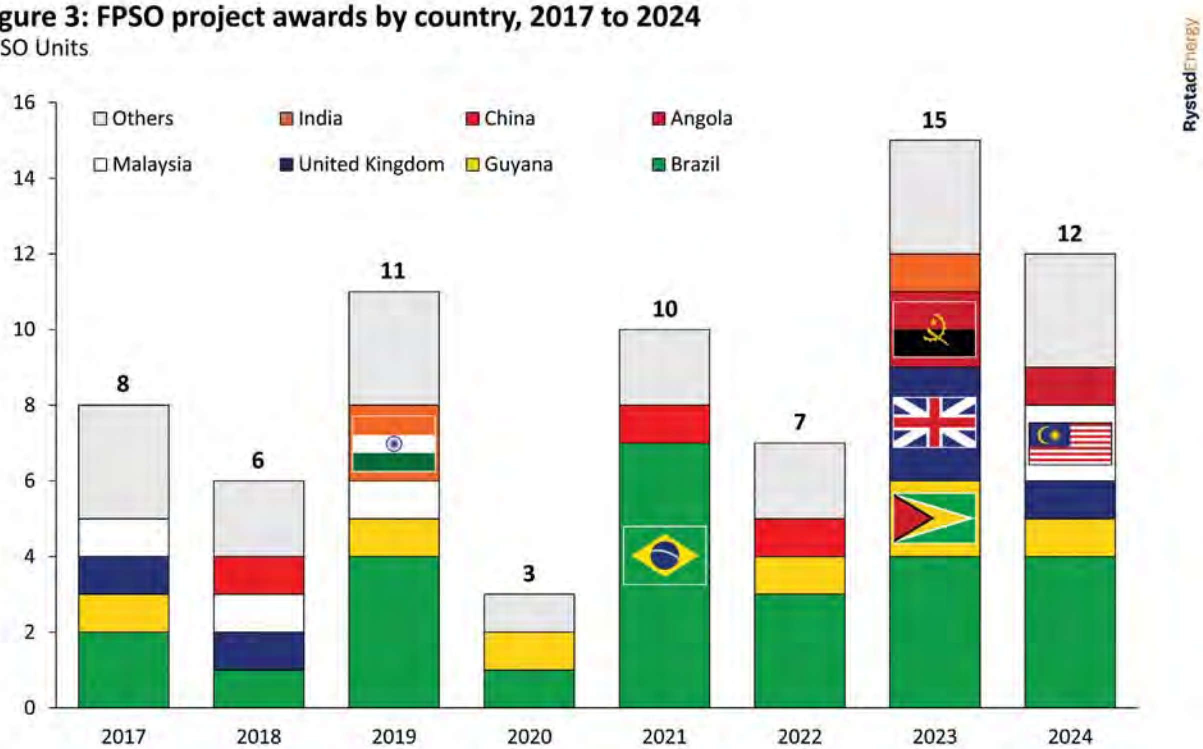
With crude oil and natural gas prices expected to stay elevated through 2023, offshore spending on oilfield services will further extend beyond 2022 levels. State operators aiming to extract valuable resources in advance of the eventual energy transition will lead the way, along with international majors which now feel confident investing in long-cycle offshore projects in core basins to grow production in a high-price environment.

Figure 2: Middle East offshore rig demand growth by country, 2019 to 2023
Rig years



Source: Rystad Energy OffshoreRigCube

Figure 3: FPSO project awards by country, 2017 to 2024
FPSO Units



Source: Rystad Energy FPSOCube

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GLOBAL OFFSHORE EXPLORATION OUTLOOK – NEW PLAY EXPLORATION APPETITE STEADY BUT STRONG

Welligence expects global offshore exploration drilling activity in 2023 to remain relatively steady year-on-year, with the majors driving much of the activity in their core regions. Two areas with big impact potential - the Atlantic Basin and the Eastern Mediterranean - will draw much of the exploration investment.

By Ruaraidh Montgomery, Head of Global Research at Welligence Energy Analytics

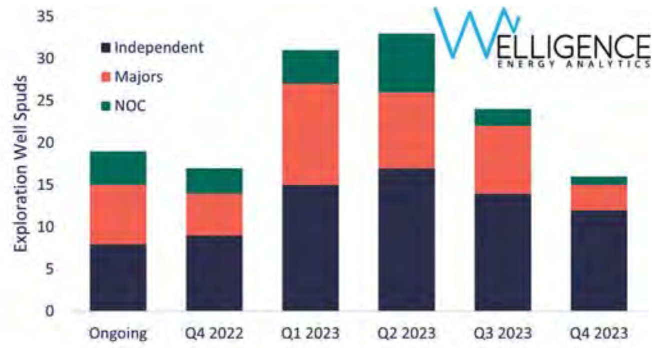
Welligence expects global offshore exploration drilling activity in 2023 to remain relatively steady year-on-year. The Majors will drive much of the activity in their core regions, along with Petrobras, the world's leading deepwater operator.

And while there are far fewer independents active in the offshore today compared to 10 years ago, Welligence still anticipates over 30 members of the peer group to operate exploration wells.

Two areas with big impact potential will draw much of the exploration investment – the Atlantic Basin and the Eastern Mediterranean.

Most companies will chase oil, but gas is the primary target in the latter region. Indeed, with FLNG starting to build momentum as a development solution, gas is an increasingly appealing option. Furthermore, new plays offer large discovery potential – these finds benefit from economies of scale and operation, making them very attractive not just under standard economic metrics, but also greenhouse gas emission metrics, an increasingly important criteria for the sector.

Offshore exploration drilling forecast by peer group



Source: Welligence Energy Analytics

Atlantic Basin exploration – will Argentina mirror Namibia's success?

Both sides of the basin will host much of the action. The world-class success achieved by Shell (Graff) and TotalEnergies (Venus) earlier this year has unlocked Namibia's Orange Basin, and it will see multiple wells in 2023, including an effort (the 5/6/7-1x well) by the French Major to extend the play into South Africa.

Equinor is looking to replicate the success on the conjugate margin in Argentina – all eyes will be on its US$100 million Argerich-1 well in the Argentina Basin, whose geology is considered analogous to the Orange Basin; success would open a new production frontier for the country.

The Equatorial Margin off South America's northeast coast will continue to attract significant exploration dollars.

The highest risk effort will be undertaken by Petrobras, which plans to spend US$3 billion over the next five years in an effort to prove up Brazil's Equatorial Margin basins. The spud of its Morpho well in the Foz do Amazonas Basin is imminent, with three additional targets to follow.

In Guyana, expect to see ExxonMobil add more resource to the 11 bnboe+ already found at the Stabroek block, while TotalEnergies continues to try to prove up the commerciality of Block 58 in Suriname. The big question, however, is whether anyone else can make meaningful finds in the Guyana Basin.

Ten offshore exploration wells to watch

Moving further up the coast to eastern Canada, bp is preparing to spud the Ephesus prospect in the under-explored Orphan Basin. This is a giant, billion-barrel target.

The Eastern Mediterranean gas province continues to heat up

Welligence's second exploration hotspot is the Eastern Mediterranean, which has already yielded multi-Tcf gas discoveries and is producing significant volumes.

With existing infrastructure in place or planned, and a ready market in Europe, this is one region where gas definitely works.

Top explorer Eni will be highly active – it just spudded the Thuraya-1 well offshore Egypt, and is drilling ahead at the Zeus prospect in Cyprus.

In Egypt, BP has secured a rig to kick off a four-well

program. In Lebanon, TotalEnergies will drill the country's second-ever well offshore with Qana-1.

Outwith the two areas highlighted, there is plenty of high impact activity planned.

Eni will explore for gas offshore Morocco at its Tarfaya block, plus attempt to open a new oil play in Mozambique with its Raia-1 well.

In Asia Pacific, TotalEnergies is drilling ahead at Tepat North prospect offshore Sabah Malaysia, targeting the Oligo-Miocene trend opened by its Tepat find in 2018. In Indonesia, Eni will drill Geng North, while Harbour Energy will look to prove up additional resource on its Andaman II block, where it made the Timpan discovery earlier this year.

Exploration will continue in more established areas.

In the mature North Sea and US Gulf of Mexico, the independents will drive most activity, targeting prospects in established plays that are typically within tieback distance to existing infrastructure.

Some new play exploration is planned, however, such as Aker BP's Rondeslottet well in Norway. And despite underwhelming results in recent years, the larger companies will continue to explore Brazil's pre-salt, with Shell, PETRONAS and bp potentially drilling.

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THE OSV OUTLOOK FOR 2023 –

It's beginning to look a lot like Christmas

After a rough few years for the offshore support vessel market, Fearnley Offshore Supply's Jesper Skjong says the OSV market is now closer to a global recovery than at any point since the market turned sour.

By Jesper Skjong, Market Analyst at Shipbrokerage Fearnley Offshore Supply

The market for offshore support vessels has been through a rather rough few years since offshore exploration and production activity took a nose-dive in 2015 following the oil price crash the year before.

The newbuild order boom that came with the ever-greener pastures imagined in the industry ensured that not only was the supply- and demand balance off by an insurmountable degree in the years that followed, but at its peak, in 2017, the oversupply of anchor handling tug supply- and platform supply vessels was in excess of 30% more units than the market required at its all-time high demand!

And while those asset classes were starting to see some significant momentum build in 2019 and Q1 2020, we saw the impact of COVID-19 bring demand right back to previous trough levels – almost overnight as restrictions that reduced energy demand were rolled out across the globe.

As we are coming towards the end of 2022, it brings us considerable pleasure, and perhaps even some degree of relief, to report a market that is closer to a global recovery than at any point since the market turned sour.

While there are admittedly some regional differences, Fearnley Offshore Supply is quite firm in its view that the OSV market, overall, has made tremendous strides towards both higher vessel utilization and dayrates.

Going forward, Fearnley expects the market recovery to improve even further driven by increasing offshore activity and tighter vessel supply.

The increased market activity has already started to materialize for large parts of the offshore supply chain.

After hitting a definite trough in 2020 at around USD 110 billion, the global offshore upstream CAPEX has since grown significantly and is set to further increase in the immediate future.

Developments in deepwater and ultra-deepwater especially are expected to see yearly double-digit growth in the coming two years. And while the support vessel element is but a fraction of this investment, it does speak volumes towards the offshore activity, and thus the OSV demand, in that same period.

When we zoom in a bit and analyze vessel spend by itself, we get an even better, albeit still high-level, picture of the market development as this perspective allows us to compare different regions with each other.

Three largest growth regions for OSVs

In total, we could see vessel spend increase by more than 30% in 2023 compared to 2022, a function of both higher dayrates and more working vessels going forward.

Herein, the largest growth is expected to occur in the Middle East, South America, and Africa at some 70-, 50-, and 45% year-on-year growth respectively, with further double-digit growth into 2024.

Perhaps unsurprisingly, within these three regions, we see increasing OSV demand as the main driver for the improving market environment for shipowners operating therein. But in other key offshore regions, including the US Gulf of Mexico and Northwest Europe, the real driver for fast-improving markets was supply, or rather lack thereof.

Total vs. commercial supply

In all our presentations concerning the OSV market, we ensure to make a clear distinction between total- and commercial supply as this matter has become all the more important due to the persistently large number of units in layup.

As it stands, around 20% of the fleet is still cold-stacked, with the vast majority of these assets now more than 20 years old, the bulk of which for at least five years.

Considering costs associated with the re-activation of such units, including their 20-year special survey after such a long idle period, and the potential earnings left in their economic lifetime, it is becoming difficult to justify the financials regardless of how cheaply they can be acquired.

When we adjust the supply in light of the above by removing units with limited commercial life, the OSV market immediately looks a lot healthier, and, depending on how one measures it, we could argue a recovered market overall sometime during 2023 and 2024.

Utilization rates, to use a familiar metric, are on par with historic averages for AHTS already next year, whereas PSVs will potentially see historical parity reached the year thereafter.

Moreover, and speaking towards the validity of our reasoning, average dayrates have already started to materialize in a significant manner.

In the North Sea region, June brought with it the second-highest AHTS dayrate ever recorded in the spot market, and peak project activity occurring simultaneously in both O&G and offshore wind saw term rates at levels last seen in 2014.

In the US GoM, PSV dayrates are breathing all-time-high levels in the neck while total fleet utilization is less than 50%, supporting Fearnley's thesis that a large share of units officially included in the total fleet is not fit for commercial life. Subsequently, the rates experience substantial uptake without the utilization passing the 50% threshold.

It would perhaps be naïve to not mention the current geo-political and macro-economic clouds on the horizon, as many economies are now experiencing recession fears.

However, the supply in many OSV segments looks sufficiently tight to bring optimism in the sector regardless, combined with the fact that years of underinvestment in the petroleum sector is likely to force increased investments in the years to come. With further increasing offshore activity and, thus vessel demand, it is difficult to imagine 2023 as anything but a further strengthening to the already improving OSV industry.

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TOP 10 OFFSHORE WIND THEMES FOR 2023

The drivers for global offshore wind growth look good for 2023. Global offshore wind is forecast to grow from over 60 GW at the end of 2022 to 240 GW by 2030 and over 410 GW by 2035. But the sunny outlook must be balanced with some building dark clouds. As we prepare for the new year, let us look at ten factors that will shape the offshore wind sector in 2023.

By Philip Lewis, Research Director of Intelatus Global Partners

The drivers for global offshore wind growth look good for 2023. Global offshore wind is forecast to grow from over 60 GW at the end of 2022 to 240 GW by 2030 and over 410 GW by 2035. But the sunny outlook must be balanced with some building dark clouds. As we prepare for the new year, let us look at ten factors that will shape the offshore wind sector in 2023.

1. Solid foundations: Optimism for the supply chain is founded on declared and inferred offshore wind deployment targets by a growing number of countries of over 400 GW, driven by energy transition and energy security policies.

2. New kids on the block: Offshore wind activity is expected to remain strong in all established markets – China, the UK, the European Union, and Taiwan. Commercial-scale wind farms will advance in the US, new European Union markets (Greece, Ireland, Italy, Poland and the Baltics, Portugal, Spain, etc.), Japan, and South Korea. Governments in Australia, India, the Philippines, Canada, Brazil and Columbia will all take steps to advance offshore wind project permitting.

3. P2X is a game changer: Power-to-X in offshore wind terms means converting electrons to moveable and storable molecules. Initially producing green hydrogen, the electrons will be converted to a range of hydrogen-based energy carriers such as methanol and hydrogen for use in the industrial, residential, and transportation segments. Offshore wind-to-hydrogen production is moving from demonstration to commercial-scale projects within this decade.

P2X is the driver for zero-subsidy wind farms, initially in northwest Europe and expanding further in the future.

4. **Shifting foundations:** The overall foundations for growth are positive, but what type of foundations will be deployed? Bottom fixed (mainly monopiles but also jackets and gravity bases) will dominate on projects installed within this decade, but 2023 will see an increased focus on the development of commercial-scale floating wind farms, which will come on stream at the very earliest at the end of this decade but mainly after 2030.

Floating wind drives different manufacturing supply chain opportunities and challenges to bottom-fixed projects. We are focusing on a potential shortage of large AHTSs, offshore construction vessels with suitable cranes and deck space and crew. The shortage will become a global phenomenon accentuated by local content requirements.

5. **The impacts of inflation:** Inflation and supply chain disruptions will result in delays and possibly cancellations. Several developers have issued project warnings and are seeking to balance rising costs with power offtake commitments.

6. **Supply chain restructuring:** The three traditional international turbine OEMs (Siemens, Vestas, and GE) are struggling to make money as they continue to develop ever-larger turbines. These larger turbines drive bigger foundations, power cables, and installation vessels, all requiring supply chain investments…and for the supply chain to make suitable returns on investments.

7. **The expansion of the Chinese OEMs:** As the Chinese market settles down after an exceptional 2021, Chinese turbine OEMs and other suppliers are looking to export to overseas markets. With large new turbines being offered, one can expect the big three international players to face stiff price competition in their core markets.

8. **Vessel (and other supply chain) shortages:** With the evolving technical, client, and local content drivers, how many companies will invest in new vessels without long-term commitments? Outside of some established players, the answer is "relatively few." The key driver for construction or support vessel investment is project commitments coupled with developer financial investment decisions. Delays in vessel investment in several key markets will pose a problem from the middle of the decade in delivering forecast capacity.

9. **Vessels are evolving, but many questions remain unanswered:** Vessel operators understand that they need to decarbonize, but what is the solution to future-proof a vessel? Will it be biofuels, hydrogen-based fuels such as methanol, ammonia, or other hydrogen carriers? How to convert the energy carriers - multi-fuel internal combustion engines or fuel cells? What about battery-based hybrid vessels or even fully electric for SOVs and CTVs? How to secure "green" fuel or electricity supply? So many questions with no firm consensus. The answer will be an individual choice based on availability of energy carriers.

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How to secure "green" fuel or electricity supply? So many questions with no firm consensus. The answer will be an individual choice based on availability of energy carriers.

10. **More local content:** Governments want a return on their investment in offshore wind in terms of local employment. We anticipate increasing local content barriers in the U.S., Taiwanese, Japanese, and South Korean markets. In some markets, like the United States, local content is established at a local and state level in addition to federal policies. Local restrictions will create barriers for developers and may result in project delays and cancellations. The established European market's open trade framework will support ongoing cross-border activity and supply chain confidence.

2023 should be a good year for offshore wind…but players in the segment need to be aware of ongoing challenges.

EMERGING U.S. FLOATING OFFSHORE WIND SEGMENT

The U.S. offshore wind sector is laying the foundations to become one of the largest floating wind markets globally by the end of the decade, but significant challenges still remain.

By Philip Lewis, Research Director of Intelatus Global Partners

The drive to grow the U.S. offshore wind sector into a leading offshore wind market continues.

The foundations are firmly in place to support the deployment of 30 GW of offshore wind by 2030 and 110 GW by 2050. Intelatus' forecast accounts for close to 70 projects that will install around 74 GW of capacity in this and the next decade and a total 110 GW by 2050.

Within the forecast, Intelatus identifies five demonstration and pilot arrays situated off both Atlantic and Pacific Coasts for over 250 MW which are the precursors to over 13.5 GW of floating wind project capacity to be deployed in the Pacific, North and South Atlantic, and the Gulf of Mexico between 2023 and 2035. Over $40 billion of capital will be invested to deliver these projects.

Intelatus' forecast is consistent with the targets of federal agencies, which have launched a series of initiatives to deploy 15 GW of floating wind capacity by 2035.

Further, and to support the California Energy Commission planning goals to deploy 2-5 GW of offshore wind by 2030 and 25 GW by 2045, BOEM recently launched the auction process for five 33-year leases with the potential for more than 4.6 GW of floating wind offshore California. The first capacity will come onstream at the end of this decade at the very earliest.

Despite the significant opportunities for both domestic and overseas suppliers and contractors, many challenges remain to be addressed to realize the opportunity. One area of particular concern is a potential lack of large anchor handlers required to install floating wind farm moorings and substructures.

Key differences between floating wind and bottom fixed wind projects

Floating wind projects bring a different philosophy than that seen in bottom-fixed projects. In bottom-fixed projects, the steps generally occur sequentially – components are manufactured in bulk and installed in multiple units at a time. In a floating offshore wind project, the steps will occur in parallel to allow installation to be completed in a timely manner.

Many elements of a floating wind farm resemble a bottom-fixed project. In particular, turbines and export cables are more or less the same. The foundations, array cables, and installation represent three major differences. This is reflected in the breakdown of CAPEX for both types of projects, shown for a typical U.S. project in **Exhibit 1**.

Floating wind project foundations feature anchors embedded in the seabed, mooring lines connecting the anchors to the floating substructure and the floating substructure that supports the turbine.

Currently, Intelatus' is tracking more than 80 floating wind substructure design concepts globally, many featuring different manufacturing solutions.

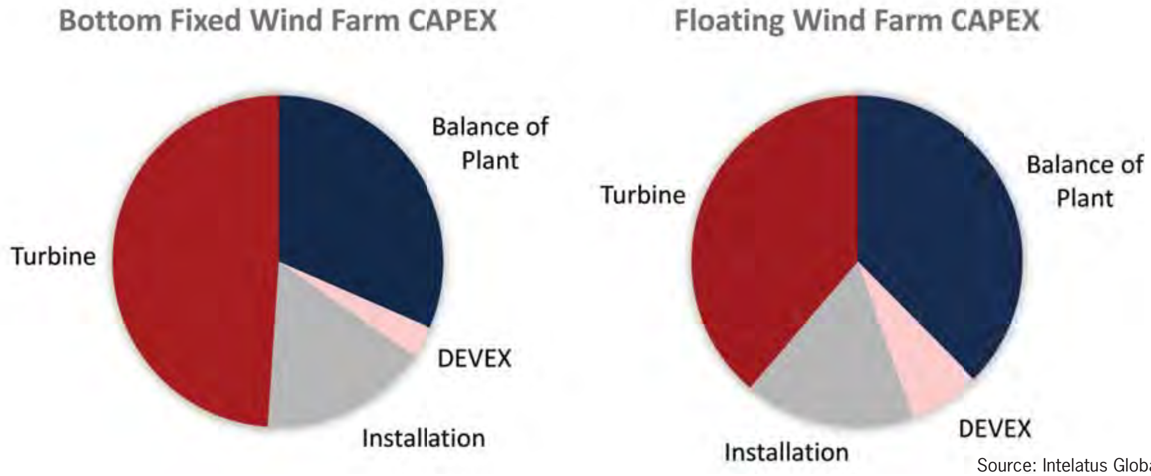
The common thread of the technologies is that they generally feature physically large and heavy substructures. The concepts can be largely grouped into four main technologies, as shown in **Exhibit 2**. All four may feature in U.S. projects:

A more detailed look at installation requirements

Irrespective of the concept, the installation of a floating offshore wind project can generally be broken down into four major steps:

- Mooring pre-installation. Anchors and mooring lines are installed up to a year before the turbine is installed. Mooring systems fall into two general categories. Tension leg moorings feature vertical tendons anchored with driven or drilled piles or suction an-

EXHIBIT 1 Comparing CAPEX Breakdown in bottom-fixed and floating projects



Source: Intelatus Global Partners

EXHIBIT 2 Floating Wind Technologies

Technology	Characteristics	Built from	Leading concept developers
Barge	Shallow draft. Can demand more robust mooring systems.	Mainly concrete suited to local casting operations. Steel options available. ~15-20,000 tonnes per structure	BW Ideol Damping Pool and SAITEC SATH
V-column semi-sub	Free-surface buoyancy stabilized structure with a relatively shallow draft.	Generally, a heavy steel structure with many welded connections, suited to large shipbuilding yards. ~3,000-5,000 tonnes per structure	Principle Power WindFloat, U. Maine Volturn US, Naval Energies SeaReed, Eolink, Hexicon TwinWind, NOV Tri-Floater, Olav Olsen OO Star, Fred Olsen Brunel Ocergy OCG Wind Floater, and several Japanese and Chinese concepts developed for domestic market.
TLP	Tension-stabilized structure with a relatively stabilized draft and limited operational motions.	Steel (tubulars or plate). Relatively lower structural weight compared to V-column semi-subs.	SBM Float4Wind
Spar	Inherently stable ballast stabilized structure with a relatively large draft. Variants include: • fixed spar buoy • hanging counterweight.	Spar buoys can be built from concrete (~10,000 tonnes) or steel. Hanging counterweight concepts can be built from steel tubulars (~4,000 tonnes). Concrete is also an option (~20,000 tonnes).	Equinor Hywind is leading spar buoy concept. Stiesdal's Tertaspar is a leader in the hanging counterweight concept

Source: Intelatus Global Partners

chors. Spread mooring features three sub-categories, catenary, semi-taut, or taut lines.

These systems are commonly anchored with drag embedment or suction pile anchors. Till now, catenary mooring has been commonly deployed with spar and semi-submersible structures, although semi-taught mooring will be deployed on a handful of projects in the coming years. Mooring lines will generally feature a combination of steel chain, steel wire and synthetic fiber rope. Due to the weight of moorings and the water depths for anchor installation, the anchor handling vessels deployed to install the turbines are amongst the largest in the world, as seen in **Exhibit 3**.

Exhibit 3 shows the average size of AHTS used for floating wind mooring pre-lay is over 25,000 horsepower or 280-300 tonnes bollard pull. AHTSs in this range will feature back decks of over 775-800 square meters.

There are currently around 80-90 active AHTS with over 20,000 horsepower globally. If we focus only on 25,000 horsepower and above, the number falls to 24. This is an immediate concern. There is currently only one U.S. flag AHTS with over 25,000 horsepower and a further two with over 20,000 horsepower.

The 800 square meter back deck is an important guide to mooring system carrying capability. Around eight drag embedment anchors, three suction anchors, or piles can be typically accommodated on an 800 square meter back deck.

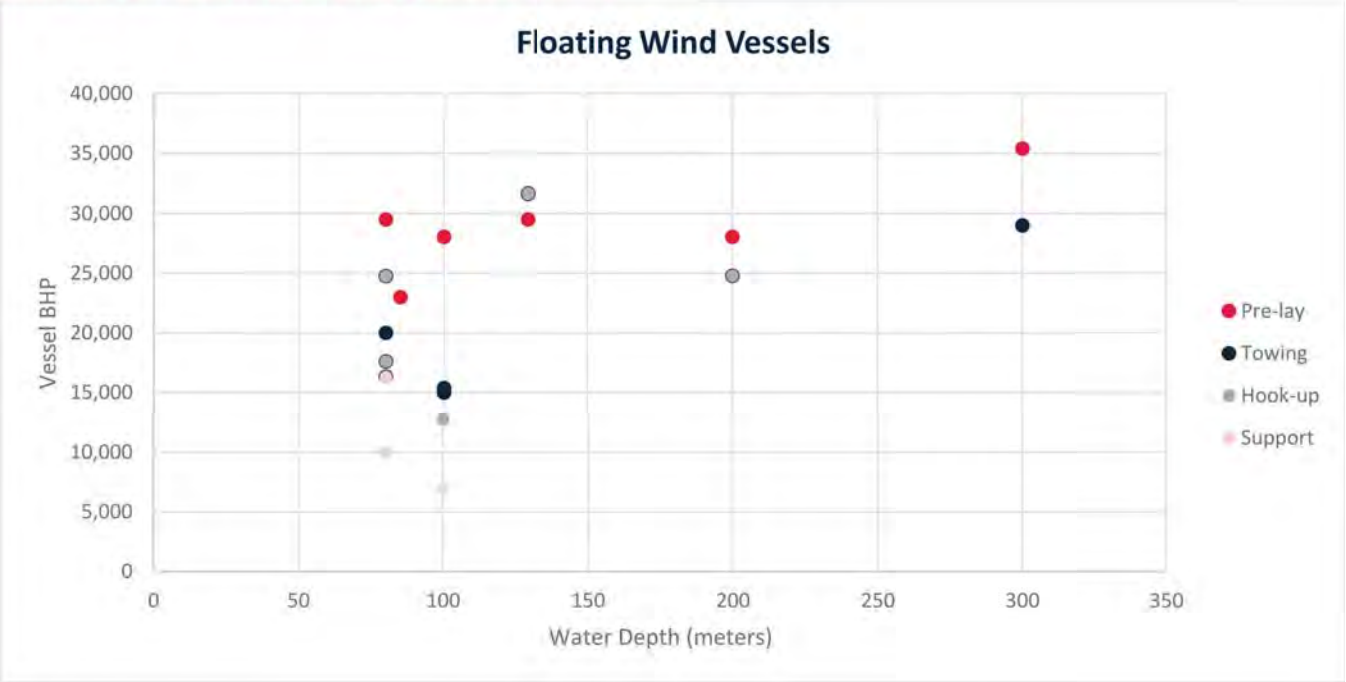
- Once moorings have been pre-laid, structures can be towed to site.
- Electrical cable installation: Export cables will likely be mostly static high-voltage cables installed by traditional large offshore wind cable layers. The array cables and an element of the export cable are likely to feature dynamic electrical cables, which will be generally laid by modified cable layers, subsea construction vessels, and MPSVs from the oil & gas fleet.
- Hooking up of the floater to the pre-installed moorings and array cables has been undertaken by medium and large AHTSs or MPSVs. On a large commercial floating wind farm, it is likely that both AHTSs and MPSVs will be required.

At the same time as commercial-scale floating wind farms emerge in the U.S., Intelatus anticipates large floating projects to be deployed in the UK, Europe (North Sea, Atlantic, and Mediterranean), Japan, South Korea, Taiwan, and other emerging markets.

Projects developed in these countries will be competing for a limited large anchor handling vessel and crew pool. The fleet of vessels is significantly reduced further if the weighting of offshore wind developer low and zero carbon drivers is amplified.

The opportunities are significant, but so are the challenges.

EXHIBIT 3 FLOATING WIND VESSEL SIZES



Source: Intelatus Global Partners

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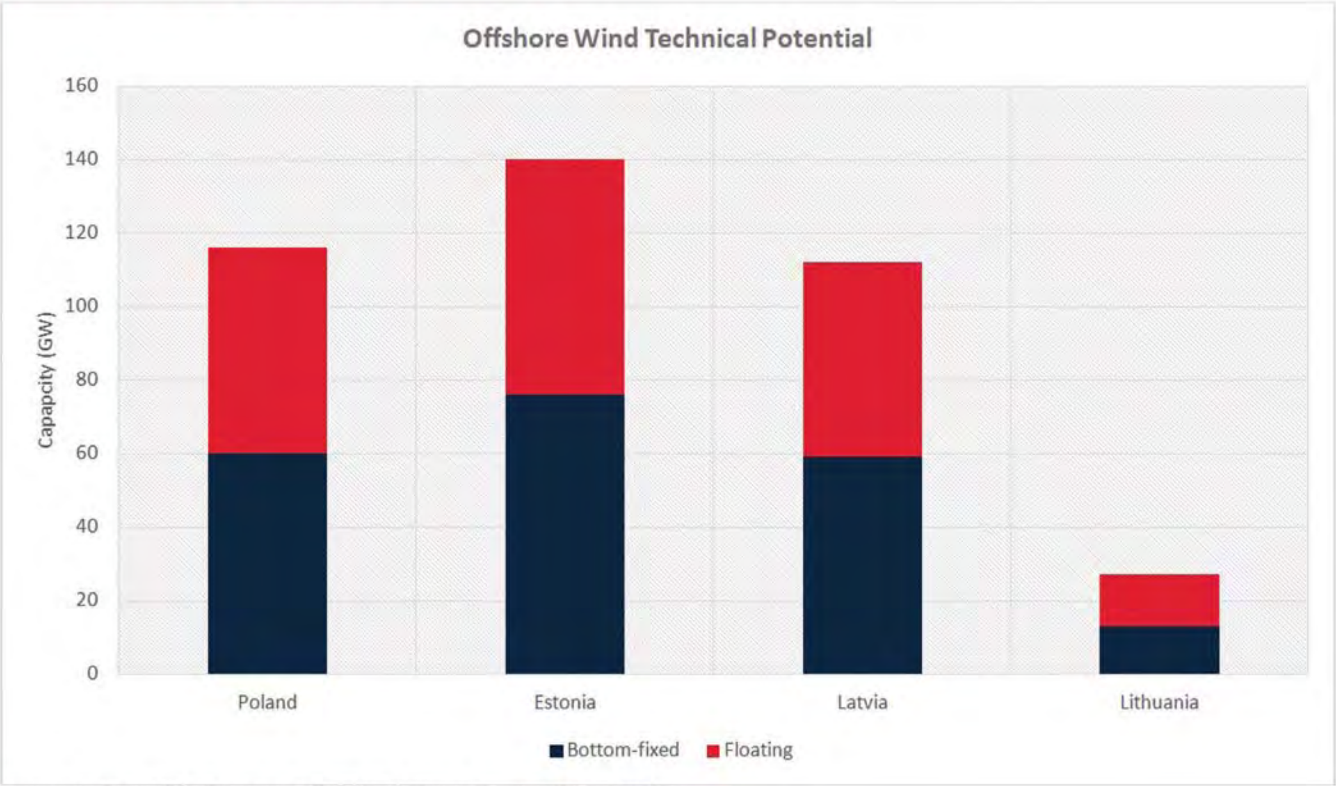
OFFSHORE WIND POWER WILL IMPROVE ENERGY SECURITY FOR POLAND AND THE BALTIC STATES

In 2024, the first Polish projects will enter the construction phase, and Baltic projects will follow soon after. At stake is the reduction of energy dependence on fossil fuels.

By Tomasz Laskowicz, Researcher at Intelatus Global Partners

Exhibit 1 Offshore Wind Technical Potential



Source: Intelatus Global Partners, World Bank Group, Esmap, GWEC, OREAC

Due to risks associated with Russian fossil fuel supplies, Poland and the Baltic countries, Lithuania, Latvia, and Estonia, have found themselves in a difficult position in terms of security of supply and stability of energy prices. The energy mix of each country differs. Poland relies most heavily on coal (almost 80% of its electricity production), Lithuania and Latvia produce energy from renewable sources and natural gas, and Estonia continues to exploit its own oil shale resources.

As a result of the war in Ukraine, Poland and the Baltic States have gained additional motivation to develop offshore wind energy even faster. Neither of these countries has built any offshore wind to date. Other countries in the Baltic Sea basin have also made very little use of the Baltic's energy potential.

Despite its relatively shallow depths and good wind conditions, only ten wind farms currently operate in the Baltic Sea, with a total capacity of 2.35 GW. The Arcadis Ost 1 wind farm recently started construction in the German section of the Baltic Sea. The largest wind farm in operation in the Baltic Sea is the 605 MW Danish Kriegers Flak project, commissioned in 2021. This situation may change in the next few years.

In August 2022, in Marienborg, Denmark, representatives of the EU countries of the Baltic Sea region, announced a target of installing 20 GW of offshore wind capacity by 2030. The technical potential for installing offshore wind turbines in Poland and the Baltic countries is 395 GW, of which about half can be installed as bottom-fixed turbines.

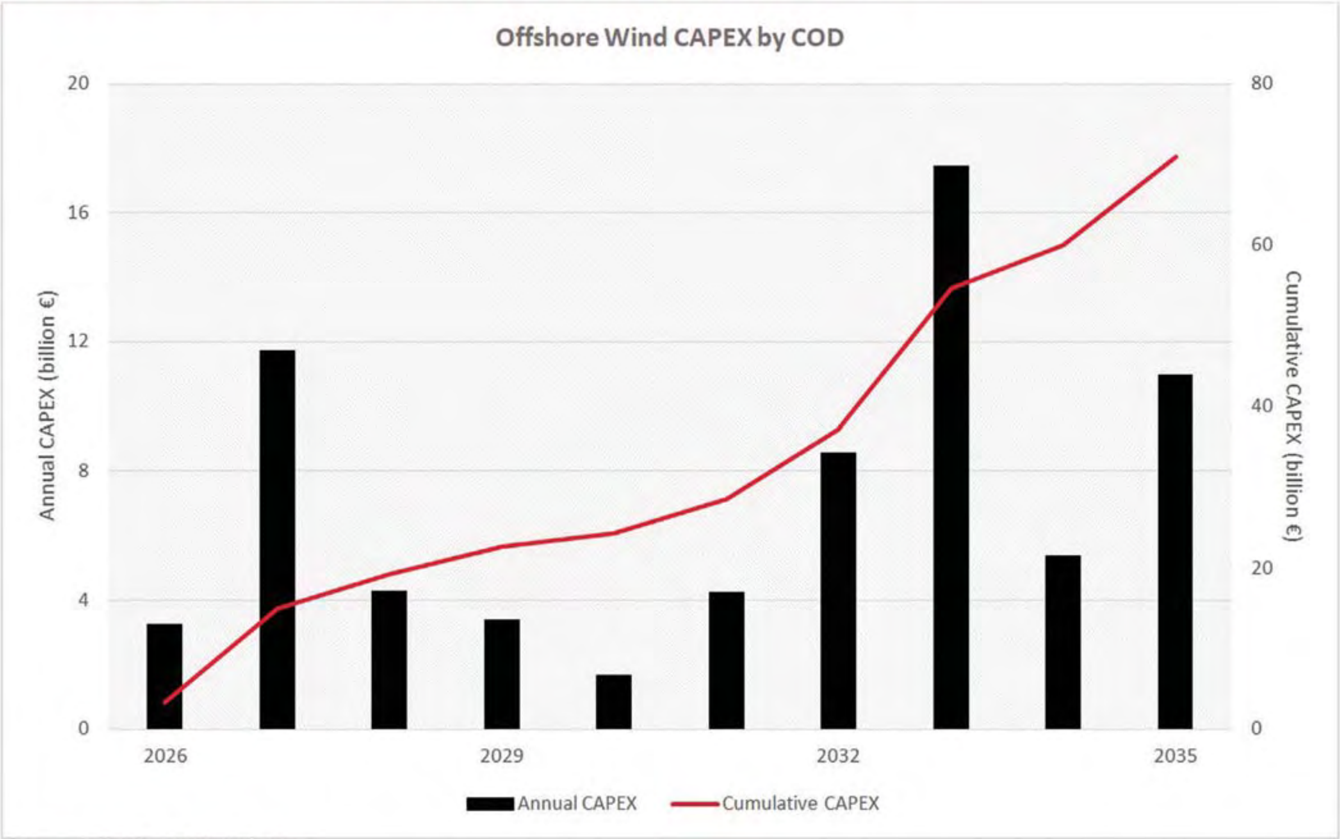
Poland is at the most advanced stage of preparation for an offshore wind project in the region and intends to put 5.9 GW of wind farms into operation by 2030.

Its footsteps are already being followed by the Baltic states, which are preparing to announce auctions. By 2035, the total value of installed wind farms in Poland and the Baltics is estimated to reach 30 GW, requiring investment of over €70 billion. As a result of construction and many years of operation, this market will offer numerous development opportunities for the local offshore sector.

Efficient permitting process key to stronger energy independence

More than 30 projects are being developed in Poland and the Baltic States. Despite the determination of govern-

Exhibit 2 Annual and Cumulative CAPEX Forecast in Poland and Baltic States



Source: Intelatus Global Partners

ments to accelerate offshore wind development, dedicated legal solutions are just beginning to be implemented. None of the ongoing development projects have yet obtained a complete set of permits.

Possible issues that could hinder the development of offshore wind farms in the region, include areas excluded due to defense activities, shipping routes, and opposition from the tourism, fisheries, and coal-based energy sectors.

So far, Poland has enacted a special law to promote offshore wind energy development, under which projects have applied for a support scheme that awards guaranteed offtake prices.

Support was granted in 2021 to 7 projects of 5.9 GW total, which are currently at an advanced stage of obtaining environmental and construction permits and must be fully commissioned no later than 2028 in order not to lose support.

The projects in the first phase of support in Poland are being developed by joint ventures, consisting of a local entity and an international partner experienced in the offshore industry. The total CAPEX for the construction of Polish projects in the first phase of support will be as high as €16 billion.

Important players in the Polish market are state-owned companies, responsible for the largest offshore wind projects together with their international partners.

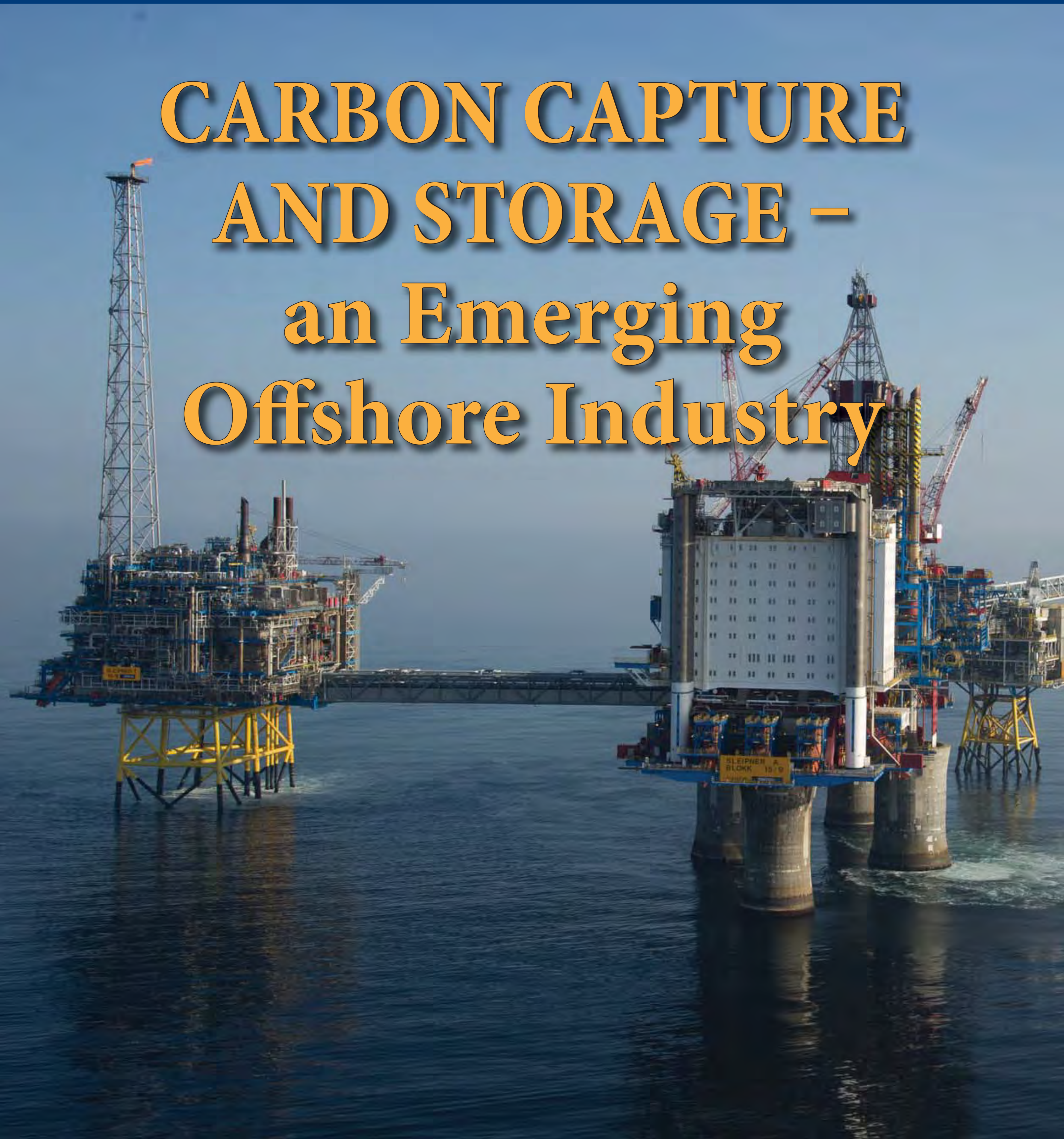
The largest identified clusters in the Polish zone are the PKN Orlen-Northland Power cluster, with a capacity of 1.2 GW; the PGE-Orsted cluster, with a target capacity of 3.4 GW; and the Polenergia-Equinor cluster, with a target capacity of 3 GW.

New projects in the Polish zone are pending proceedings for 11 sites, with decisions expected in the first half of 2023.

Lithuania has so far announced two auctions for wind farms of 700 MW each; the first will take place in the second half of 2023. The 1 GW Latvian-Estonian Elwind project is to be built by 2030, with the final location approved in October 2022.

Estonia plans to develop projects in three clusters: in the Gulf of Riga and in the vicinity of Saaremaa and Hiiumaa islands. The largest project under development in Estonia is Saare-Liivi (5.9 GW) by Utilitas Wind OÜ. Once the approvals are complete, further challenges are expected, among them a lack of existing port infrastructure and limited local and international supply chain resources.

CARBON CAPTURE AND STORAGE – an Emerging Offshore Industry



Oyvind Hagen - ©Equinor

We are heading towards 2.2°C of global warming - the uncomfortable conclusion of DNV's recent Energy Transition Outlook report. Closing the gap between our current 2.2°C trajectory and the 1.5°C future we need requires significant deployment of carbon capture and storage (CCS) technologies.

By Jamie Burrows, Head of Business Development – CCUS, Energy Systems at DNV

We are heading towards 2.2°C of global warming - the uncomfortable conclusion of DNV's recent Energy Transition Outlook report.

Closing the gap between our current 2.2°C trajectory and the 1.5°C future we need requires significant deployment of carbon capture and storage (CCS) technologies. CCS is required to decarbonize hard-to-abate industry and hydrogen production, but can also be used to address entrained CO2 produced with hydrocarbons.

Reflecting growing recognition of its importance, the CCS project pipeline has grown significantly in recent years. The Global CCS Institute's 2022 annual status report shows that 61 facilities were added to the pipeline in the last 12 months, taking the total in operation and development to 191 and representing an annual capture capacity of 244 million tonnes.

Many projects in development plan to store CO2 offshore. The first facility to do so was Equinor's Sleipner in Norway. Following the 1991 introduction of a tax on offshore emissions, it was recognized that returning CO2 produced with natural gas to the geosphere would be both environmentally beneficial and economic. Operating since 1996, Sleipner has now stored over 20 million tonnes of CO2 deep beneath the seabed in the Utsira formation.

Today, a new Norwegian project - Longship, and its transport and storage facility, Northern Lights represent a major milestone for global CCS deployment. Currently in construction, the project will be the first to use ships to transport CO2. This will enable emissions to be captured from industrial sources across Northwest Europe. Captured CO2 will be shipped to a receiving terminal in Øygarden and sent via a 100km pipeline to a location south of the Troll field where it will be injected to 2600m below the seabed. First injection is anticipated in 2024 and a second phase is currently in development.

Around the North Sea, many other CCS projects are emerging that plan to store CO2 offshore.

Some of the more mature ones are Greensand in Denmark, Porthos in the Netherlands, and the Northern Endurance Partnership in the UK.

As the storage facility for the East Coast Cluster, the

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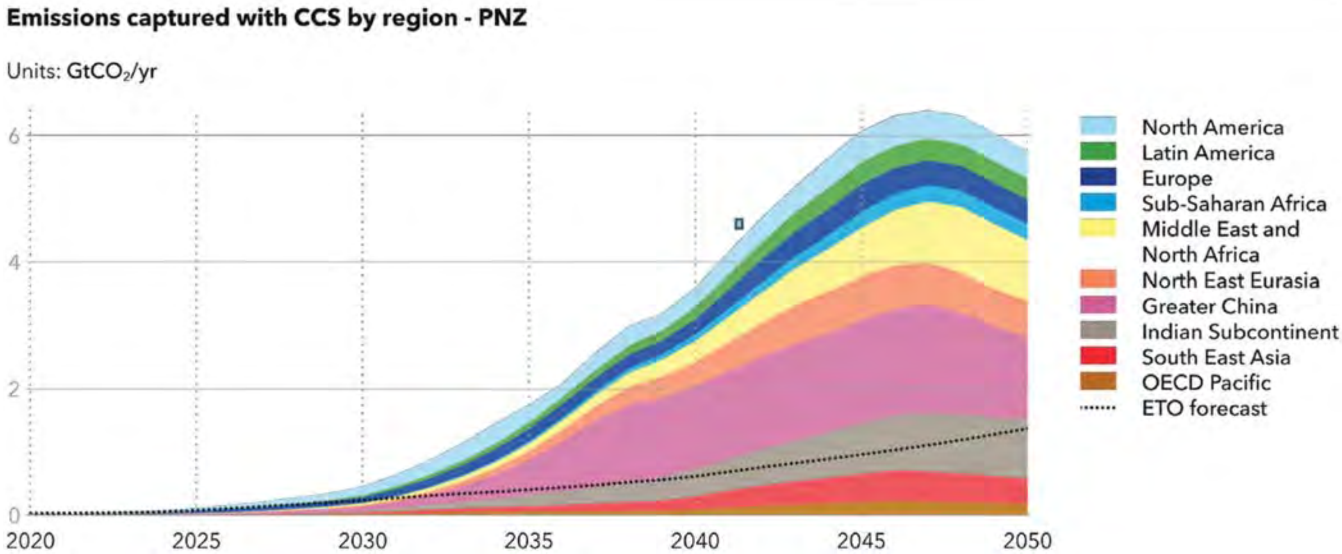

Northern Endurance Partnership will store CO2 from industrial emitters in Teesside and Humber in the Endurance deep saline reservoir.

In Europe, avoidance of regional carbon taxes, as well as specific policy mechanisms, such as those being established in the UK and the SDE++ in the Netherlands, are enabling projects. In parallel, the potential to re-purpose hydrocarbon pipelines and depleted reservoirs can help to reduce Capex costs.

While the greatest concentration of offshore CO2 storage projects is in Europe, this is by no means the only region where such projects are emerging. In recent years several projects have been announced in the Gulf of Mexico. The most ambitious of these will store emissions from refineries and industrial sources along the Houston ship channel. The Houston hub led by ExxonMobil is exploring plans to store 50 million tonnes of CO2 annually by 2030 and double that by 2040.

In Asia several projects have emerged that will store CO2 associated with offshore gas production. PTTEP is developing a CO2 storage facility as part of its major Lang Lebah gas development offshore Sarawak. It is estimated the reservoir may contain 17 per cent CO2.

Petronas has recently announced a Final investment decision (FID) for what could become the largest offshore CO2 storage project globally. As part of the Kasawari development, the facility is expected to sequester more than 3 million tonnes of CO2 annually. Building on this project, Petronas aims to develop Malaysia into a regional CCS hub, potentially storing CO2 for emitters across the region. Other projects are in development in Indonesia, Timor Leste, Australia and China.

With a focus on driving down costs, many Carbon Capture innovations are in development. In several locations floating storage and injection concepts are emerging such as Stella Maris in Norway and DeepC store in Australia.

Driven by emerging emissions regulation, a number of organizations are exploring the use of Carbon Capture technologies to tackle emissions from ship engines.

Whilst new-build vessels may in future use zero-carbon fuels such as hydrogen and ammonia, the decarbonization of existing vessels will remain crucial. With CCS value chains emerging at major ports such as Rotterdam, Singapore, and Houston, access to storage is likely to be available.

The Global CCS Institute forecasts that to deliver Paris climate commitments, we need to scale up current CCS capacity more than 100 times by 2050, requiring a significant deployment. Increasing demand for offshore CO2 transport and storage infrastructure is likely to present a growth opportunity for the offshore industry in the coming years.

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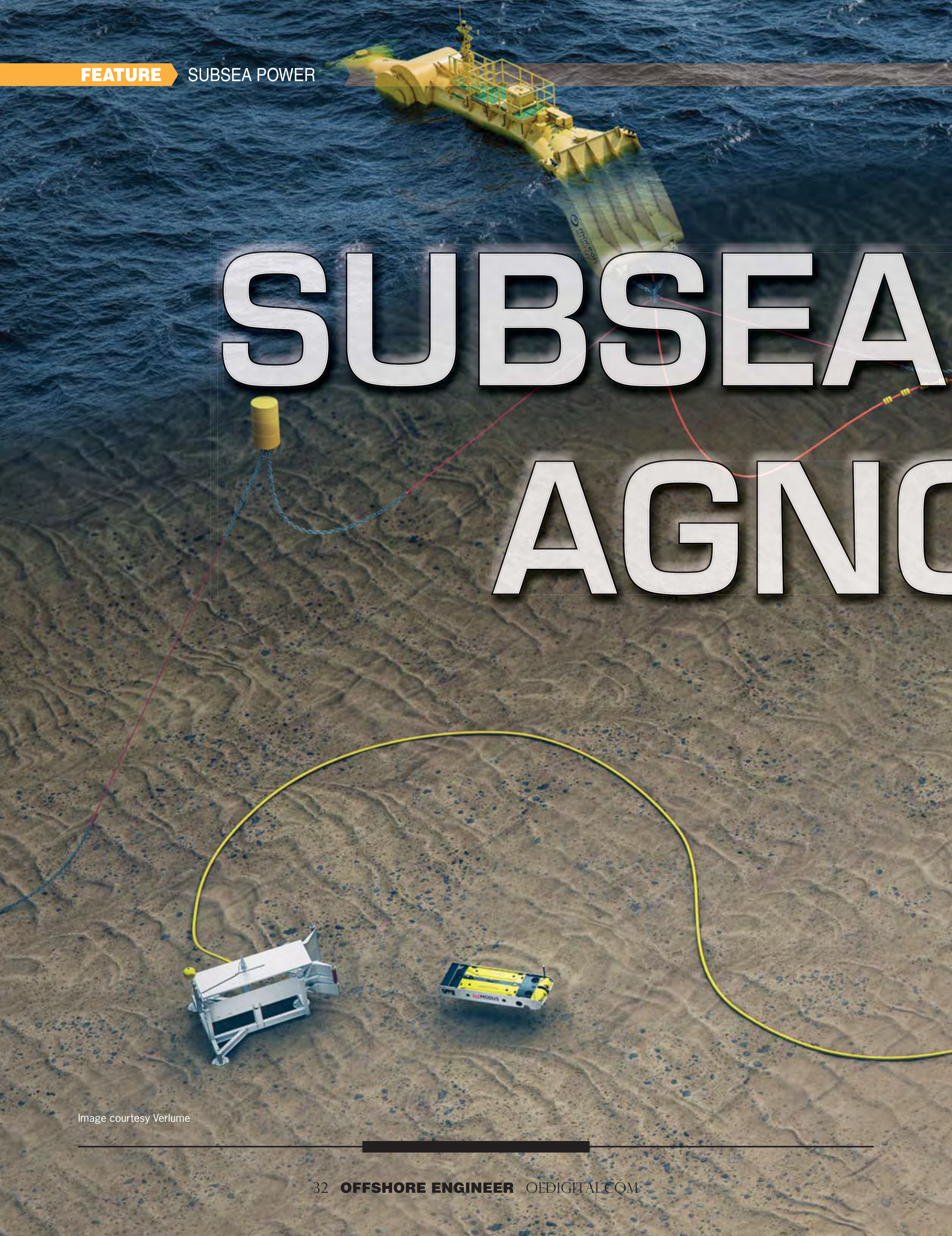
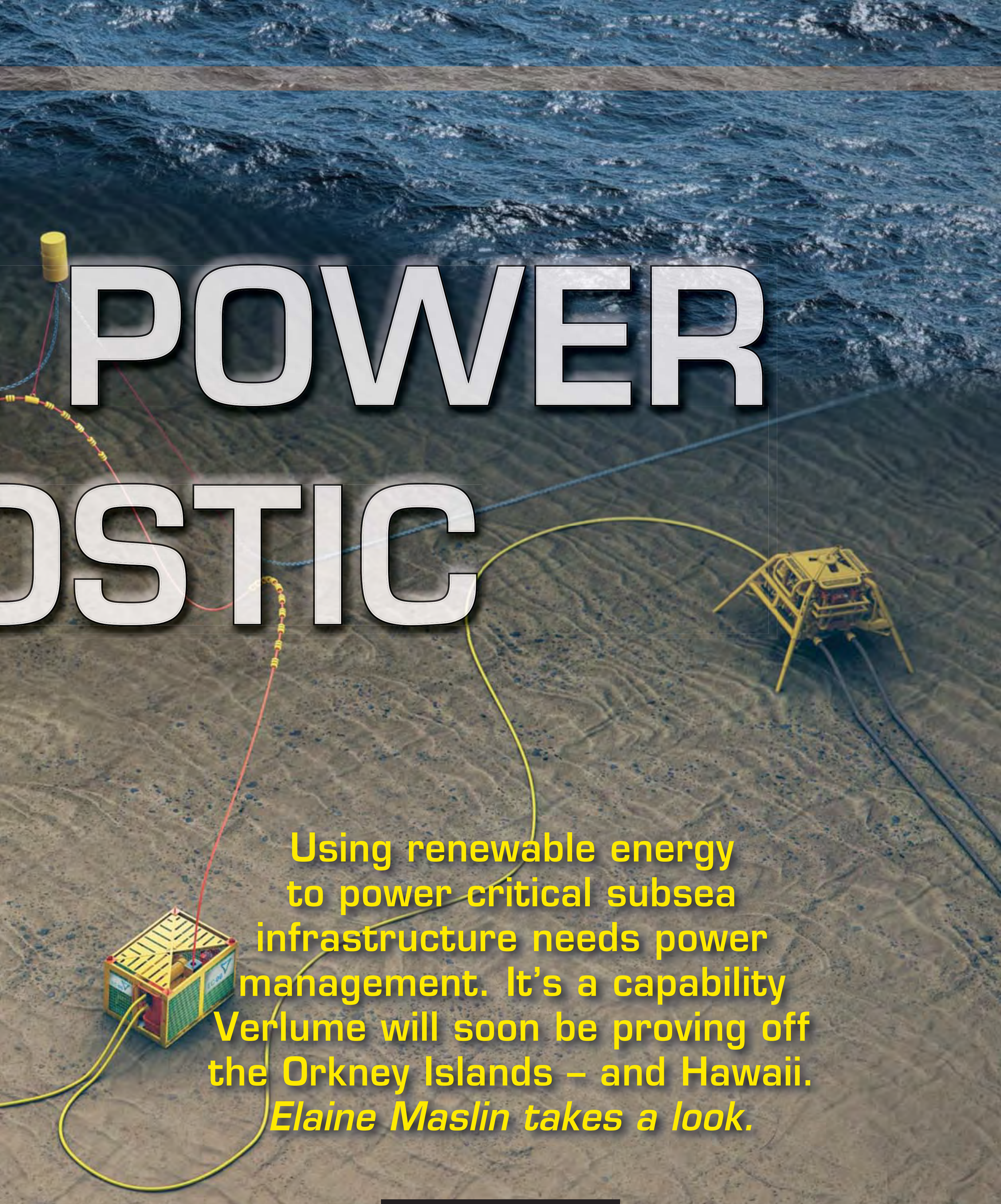


SUBSEA AGNO

Image courtesy Verlume



POWER
OSTIC

Using renewable energy to power critical subsea infrastructure needs power management. It's a capability Verlume will soon be proving off the Orkney Islands – and Hawaii.

Elaine Maslin takes a look.

Integrating offshore renewables into offshore operations has become a major goal for oil and gas companies.

A remote power supply could improve project economics for long step-outs, where they replace long power cables. Powering facilities from a nearby offshore wind park could help reduce the carbon intensity of oil and gas production. But how do you balance that power – ride out intermittency – to provide a stable supply to what could be critical applications?

It's a challenge many, from navies to offshore wind parks hoping to integrate vessel charging, are mulling and one Aberdeen, UK, based engineering firm Verlume is offering to solve.

The company has come a long way since it was founded in 2013. One of its goals then was to develop a tidal energy-based solution that could supply local power to subsea infrastructure, removing the need for power umbilicals.

Indeed, the company launched its own kW-scale subsea Powerhub concept in 2017, comprising three of its own vertical axis tidal/ocean current turbines, connected to direct drive DC power generators and in turn batteries to store power.

ENERGY AGNOSTIC

Today, as focus on transitioning to renewable energy has ramped up, Verlume's sights are much broader.

It's now energy generation agnostic, says Paul Slorach, the firm's chief technology officer, who has been working with Verlume founder Richard Knox since the firm started, meaning it's happy to work with any renewable energy technology, and it's also looking a much wider range of power users.

Providing power for brown and greenfield subsea production infrastructure was the initial goal. But before the end of this year (2022), Verlume will be starting demonstrations involving two different wave energy devices, from third parties, working with US defense organizations as well as oil and gas operators and service companies in Scotland and Hawaii. The company is also working with wind energy developers, an underwater robotics technology developer, and more.

It's all about delivering power. Slorach says there are a number of energy sources – including even degraded power umbilicals – but they are largely variable and or intermittent, so there needs to be a good way to connect them to users that need a constant power supply available.

That's now Verlume's niche – to be the middleman via energy storage and management. It also means that the company can select an appropriate power source for specific use cases or particular site characteristics.

HALO

Its core technology is its Halo energy storage system, which includes its Axonn intelligent energy management system. Halo is a modular (scalable), battery-based energy storage and management system.

It takes in power from a variable or intermittent producer, such as a wave energy converter, and stores it in batteries – currently lithium ion, as they're the most reliable and advanced in the market for the scale they're operating at, explains Slorach.

Verlume both manufactures its own battery modules from standard cells and buys third party modules – used for EVs like the Nissan Leaf, as well as trains, buses and even JCBs – assembling them into packs that then form its systems.

A key part of Halo is the Axonn, which ensures reliable, stable power to multiple payloads, via software, firmware, and hardware. This includes an output management system, for autonomously managing multiple power outputs.

In simple terms, it's the bridge between intermittent renewable energy production and power users that need reliable, stable power, says Slorach, whether that's low power over long periods, short duration high power use, or fast-charging of subsea vehicles. In-built into the system is wireless communications for applications where an umbilical has failed or for communicating with subsea vehicles.

RENEWABLES FOR SUBSEA POWER PROJECT

Two demos are currently imminent. In December, one of its Halo units will be deployed offshore Orkney, Scotland, alongside a wave energy converter (WEC), subsea controls infrastructure, and an underwater vehicle, as part of the Renewables for Subsea Power project. The project is supported by the Net Zero Technology Centre (NZTC) in Aberdeen, Harbour Energy, Serica, and Mocean Energy (the WEC provider) and Transmark.

This will see wave energy firm Mocean Energy's 20m long, 56-tonne, 10kW rated Blue Star 10 wave machine coupled with Verlume's third Halo system to demonstrate the ability to work reliably with subsea systems, such as oil and gas wells, carbon capture and storage sites or even subsea vehicles.

Verlume

Halo under construction

Verlume

Verlume

Robert Heron,

Product Manager for Verlume's Axonn

The project includes testing these systems with Semstar5 subsea electronics equipment from Baker Hughes (although not connected to any live facilities), with which Verlume and Mocean have a non-exclusive memorandum of understanding on these types of projects, and Norway-based Transmark Subsea's ARV-I autonomous underwater vehicle (AUV).

Verlume has already proven the ability to power a commercial subsea control module (SCM) through trials in 2019 using lithium-ion batteries and Verlume's energy storage and intelligent energy management system.

Slorach says, "This trial is not proving we can provide power, it's proving we can provide the right uptime to support a subsea production system. It's proven we can provide power, that the batteries can provide power, it's how to keep on station, the connection to systems and communicating with it. Those are the unknowns."

TESTING IN HAWAII

The firm is also working with C-Power in the US on a demonstration at the US Navy's Wave Energy Test Site (WETS) in Hawaii, also due to go in the water as we go to press. There, C-Power's 2kW SeaRAY** surface-based wave energy converter is due to be moored and connected to a 55kWh battery capacity Halo system via a single combined communications and power cable/mooring system down to the seabed. This project will see a number of payloads connecting to the Halo for power (max ca. 3kW), including a Sabertooth AUV in untethered mode, a BioSonics sensor package, and a Franatech leak detection device. Two-way communications to the beach will be via the WEC at the surface.

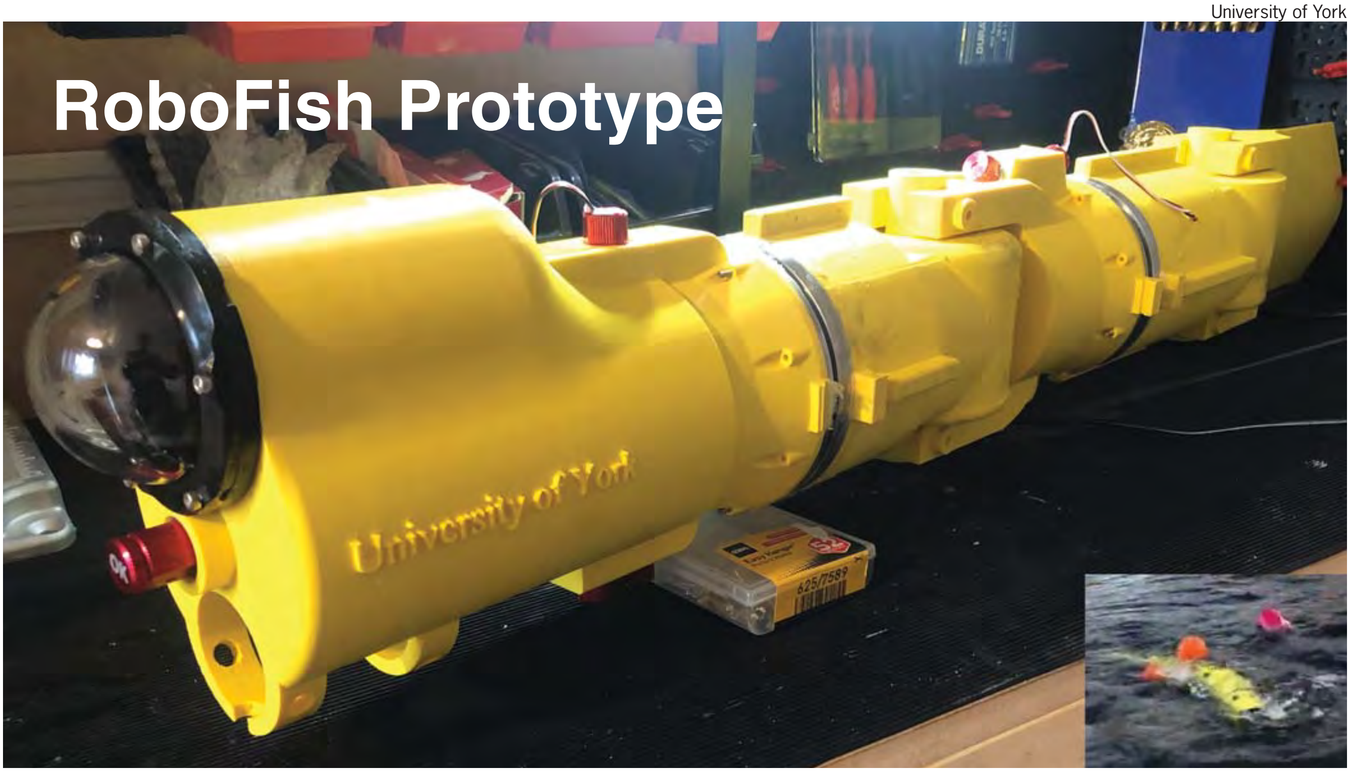
For the Hawaii demonstration, they're using dual chemistry batteries. This means that different packs within the system can be used according to the requirement – i.e. longer use with a low load or shorter term higher load – alongside an auxiliary pack.

MICROGRIDS

Verlume also has two projects with the NZTC. One is looking at sustainable subsea microgrids with Glasgow Caledonian University, aimed at supporting the UK's Innovation and Targeted Oil & Gas (INTOG) program – a targeted leasing round that encourages the use of wind energy to power offshore oil and gas infrastructure. Combining offshore wind with gas turbines in a micro-grid creates control system logic challenges, says Slorach, which they're trying to resolve.

It's also working with German utility RWE after winning the operator's first international innovation competition in July this year. Several use cases are being explored, including recharging vessels, e.g. crew transfer vessels and potentially service operation vessels (SOVs), within an offshore wind farm. "Black start" (i.e. when wind turbines are not yet producing power but need some to get started) and load

University of York



balancing for electrolyzers are other potential use cases.

Another opportunity is to be a buffer for short-term ramp events. This is when the wind does an about-turn, and the power generation drops through that turn.

"It's a huge problem for the renewable grid," says Slorach. "Providing a level of storage at a turbine level could balance that out." This would be particularly beneficial in floating wind, he says, where it would be cheaper to put the storage and management system on the seabed, he says, where it also has the right environmental conditions for operating (natural cooling).

Verlume is also working with Oasis Marine Power to look at what an offshore 'fuelling' station could look like, for vessels and subsea vehicles.

ROBOFISH

It's also supporting an underwater robotics project, RoboFish, that's targeting offshore wind inspection work. This is a biomimetic AUV initially devised by researchers at the University of York, Department of Electrical Engineering, and the University of Strathclyde, Department of Naval Architecture, Ocean & Marine Engineering, with grant support from the EPSRC Supergen Offshore Renewable Energy Hub. Verlume is advising on the underwater power system for charging, as well as an integrated intelligent battery management system.

"(Seabed residency) is getting closer to becoming accepted by operators," says Slorach, particularly with the example being set by Equinor. But oil and gas operators are not the only ones eyeing this technology, he says. "Within the defense community, there's been a much higher level of interest over the last 24 months," says Slorach. "The projects we're doing now are being watched by offshore wind, oil and gas, and defense."

There's a lot going on. As well as all of these projects, the company recently moved into a new 20,000 sq ft facility (six times the size of its previous operational base) in Aberdeen, giving it space for manufacturing, development, and testing. The (power) umbilical may finally be about to be cut, and much more besides.

*Mocean is also working on Blue Star 10 – a 10 kW machine based around the Blue X design, which will begin commercial trials in 2023. In parallel, it's developing its next-generation Blue Star 20, a 20 kW machine based on a new optimized geometry, which will include solar panels and a novel direct-drive generator, with trials and rollout targeted for 2024-25.

**SeaRAY is configurable from 750W to 25kW. C-Power also has a StingRAY design, for utility-scale power, and TigerRAY, a "next generation SeaRAY", built for the University of Washington Applied Physics Lab to conduct a US-Navy sponsored project to investigate at-sea charging of unmanned underwater vehicles.

Floating Power: Electricity and Future Fuels

By William Stoichevski

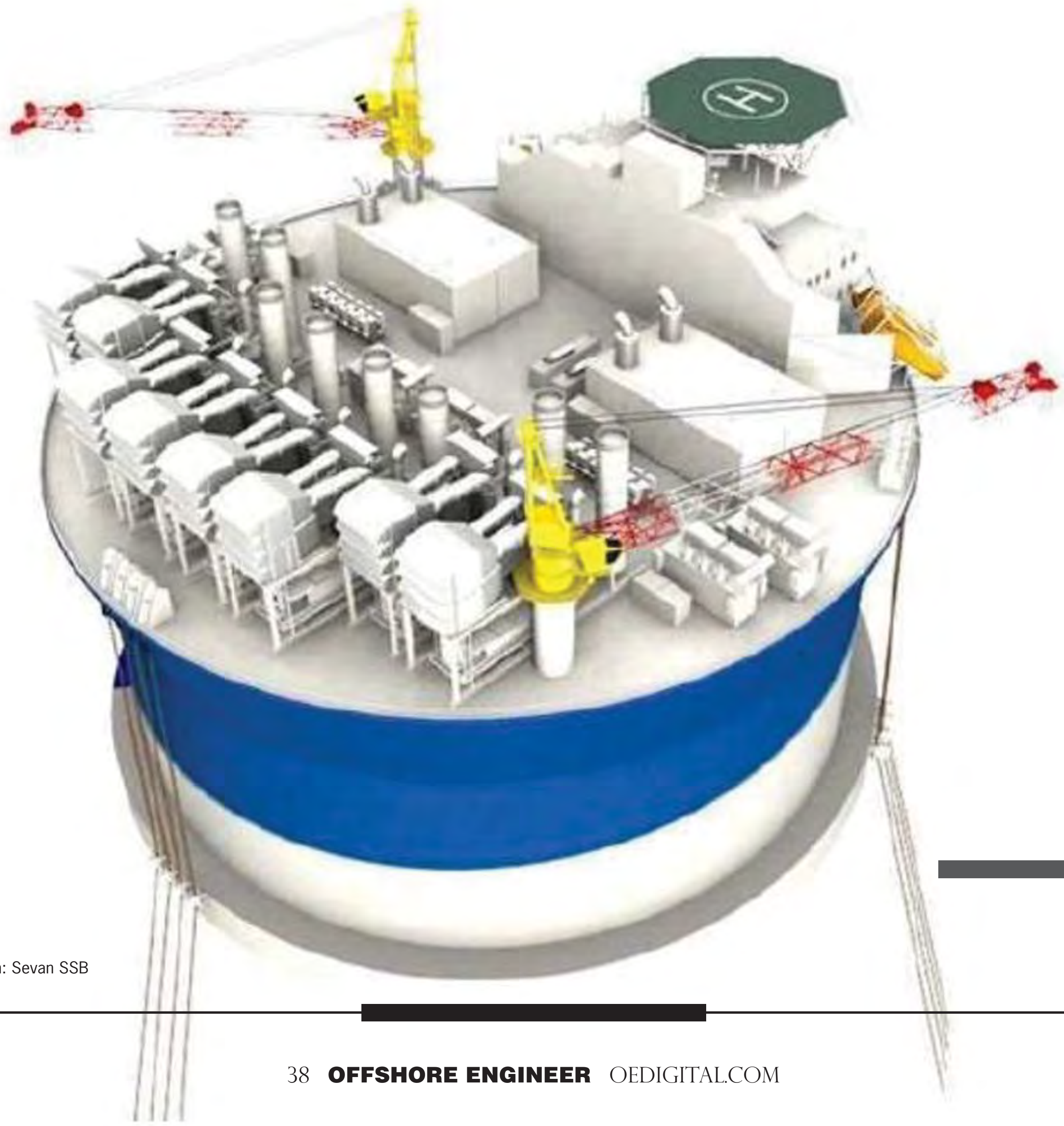


Illustration: Sevan SSB

Beyond shoreside hotel power, there's floating, utility-sized power, or floating power plants. At the core of these are some familiar names in marine propulsion and national grid power — Wartsila, Siemens Energy, MAN Energy Solutions. Challenging the status quo and working with these paradigm power producers are consortia of companies from the renewables and offshore sectors. Driving development are developing-world demand, the renewal of diesel plants, subsidy and electricity shortages worldwide. Sweetening the pot is a chance to produce unproven fuels hydrogen and ammonia.

Low-water marks in reservoirs that once provided the cheapest electricity in Europe now trigger electricity price shocks and national power-bill bailouts in the world's richest country. The government action here and everywhere during the 2022 energy crisis are stirring new faith in power projects. What follows is a survey of floating power players and projects with heavy backing.

In Norway, going greener has pushed bewildered politicians into supporting the electrification of oil platforms from land. That has helped jack-up power bills, as the raw, equivalent diesel power required by an offshore oilfield can be equated to the power needs of a city. The solution, says a coalition of companies in Norway, is floating gas-fired power plant, or FGPP, that captures and injects carbon-dioxide into subsea reservoirs and can send power to shore.

As elsewhere with emergent floating power, Siemens Energy is at the core of Norwegian designs to float a gas-fired power plant, or FGPP, out to somewhere between land and power-hungry offshore platforms. Together with gas process engineers, Kanfa, Siemens Energy is part of the Blaa Stroem (Blue Power) alliance that aims to put a GPP aboard a Sevan cylindrical rig and sequester and pump the CO2 it produces, its flue gasses, into the oilfield reservoir as "gas lift" to keep pressure and oil production up and increase reserves: or just to store the maligned gas permanently in a saline aquifer. The floater's tanks could be used to store fuel, CO2, well stream or, conceivably, hydrogen — turning "grey" (flue-gas derived) hydrogen "blue" (produced via steam methane reforming, or SMR, with carbon capture and storage/sequestration, or CCS). H2 can also be derived from heated sea water (electrolysis) or directly from natural gas.

Floating Gas Plant

Yet, there's much more to the idea's potential than meets the eye. A Sevan SSP engineer ***Maritime Reporter*** spoke to says the concept is very scalable for shoreside power production if desired. Conceived by Erling Ronglan (who studied at Norway's answer to MIT, NTNU), the project's heart is technology from a "start-up" called Ocean GeoLoop, part of a greater alliance that includes Siemens Energy and others under the Blaa Stroem umbrella.

"The business model is to connect with (offshore or grid) operators in order to provide offshore power to their installations," Ronglan says. "There's a discussion in Norway right now on power from shore to sites offshore, but this is an alternative and a better way of utilizing electricity and producing it locally and using it locally."

Launched two years ago, the combined Ocean GeoLoop carbon capture storage and utilization tech, or CCSU, and the floating offshore or nearshore GPP attracted shareholder Chevron in September. Yet the plan — to power the platforms and, possibly shore — offers the chance to produce "blue H2" and "blue power". Hydrogen is central to an EU scheme to get largescale (but very modular) H2-electrolyzers producing ammonia fuel and H2 fuel cells onto BMW's — ASAP.

Dual-use: an engineer's design of an SSB GPP able to supply electricity to both offshore installations and onshore population centres while sequestering carbon-dioxide.

Methane-driven: Wärtsilä's triumphal Kivuwatt FPP floating in and drawing methane from Lake Kiwu, Rwanda, in 2016.

Wärtsilä

Chevron's $10 million investment in the concept gives the major greener hydrocarbon production and, if desired, upstream and downstream gas and electricity — or even tradable carbon credits for the sequestered CO2 — plus the inherent earnings.

Ronglan, an FPSO expert with Sevan, is aware that Siemens already has a number of floating barge power concepts (keep reading!). The Ocean GeoLoop/Ocean-Power CCSU tech can alone, or with a GPP, also be barge-mounted. In the Blue consortia, Siemens Energy is providing engineering plus the floater's grid equipment and FGPP's combined heat and power gas- and steam turbines and generators.

The FLPP-produced electricity offshore is seen costing from about $0.03 to $0.05 per kilowatt hour, or far less than prices charged by Norway's land-based gas-fired power plants. Current electricity prices on land soared recently to as much as $0.70, before settling back down with government to about $0.27/kWh, on average.

CCS-to-Power

The cylindrical FPSO-style FGPP would bring CCS offshore while sourcing gas fields for fuel.

"CCS … and yes power, because the idea of a GPP is to sell electricity and get fuel gas from a nearby host and produce electricity to sell to nearby platforms. But, also onshore. There is that possibility. Power cable is for any purpose, including power to shore. What we're providing the Blue Power partners is electricity sales."

Using traditional gas turbines, "There is nothing new in that, but the exhaust from those turbines is where we use the GeoLoop tech in order to capture CO2 from the exhaust," Rogland says.

A barge of the same tech would work nearshore. The FGPP's draft can be reduced, and plant weight is but a fraction of a storage tank. Its (beam) is "very small".

"The draft is no problem. You can keep it quayside," he says, when asked if it could function in FGPP-only mode.

With Siemens turbines providing primary gas-fired power, or heat and power, Ocean GeoLoop's CCS tech may also provide surplus electricity. While still in the pilot-stage, well-entrenched backers can rejoice at the Ocean GeoLoop's successful capture of phosphorous from a papermill's water supply, another aspect of the loop. The turbine tech also seems to show that any flue

“We haven’t done any benchmarking, but for a newbuild like this — with all the facilities available at a typical yard — it should be cheaper than purpose-building (a GPP with CCS) somewhere on land … The hull doesn’t drive costs much, and inshore, we might change to a different hull to be cheaper to construct.”

Erling Ronglan, Ocean GeoLoop

Ocean GeoLoop

gas can be captured and “burned” for electricity production. The papermill pilot is succeeding in parallel with an industrial-scale CCS build-up. The “applied CCS”, or CCUS — “utilization” — is partly aimed at offering industry extra electricity.

Self-Finance

“We’ve not indicated a timeline for this second generating technology, whether onshore or offshore, it’s the early sprint from the design stage,” said Ocean GeoLoop CEO, Oddgeir Lademo, who cautions that, “It’s too early to say how the system will link to CCS. The CCS-power-generation part is a work in progress.” Moreover, “Utilization of the e-Loop is expected to provide significant positive cashflow effects through sale of surplus energy to the emitters and/or downstream users.”

Company documents laud the “embedded electricity generating capacity of the e-Loop”, from which surplus power is derived from the “100-percent” of flue gases captured by its “point-source” process unit. “The technology is designed to achieve … unprecedented capacities,” including being “100-percent self-financed” plant, where Ocean Power or its industrial clients can produce electricity to cover its operation with a surplus sold to clients. The process plant, the company says, «mimics nature» by using small heat differences between liquids and gases to power a hydropower turbine.

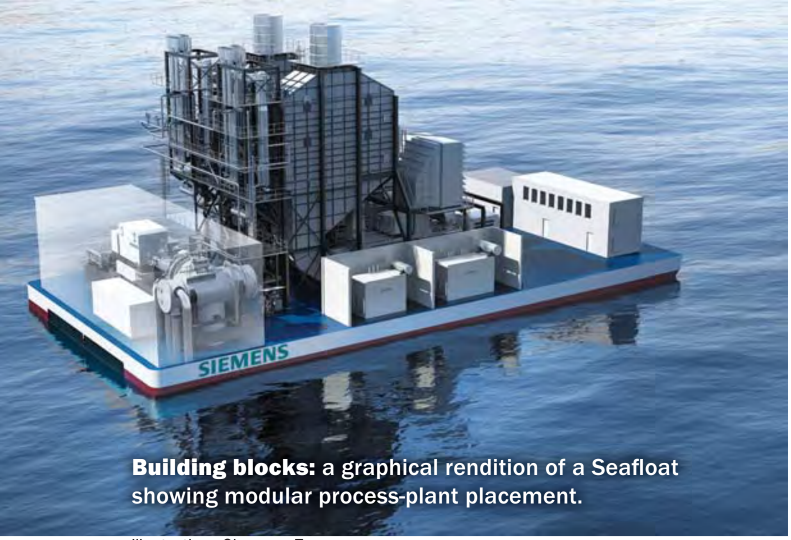
Siemens Energy

While the Norwegians look offshore with concepts that also serve shoreside industry and potentially “regions”, Siemens Energy’s flagship FGPP, Seafloat, keeps evolving and “is relevant for all locations with access to the sea or large river systems”.

“SeaFloat can replace conventional power barges which often run on diesel or heavy oil,” says Siemens Energy SeaFloat sales lead, power plants, Stavros Zissis. The most recent SeaFloat, the del Mar III, was put together in Singapore by shipyard and gas plant fabrication crews. Modular Siemens plant was hoisted onto a fabricated barge which was no match for the season Sinaporeans accustomed to mammoth semisubmersible builds. The voyage of Estrella del Mar III showed it piggybacking onto a heavy lift vessel and passing on its barge through narrow canals.


Floating power: the arrival in downtown Santo Domingo of a Siemens Energy Seafloat, complete with energy storage.

Siemens Energy



Building blocks: a graphical rendition of a Seafloat showing modular process-plant placement.

Illustration: Siemens Energy

Seafloat

"You cannot simply put a gas turbine constructed for land-based applications on a floating vessel," Zissis says, adding that SeaFloat GPPs are "marinized" tech "optimized" and specially made "to withstand motions, accelerations, and hull deflections".

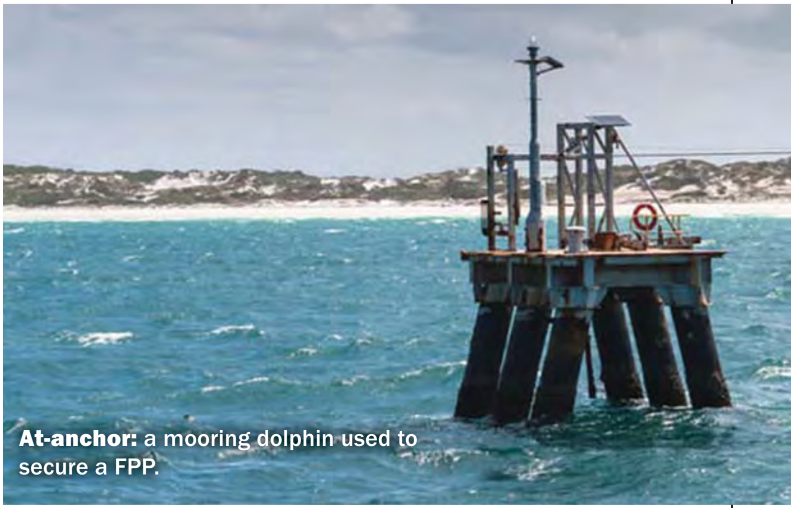
"The gas turbine and steam turbine packages are installed on three-point mounted frames, forming single-lift structures that facilitate and expedite the installation and erection efforts at the shipyard. It's like putting together big LEGO bricks," he says. SeaFloats, he adds, are "wet- or dry-towed" from the shipyard. The barge's layout and size are dependent on whether the unit is fully integrated with LNG storage, regasification and power plant — the Siemens FSRP concept — or related to power output.

The 150-megawatt (MW) combined-cycle Estrella del Mar III began powering the Dominican Republic with its two SGT 800 gas turbines in 2022, two years after being ordered. It has "5 to 10 megawatts" of power from energy storage onboard for "primary frequency response". SeaFloats mainly come in 145/150 MW, 220 MW, and 300 MW models — increasable by lifting aboard more "blocks", modules that might in future be hydrogen electrolysers to enable both H2 and ammonia production. The LNG storage capacity can reach 180,000 m3. The barge itself can be floating, fixed, or bound to a mooring dolphin, a steel construction piledriven into the sea or river bed and visible above water.

The Estrella del Mar III is reportedly "quieter" than downtown Santo Domingo, where it's moored. Its size — 80m x 35m — is half the size of a comparable, land-based plant.


Shipyard-capable: The Seafloat hull as it appeared in 2021 when completed in Singapore.

Siemens Energy


At-anchor: a mooring dolphin used to secure a FPP.

Greens Bayou Pipe Mill

Propulsion Players

Propulsion powerhouse Wärtsilä is also a major provider of grid power in the United States.

Wärtsilä delivered the FPP Dominican II to the same Caribbean nation. The Finland-based company has also delivered diesel FPPs, and now gas or dual-fuel power plants are sought, as they allow for the switching of fuels as markets and supplies swing. Combined cycle heat and power steam turbines and desalination are offered as options. "When required, various NOx and SOX reduction options are available," a commercial note says. "When natural gas becomes available, plant can be converted". How's that for flexible fuel!

Like the other barge and cylindrical "drum" FGPPs, Wärtsilä points to "short construction time" for barges that range in length from 64.8 m to 90 m. All are 27.4 m across.

Air intake filters below exhaust outlets, roof-mounted ventilation and radiators make models like the Wartsila 32 Power Barge ideal for the tropics. Between 1990 and 2011, FGPPs in Bangladesh and Papua New Guinea joined two in the Dominican Republic on the Wartsila hot weather, salt water client list.

MAN Energy Solutions

MAN Energy Solutions also offer flexible dual-fuel or gas engines (as well as trusted diesel models). MAN bases its LNG-to-power floater concept on the flexibility premise, as well as efficient gas turbines that deliver 10 MW to 300 MW. It's about "low-cost energy production" and "independence from gas suppliers", both super-topical in November 2022.

MAN gas turbines of from 6 MW to 13 MW offer gas-fired power generation fed from centrifugal pumps transferring LNG to a vaporizer "injecting" natural gas. Condensing turbines or steam turbines offer the ability to produce electricity from a variety of energy feedstocks, where turbines are either "backpressure" or "saturated" types in modules meant to work with some of the types of innovations we've obliquely referred to. The MAN steam turbines target combined heat and power; biomass production and burning; steam from concentrated solar power; geothermal energy (the Icelandic government is an Ocean GeoLoop partner); waste-to-energy and regeneration in energy storage. The MAN steam turbine power-generation portfolio — turbines like the new, "urban and industrial" MGT6000 — covers the range up to 180 MW, or the equivalent of a medium-sized hydropower dam.

Hydrogen PP

In the most technologically advanced states, especially in Northern Europe, "green, blue and pink" hydrogen are touted as the future, and gas plant that can burn gas now and hydrogen later is seen as the right backstop.

"With our H2-ready concept, we can confirm we are in the planning phase for new power plants suitable for future use with hydrogen," Zissis says. "As a turbine manufacturer, we ensure the burners and combustion chambers are designed for H2, as this has different combustion properties than natural gas. In addition, other auxiliary systems, such as piping and explosion protection, must be designed … The independent certification body TÜV SÜD issues certificates for H2 readiness in a power plant's design phase," he says.

So, there's a FGPP's readiness to take on hydrogen as a fuel. There's also a hydrogen supply chain, including bunkering for and by vessels that'll service floating hydrogen

Integrated plant: inbound LNG, an LNG terminal and a FGPP.

Illustration: Siemens Energy

power plants. Hydrogen supplier networks, some only in name, have mushroomed across Europe in imitation of the Boston medical cluster (much lauded in these parts). Norway alone has several "zero-emission supply chains". "Centers of excellence" address energy transition strategies, and hydrogen "learning" is on the agenda all across the Continent.

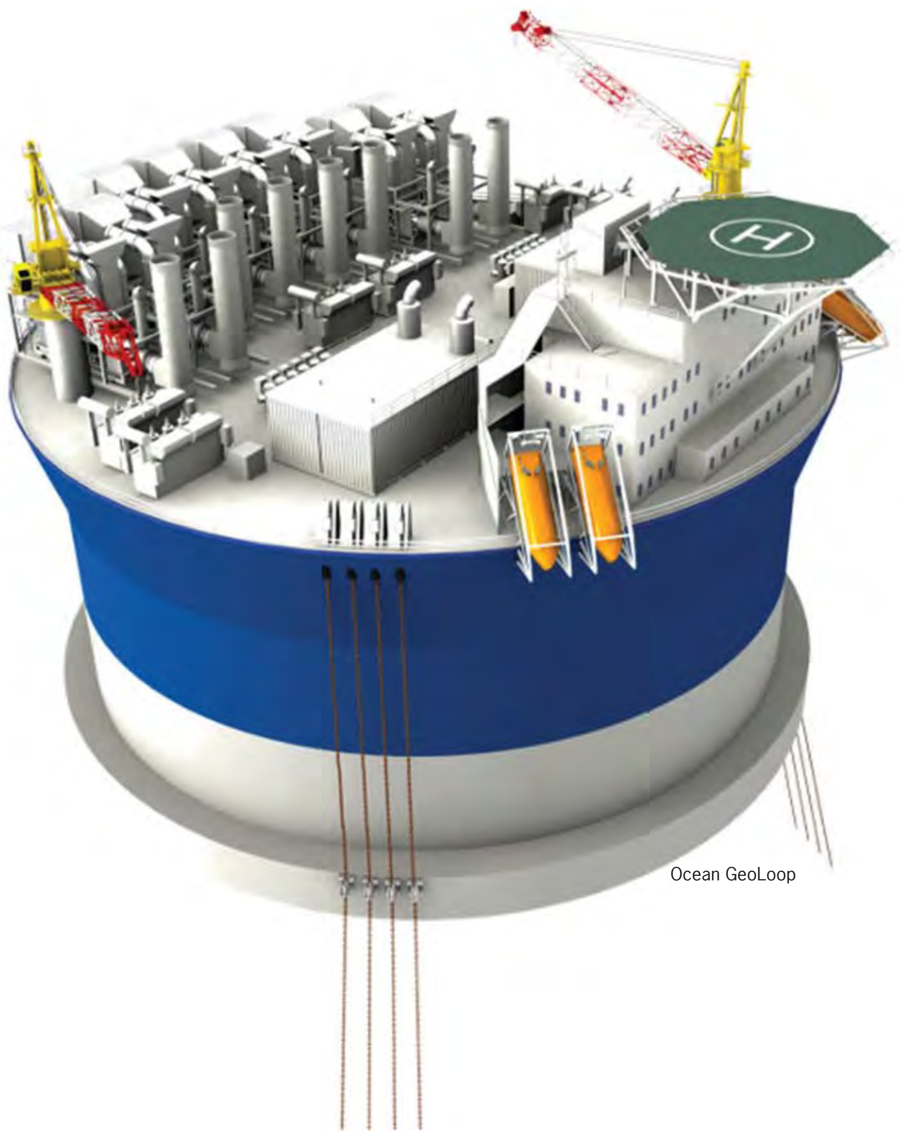
Still, Class informed the Norwegian Arena Ocean Hyway Cluster that "there are uncertainties" in H2 infrastructure. From handling to the production of compressed hydrogen, liquid hydrogen and ammonia.

Water-to-Fuel

It's in the Far East, however, where a certain hydrogen PP offers clarity on the future path of "floating HPPs".

September 2022 saw Keppel Energy decide to build a $526 million, 600 MW advanced PP based on a combined-cycle gas turbine. Mitsubishi will engineer and build the Keppel Sakdra Cogen plant as "the first hydrogen-ready power plant in Singapore", a communique heralds. "Running initially on natural gas as primary fuel, the (plant)) is also designed to operate on fuels with 30-percent (H2) content and has the capability of shifting to run entirely on (H2). Starting in 2026, its produced steam will bolster industry energy and chemicals customers on Jurong Island.

As certain fuels are banned (at least in emissions-control areas, or ECAs), the ability of FPPs to produce future fuels, like ammonia, might become "standard". The Keppel deal includes an "aside" MOU with Mitsubishi Heavy Industries for "a feasibility study on the development of a 100-percent ammonia-fuelled power plant on a selected site in Singapore". That's 3-for-1: gas-firing at the same plant gives way to H2 either from water or natural gas, which is then converted to ammonia. Energy trilemma solved.


Ocean GeoLoop

"When completed, this asset will grow Keppel's power generation portfolio from the current 1,300 MW to 1,900 MW," Keppel says, although Mitsubishi Power CEO, Osamu Ono, adds, "Mitsubishi … looks forward to supplying … Sakra Cogen …with our hydrogen-ready JAC gas turbine." The race is on.

There's no word on whether compressed or liquefied hydrogen will be the goal at Sakra, or whether refrigerated or pressurized liquid ammonia will be made. There's no certainty, either. "Today 95 percent of (H) is produced from fossil fuels, more than half is used for ammonia production, and almost 90-percent (of that) is used to produce fertilizers," the Lloyd's Register report says (for perspective).

Capture loop

As for the Ocean GeoLoop? The Norwegians whose designs and capital have helped fabricate many a gargantuan, super-complex, Singaporean floater newbuild are already building a small and a large pilot, at least of the CCS.

Whether a Sevan cylindrical semisub with GPP on top, or a barge, ship and fabrication yards are in our survey are not expected to have difficulty building FPP floaties or their associate plant (although Siemens suggests the "controlled environment of Singapore" for a newbuild FPP). The plant providers have perfected their module stacking procedures, so "a crane" and secure wet dock are all the physical pieces that need to be in place (followed by heavy lift availability).

Forecasts

"We haven't done any benchmarking, but for a newbuild like this — with all the facilities available at a typical yard — it should be cheaper than purpose-building (a GPP with CCS) somewhere on land, where they might be lacking in (key) people and (vital) equipment," Rongland says, adding, "The hull doesn't drive costs much, and inshore, we might change to a different hull to be cheaper to construct."

The Blue Power partnership comprises many parts. "We provide the electricity and the transport (of gas and the FPP with CCS). We can even own and operate the installation if required."

Indeed, looking around the North Sea and elsewhere, offshore and grid operators seem to like that model. So do certain national governments.

Point of capture: a graphical drawing showing the theoretical layout of CCS and CCSU capture tech.

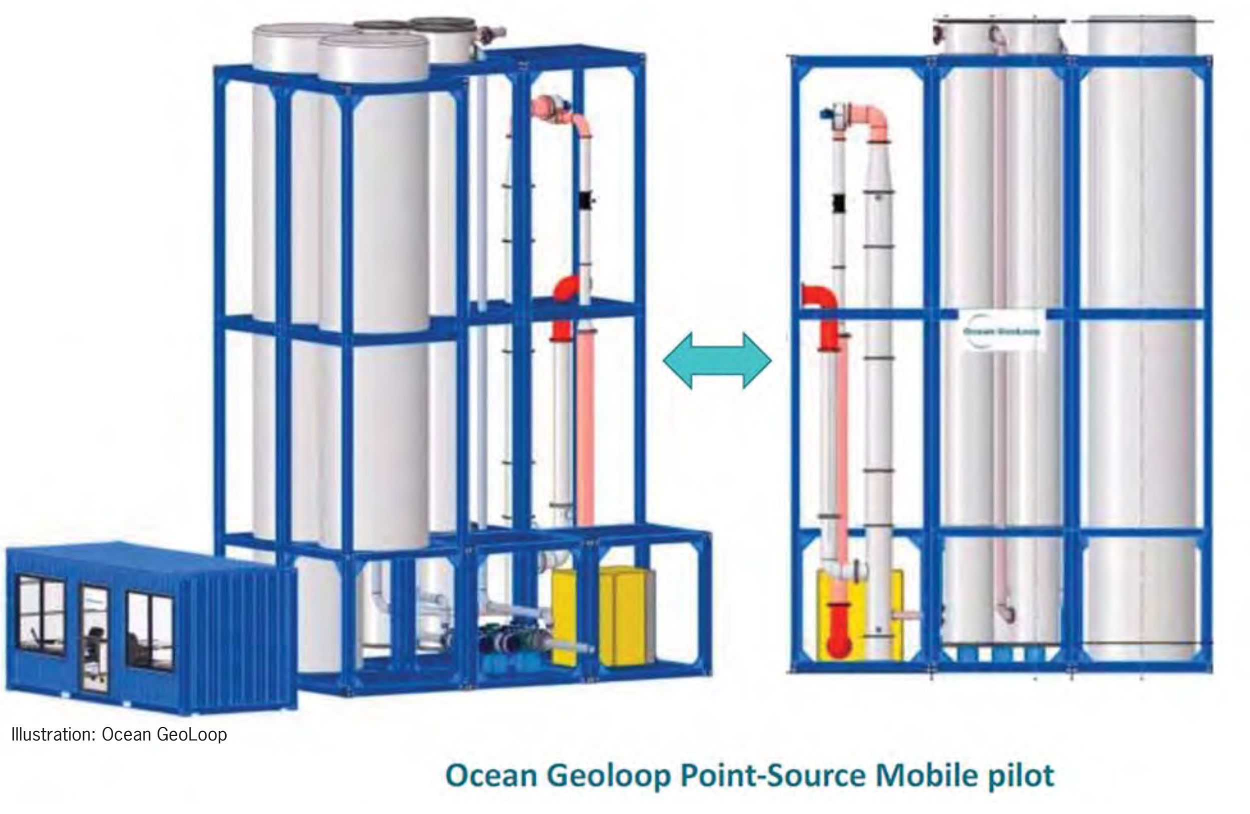
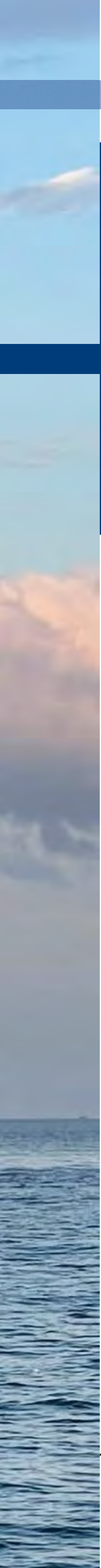


Illustration: Ocean GeoLoop

A Look inside the

"World's First Eighth-Generation Ultra-Deepwater Drillship"

TransOcean



DEEPWATER ATLAS

Marijana Sosic, Manager, Technical Marketing at Transocean, discusses some of the outstanding features of the Deepwater Atlas and sister-ship Deepwater Titan, which together represent an investment of more than $2 billion.

The Deepwater Atlas was launched this year in Singapore. What, specifically, is so special about it?

The Deepwater Atlas is the first of its kind eighth-generation drillship that will offer 20,000 psi well control capabilities and a 3.4 million pound hoisting capacity. The Deepwater Atlas and the Deepwater Titan, the Atlas' sister-rig that will follow her to the Gulf of Mexico next year, offer the highest rated equipment in the industry. These eighth-generation, ultra-deepwater drillships will allow Transocean, and its customers, to access high pressure and high temperature reservoirs that previously were not accessible. The equipment on our newest drillships can reduce the time it takes to drill a deepwater well, bringing total costs down.

Among the special aspects of the Deepwater Atlas is the story she tells about resilience. Despite an industry downturn and global pandemic challenges, she has now made her way to the Gulf of Mexico, where she commenced drilling operations. Transocean owns the only two assets in the world specifically designed to maximize efficiencies for 20,000 psi well completions.

It has been said that this is the first 8th generation drillship in the world. What does this mean, exactly?

Transocean's eighth-generation drillships are designed to be outfitted with well control systems rated for 20,000 psi and possess a 3.4 million pound hoisting capacity. To provide this capability, upgrades were made to the derrick and a new, higher-rated drawworks, top drive and rotary table were added. This new equipment was designed and delivered specifically for these projects – marking new firsts, not only for Transocean, but for the entire industry.

For context, seventh-generation rigs offer 2.5 to 2.8 million pound hoisting capacity, and 15,000 psi well control systems. Sixth-generation rigs offer a hoisting capacity of up to 2.0 million pounds and are rated for water depths up to 10,000 feet. Seventh- and eighth-generation rigs are designed for water depths of up to 12,000 feet.

How, specifically, will these ships create an opportunity to drive the total well cost down?

The upgraded hoisting capacity will provide our customers with numerous cost and time-saving opportunities, especially when drilling programs and well configurations require the handling of heavy, large diameter casing strings. With a higher hook load, more work can be accomplished in a shorter period. Additionally, the 20,000 psi blowout preventer (BOP) stacks have been designed with extra attention to features that result in reduced maintenance times. The well test and completion deck is the biggest in the offshore drilling industry. The aft hull was designed for improved efficiency, which was accomplished by reducing double-handling of equipment and materials.

The completed drillship features three-million pound hook-load hoisting capacity. Why is this important?

The hoisting capacity of the drawworks is 3.4 million pounds with a net hook load of 3.0 million pounds. The weight of the traveling equipment, including the motion compensator that maintains the drill string position, the traveling block and hook, are all included in the hoisting capacity. This allows us to pick up a full 3.0 million pounds at the elevator. This is important to Transocean, and our customers, because it is more cost effective. The maximum capacity is higher than on any other rig, allowing us to run longer casing strings, reducing handling, running and cementing times.

The rig has a 15,000 psi blowout preventer, and will eventually have a 20,000 pounds psi BOP, too. Why is there a need for two BOPs and why is the second one being installed at a later date?

The two BOPs improve efficiency by providing redundancy and reducing downtime between wells. For example, it allows for operations to continue with one BOP deployed while maintenance is performed on the other stack. Currently, the Deepwater Atlas has two 15,000 psi BOP stacks, which provide all the efficiency of dual stack rigs. To complete 20,000 psi wells, one of the 15,000 psi BOPs will be replaced by a 20,000 psi BOP once manufacturing and testing is completed.

Can you share any info on the Atlas' first project in the Gulf of Mexico with Beacon at the Shenandoah?

The Deepwater Atlas has arrived in the Gulf of Mexico, where customer and third-party equipment load out took place ahead of the rig proceeding to the Shenandoah field to commence her first contract. Transocean follows a robust system of operations readiness covering everything from crew training and procedures to maintenance plans and spares. We are excited to have achieved the milestone of commencing operations on another newbuild.

The Shenandoah program comprises two phases. The

Deepwater Atlas commenced operations in late October on a four-well drilling program, which is expected to last approximately 255 days. Upon completion of the initial drilling program, a 20,000 psi BOP will be installed on the rig. Following the installation, the Deepwater Atlas will commence the second phase of the project – the well completion program.

Deepwater Atlas and its sister ship Titan were ordered back in 2014, and they're only being delivered now. Can you provide some color on the challenges faced since the original order? The rigs reportedly cost $2.25B in total, versus $1.08B when originally ordered.

While the rigs were originally ordered in 2014 just before the industry downturn, these two projects shifted in 2018 when one of our customers approached us with an opportunity to design and construct a rig capable of drilling in 20,000 psi environments – the new frontier of ultra-deepwater drilling. As a result of the new rig design and construction management contract, and a five-year drilling contract, we shifted gears and got to work to accomplish the design, construction and delivery requirements set forth in the construction contract. The initial contract for the Deepwater Titan adds $830 million in backlog and the initial contract for the Deepwater Atlas adds $252 million in backlog to Transocean's industry-leading $7.3 billion backlog as of October 13.

How much do these high psi BOPs add to the cost? Can they be installed on rigs in the existing fleet?

The 20,000 psi BOP stacks are very complex, requiring certain modifications to the rig: the entire well control system would require modification and upgrading. The work would take existing rigs out of operation and include hull piping changes, among other things. Essentially, it would be similar to replacing an entire air conditioning and heating system and all of its associated duct work – when it is working efficiently in a new house – within a year or two of its installation.

Transocean has said that, apart from the two rigs being "the most capable and highest specification rigs in the world" they are also equipped to reduce fuel consumption and cut emissions. Can you share further info on how this is being done?

While we are always looking for ways to reduce our carbon footprint, we currently reduce emissions and fuel consumption through the use of fuel additives that optimize fuel consumption, hybrid power systems, LED lighting and a high-efficiency power plant configured to comply with Tier III International Maritime Organization emissions standards. Importantly, reducing well construction time using the design features of our newest rigs, such as their industry-leading hookload capacity, leads to less fuel consumption and emissions per well.

Transocean's eighth-generation drillships are designed to be outfitted with well control systems rated for 20,000 psi and possess a 3.4 million pound hoisting capacity. Seventh-generation rigs offer 2.5 to 2.8 million pound hoisting capacity, and 15,000 psi well control systems. Sixth-generation rigs offer a hoisting capacity of up to 2.0 million pounds and are rated for water depths up to 10,000 feet.

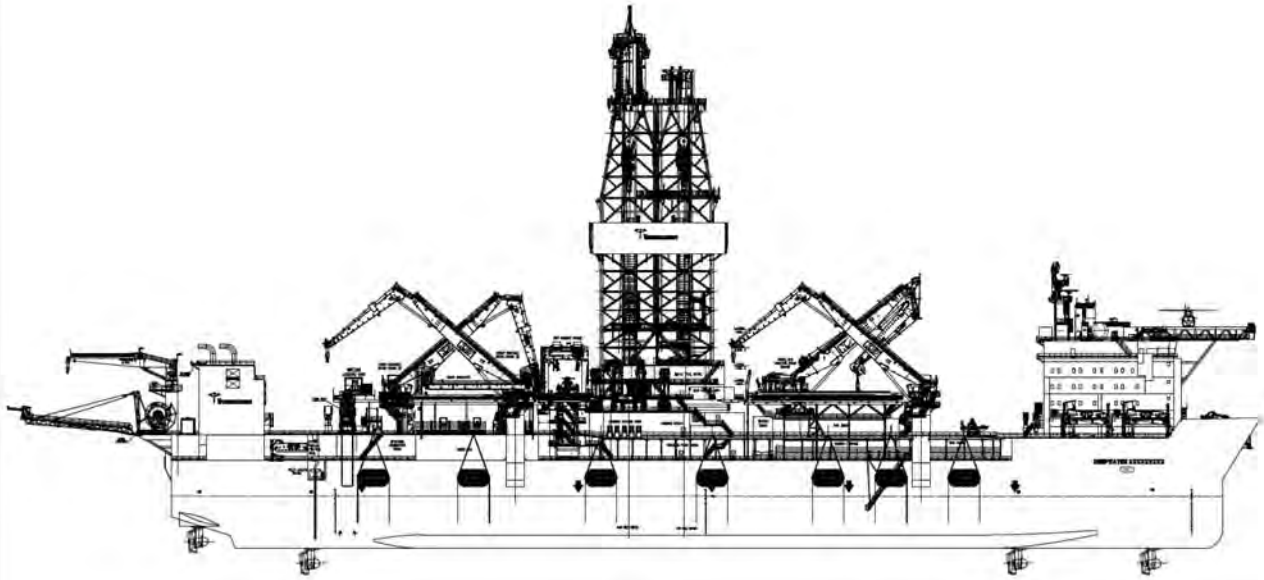
►Marijana Sosic, Manager, Technical Marketing, Transocean

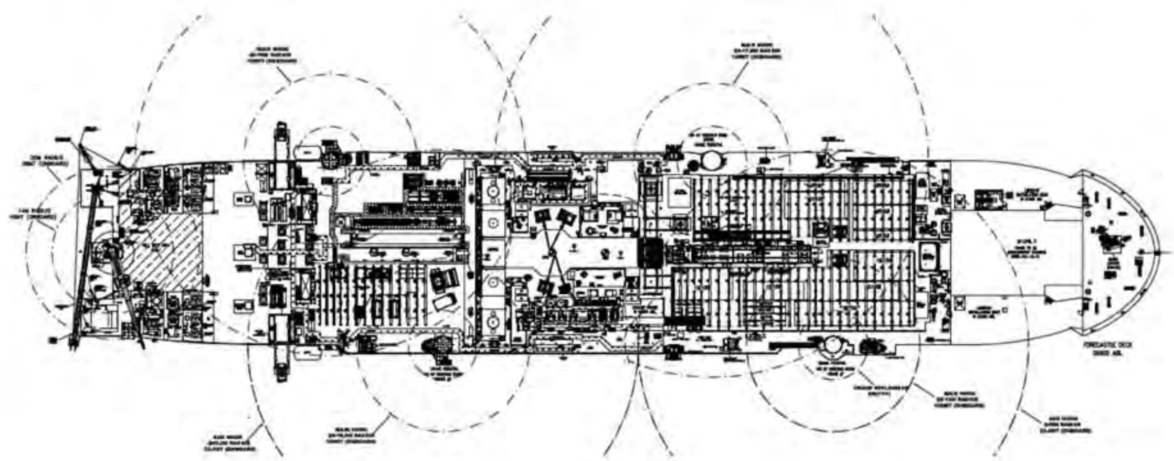
Can you tell us how you see the deepwater drilling market and day rates at the moment, and going forward. With the oil prices this high, the future seems bright, right?

In the context of strong demand for oil and gas across most regions of the world, as well as the recent global energy supply disruption caused by the Russian invasion of Ukraine, there is a pronounced appreciation for the importance of energy reliability and security. In this context, the increase in marketed rig utilization and dayrates is unsurprising. Given the underlying fundamentals, it is clear that the drilling industry, and particularly deepwater offshore drilling, is in the vanguard of a sustained market recovery.

DEEPWATER ATLAS

ULTRA-DEEPWATER DUAL-ACTIVITY DRILLSHIP





BOUNDLESS

SERVICE FOCUSED
DATA DRIVEN
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Revision Date: 16 May 2022

Transocean

DEEPWATER ATLAS

ULTRA-DEEPWATER DUAL-ACTIVITY DRILLSHIP

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General Description

Design / Generation	Jurong Espadon JE3T Ultra Deepwater Drillship
Constructing Shipyard	Jurong Shipyard, Pte Ltd, Singapore
Year Entered Service / Significant Upgrades	2020
Classification	DNV +1A1, Ship Shaped Drilling Unit, E0, DYNPOS AUTRO, DRILL, CRANE, HELDK, BIS, MPD
Flag	Marshall Islands
Dimensions	816.6 ft. (249 m) x 139.4 ft. (42.5 m) x 64 ft. (19.5 m) depth
Drafts	Operating 33.5 ft. (10.8 m) / Transit 26.3 ft. (8 m)
Accommodation	220 persons
Displacement	101,471 st. (92,053 mt) Operating
Variable Deck	24,250 st. (22,000 mt) operating / 17,637 st. (16,000 mt) transit
Transit Speed	12 knots
Maximum Water Depth	12,000 ft. (3,658 m) designed / 10,000 ft. (3,048 m)outfitted
Maximum Drilling Depth	40,000 ft. (12,192 m)

Drilling Equipment

Derrick	Dual Dynamic Bottle Neck Type (DDBN-1750/1250). 168.86 ft. (51.5 m) clear lifting height x 80ft (24.4m) x 60 ft. (18.3 m). Designed to API-4F, SSL E2/U2
Gross Hook Loads	(Main) 1,700 st. (1,542 mt) (Aux) 1,250 st. (1,134 mt) Capacity
Drawworks	(Main) NOV AHD-1700-10500 hp (Aux) NOV AHD-1250-9000hp
Compensator	(Main) NOV CMC-E-1500/3300-7x78, rated 1650 st. (1,497 mt) locked, 750 st. (680 mt) compensating, 25 ft (7.62 m) stroke
Rotary Table	(Main & Aux) NOV RST-755 75-1/2 inch hydraulic rated at 1,500 st. (1,360 mt) (main), 1,250 st. (1,134 mt) (aux); both 45,000 ft.-lbs. maximum continuous torque
Top Drive	NOV TDX-1500 1,500 st. (1,360 mt) (main), NOV TDX-1250 1,250 st. (1,134 mt) (aux) Maximum Speed 275 rpm, continuous torque 105,000 ft-lbs at 130rpm
Tubular Handling	Two (2) NOV ARN-270-(TW-3/60) Iron Roughnecks for tubulars ranging from 3-1/2 inch to 10 inch. Racking systems for tubular range of 3-1/2 inch to 22 inch with two (2) vertical NOV/HR-IV-ER Hydraracker pipe racking systems. One (1) NOV Pipe Catwalk Shuttle, CWS-P20-90HS-90-HS. Maximum capacity 22 st. (20 mt), 93 ft. (28.3 m) tubular at 36" Diameter.
Riser Feed	One (1) NOV Riser Catwalk Machine, CWM-R45-90-HS Maximum capacity 49 st. (45 mt). (2) Riser Cranes and a Riser Lift.
Mud Pumps	Four (5) NOV 14-P-220 AC triplex pumps, 7,500 psi, each driven by two (2) x GE 1,150hp 690VAC motors plus space for a fifth optional pump
HP Mud System	Rated 7,500 psi
Solids Control	Six (6) Brandt Single VSM-MS triple deck shale shakers.

Cranes

Cranes	Three (3) 110 st. (100 mt) knuckle boom cranes at 62 ft (19 m) radius, rated at 27 st. (25 mt) at a radius of 147. (45 m)
Subsea Crane	One (1) 181st (165mt) active heave compensated knuckle boom crane for handling subsea equipment to 9,842 ft. (3,000 m) WD
Stern Crane	One (1) 44 st. (40 mt) crane for thruster motor removal and flare boom handling

Power & Machinery

Main Power	6ea Wartsila 16V32E 4-stroke, 720 rpm,7680 kW each total 46,080 kW, each driving a 7200 kW, 11kV generator each, total 43,200 kW
Emergency Power	One (1) 4-stroke, 1,800rpm Cummins CSMXTA60OLGS diesel engine rated at 1,900 kW driving a 690 VAC 1,700kW, 2125kVA generator. One (1) Schneider emergency power switchboard
Power Distribution	Three (3) Siemens 11KV AC switchboards with (AGP)® (Advanced Generator Protection). Three (3) Siemens 690VAC Drilling VFD Switchboards. Six (6) Schneider 690VAC Low Voltage Switchboards (3 Forward, 3 Aft)

Storage Capacities

Fuel Oil	53,069 bbl. (8,437 m3)
Liquid Mud	(active + reserve + slug) 20,548 bbl. (3,267 m3)
Base Oil	6,289 bbl. (1,000 m3)
Brine	19,580 bbl. (3,113 m3)
Drill Water	23,989 bbl. (3,814 m3)
Potable Water	12,975 bbl. (2,062 m3)
Bulk Material	(mud + cement) 38,140 cu. ft. (1,080 m3)
Sack Storage	10,000 sacks

BOP & Subsea Equipment

BOP	Two (2) x seven (7) ram 18-3/4" x 15,000 psi NOV BOP's consisting of two (2) triples and one (1) single (at delivery). *1 x 15K BOP & 1 x 20K BOP (in 2023). Separate test control system for the second BOP while the primary BOP is deployed.
LMRP	Two (2) LMRP's, each including one (1) NOV/Schaffer 18-3/4" 10,000 psi Schafer dual spherical preventer.
BOP Handling	NOV BOP Moonpool Trolley rated at 716 st. (650mt). BOP Gantry Crane with two (2) x 330st (300mt) main hoist and two (2) 38 st. (35 mt) auxiliary hoists
Marine Riser	NOV FT-HC 21" OD Flanged. With 4 ½" ID K/C lines, 4" ID booster line and 2ea conduit lines
Tensioners	4,000 kips combined capacity using eight (8) NOV WRT-250-D50PL dual riser tensioners rated at 250 kips each, 50 ft. (15.24 m) Stroke
Diverter	NOV/Shaffer / 21-500-75-EXT, 21" x 500 psi with one (1) 16" Overboard Valve feeding a 16" Flow selector with two (2) 16" overboard line.
Tree Handling	One (1) 1,102 st. (1000mt) Combined Xmas Tree Trolley and Riser Trip Handling Cart. Two (2) 165 st. (150mt) skid cart with 4-way skidding
BOP Controls	NOV Multiplex control system, with deadman system, auto-shear, acoustic back-up system and ROV Intervention
Moonpool	91.86 ft. (28 m) length x 35.43 ft. (10.8 m) width

Station Keeping / Propulsion System

Thrusters	Six (6) Rolls Royce UUC 455 FP variable speed, demountable azimuthing thrusters, 5,500 kw. Each, with advanced thruster capabilities (ADCAP)
DP System	DPS-3 rated for water depth up to 12,000 ft. (3,658 m)with backup DP system. Kongsberg DP-32, DP-12 & C-Joy System

Other Information

Additional Features MPD Ready - Upgraded

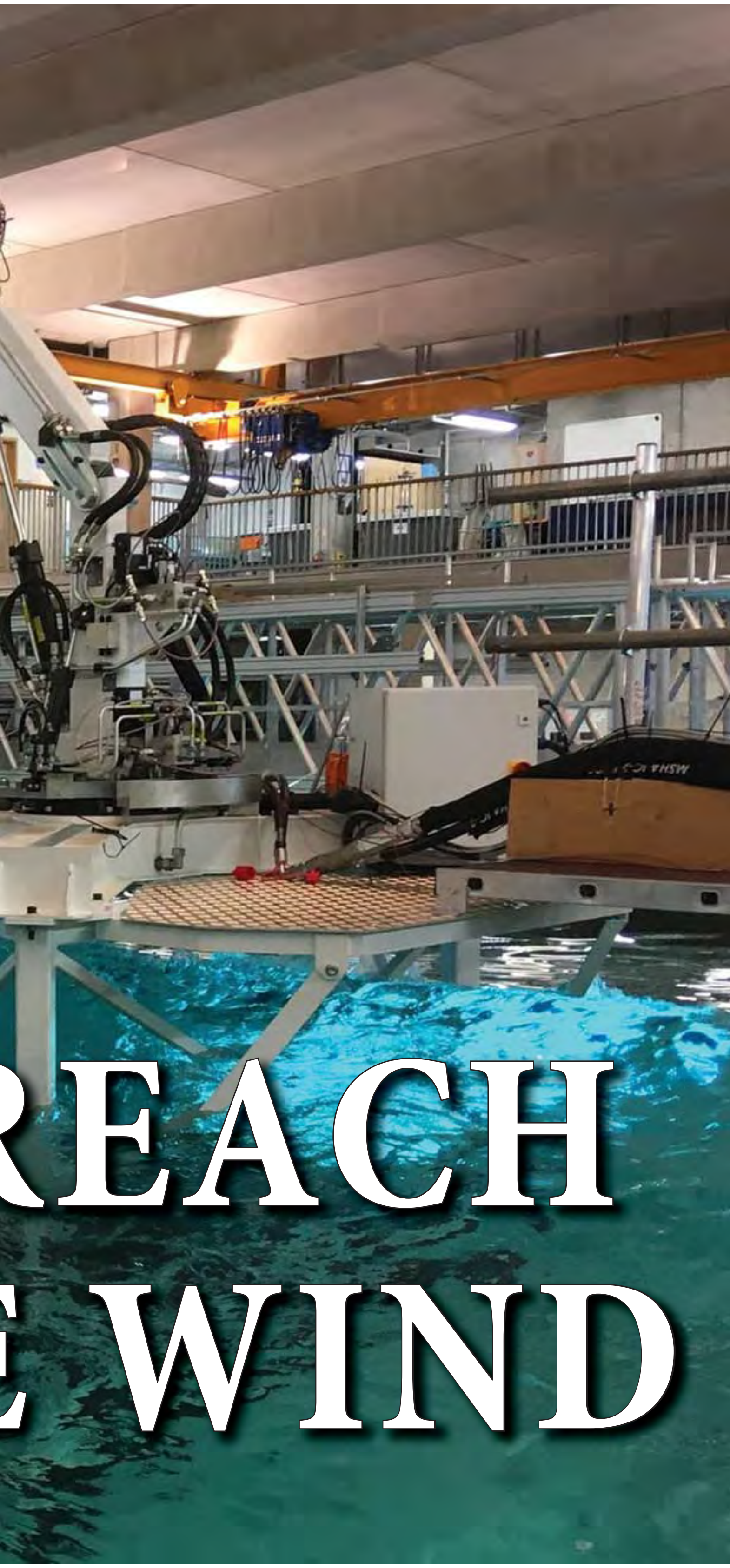
Revision Date: 16 May 2022

Transocean

STL's Autonomous Synchronised Stabilised Platform being put through its paces at the University of Plymouth's COAST Laboratory.

A ROBOTIC R
IN OFFSHORE

All photos courtesy STL



With a background in subsea and offshore, coming up with new ideas is the norm' for UK-based engineering consultancy STL (Submarine Technology Limited), writes Elaine Maslin.

The last few years have been no different. The company has been focusing on ship-based robotics, including robotic arms. These aren't just any robotic arms – they're motion compensated systems for deploying/recovering people and robots to and from fixed or moving objects. That could be wind technicians to an offshore wind turbine or an autonomous underwater vehicle (AUV) in and out of the water – all with a single arm system from a vessel.

In fact, STL has developed two different systems, one for moving people to locations up to 20m above the sea surface and another, an articulated system, for launch and recovery of remotely operated vehicles (ROVs) and AUVs, using a remote sensing system.

Andreas Fechs, project and business development manager at STL, explained both systems at the joint Society of Underwater Technology (SUT), IMCA and Hydrographic Society Scotland seminar in Aberdeen in mid-November.

A key goal has been to improve the safety of and ability to access offshore structures, initially fixed structures, from ships, including those that are relatively smaller than current gangway-system based vessels, he says. But another goal is to give future uncrewed surface vessels (USVs) more capability.

It's been a challenge STL has been looking into since the early 2010s, when the need for better access systems became an issue, for offshore wind, but also normally unattended oil and gas facilities. While others have now commercially introduced gangway systems, STL has been developing "space stabilisation" and "synchronous stabilisation". Its first concept, Neptune, got going in 2012, with government R&D funding.

The Neptune a two-part articulated arm that has been designed to be able to carry 3-4 people or 1,000 tonne of equipment up to a height of 20m above the seabed and 20m reach, with +-10cm station keeping accuracy.

It weighs 12-tonne, with a 2.5m x 3m foundation footprint, and is based on a steel truss structure, "For lightness and stiffness, as they have to be mounted on to relatively small vessels, but reach up to 20m high and be moved relatively quickly," explains Andreas, allowing the system to be installed on a 36m catamaran or a 54m-long monohull.

All joints, the slew-ring and the gimbal base are moved with hydraulic cylinders or motors (the HPU isn't part of the 12 tonne), because of the need for speed and accuracy, using a computer control system – software and hardware at the heart of the system – that takes in the vessel's six de-

STL's Neptune during onshore trials.

grees of movement (via an IMU and GNSS), including up to 3m significant wave height. The Neptune system uses dual, high speed CAN networks for rapid data transfer between sensors, controllers and actuators. This enables full motion compensation and station keeping accuracy.

The company has developed a full-scale prototype, first tested onshore in 2017, both on a six degree of freedom ship-motion simulator STL has and on land at STL's research facility in Cowes on the Isle of Wight, using real vessel motion data as input. Andreas says a vessel-based trial of this system was planned before the end of 2022.

Having developed Neptune, STL decided to take the concept further. Why not a multi-axis articulated arm with more intelligence, so that USVs could do more, such as equipment transfers, survey and inspection or launch and recovery operations, from a moving object, i.e. a ship or USV, to another moving object?

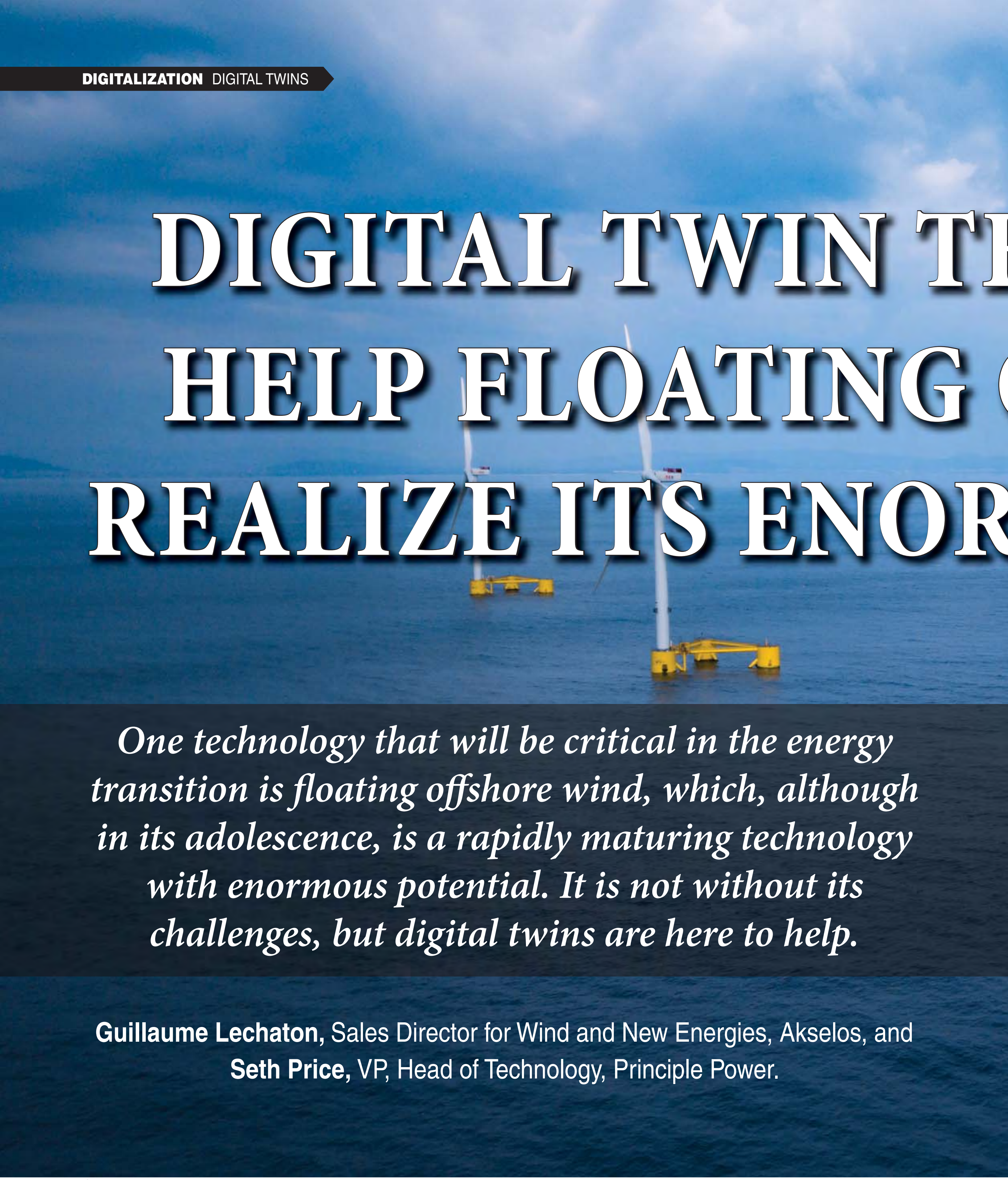
This is the synchronous stabilisation the company has been working on, or its Autonomous Synchronised Stabilised Platform (ASSP), that's had European Regional Development Fund through the Marine-I programme in Cornwall, where the company has another base. It adds machine vision to synchronise the payload motion with the moving target, so that, whatever motion the articulated arm is experiencing, the end of the arm has no residual motion with regard to the moving (floating) object it's synchronising with.

This could be used from ships for launch and recovery of ROVs and AUVs, says Andreas. Using a remote sensing system (RSS), developed by STL, and machine vision to detect robots in the water, the arm, from a host vessel, could be used to pick them out of the water, tho this would need a latching system added to the vehicles, he says.

A critical part of this system is a "Remote Sensing System" (RSS), which STL had further Marine-I funding to develop. The RSS adds machine vision to the robotic control system, enabling the movement of objects of interest to be tracked relative to a known datum. This is fed into the control system so the arm can synchronise with the object, such as an AUV, ROV, another vessel or a floating wind turbine, says STL.

The system was initially tested in 2020 using a ship-motion simulator and a moving target test rig, and since then there's been a demonstration at the University of Plymouth's COAST Laboratory, which has in-water testing enabling physical model testing with combined waves, currents and wind. This involved a research prototype with a three-part articulated arm. It was limited to a 100kg payload, which would support deployment of a Falcon ROV or Gavia AUV, says Andreas. "But it would be applied to any robotic crane arm," says Andreas. "It could allow ship-to-ship transfer. The geometry can be adapted to any application and heavy objects." I.e. the technology can also be applied to a bigger system such as Neptune, says STL.

There's still work to be done. The machine vision for remote sensing will need to be at a point where adequate robustness and reliability offshore is demonstrated.



DIGITAL TWIN TE
HELP FLOATING (
REALIZE ITS ENOR

One technology that will be critical in the energy transition is floating offshore wind, which, although in its adolescence, is a rapidly maturing technology with enormous potential. It is not without its challenges, but digital twins are here to help.

Guillaume Lechaton, Sales Director for Wind and New Energies, Akselos, and **Seth Price,** VP, Head of Technology, Principle Power.

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ECHNOLOGY CAN OFFSHORE WIND RMOUS POTENTIAL

WindFloat Atlantic - Principle Power's floating wind farm off the coast of Portugal

© Principle Power

Digital Twins are real-time, virtual representations of assets such as floating wind turbines

The world is in the midst of a huge challenge. To avoid the worst of climate change and leave a habitable planet for future generations, we must transition to net-zero emissions by 2050.

One technology that will be critical in the transition is floating offshore wind, which, although in its adolescence, is a rapidly maturing technology with enormous potential. In European seas, approximately 80% of the world's offshore wind resource potential is in water deeper than 60 meters, where the most reliable renewable energy technology that can be built is floating wind turbines.

Obstacles to Growth Holding the Industry Back

However, there are several barriers to growth that are hampering the potential of offshore wind and putting at risk the transition to net-zero 2050.

The first of many challenges is the growing expense of sending technicians offshore to perform routine maintenance or fix issues due to their location far out at sea. To yield the highest output, floating wind farms are located in remote areas and are highly exposed to the elements. Unlike other offshore industries, wind turbines are trickier to navigate safely in bad weather without the protection of platforms.

Also, weather windows limit the time work can be conducted safely and efficiently. If a significant issue of fault requires a turbine shutdown, it may have to remain inactive for some time if the weather does not permit engineers to reach it safely to bring it back online - resulting in a loss of time and money.

A lack of reliable data is also slowing progress. As a relatively new industry, floating wind has little performance data to draw on to inform engineers of design improvements that could be made to make operations more efficient.

To date, design safety factors have also been based on conservative factors commonly used in the offshore oil & gas space, which, while helpful, are not directly applicable. With the data made available via new and exciting technology, designers can challenge these conservative factors to optimize the design for the specific risks and failure impacts aligned with floating wind projects.

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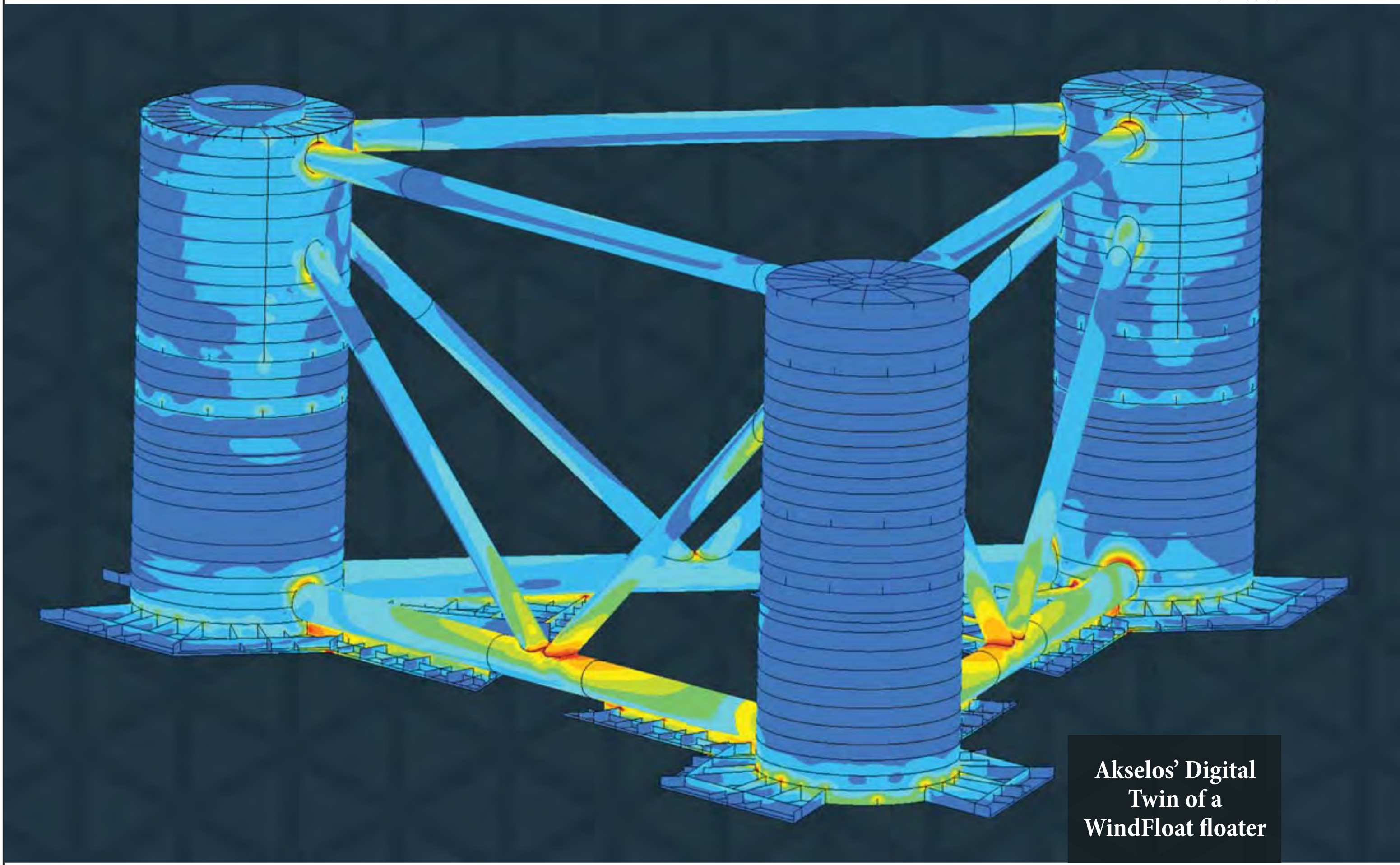


Akselos' Digital Twin of a WindFloat floater

Digital twin technology can be the solution

The floating offshore wind industry can overcome these challenges and supercharge its growth by embracing digital twins, virtual representations of physical, real-world objects.

To create a digital twin of an asset, engineers first build a detailed model, reflecting the "as-is" condition as much as possible, and then pair it with real data, including inspection and sensor data. This data is then fed into the model to create a structural digital twin. This twin can run near real-time simulations, analyze performance issues and suggest improvements that engineers can make to the original asset to increase energy output.

Since they are fed with near real-time data from the asset, digital twins provide a clear picture of asset health which operators can use to pinpoint issues proactively before they become critical. As a result, operators can fix problems before they escalate into costly failures, reduce the number of expensive and time-consuming trips offshore, and schedule work to minimize waiting on weather and lost production.

Digital twin technology is being developed to optimize floating offshore wind platforms.

Today, Principle Power, with digital twin pioneer Akselos, is building a structural digital twin of the WindFloat Atlantic offshore wind farm.

This digital twin is being constructed as part of the DigiFloat Project - aiming to develop the world's first digital twin software tailored to floating offshore wind applications. When completed, the solution will help Principle Power reduce the amount of maintenance required on the assets and provide valuable, actionable data to help further improve this growing industry.

The floating wind industry has enormous potential to scale the energy transition and drive us to net zero by 2050.

By embracing digital twin technology, the industry can reduce the maintenance required on turbines and platforms, helping to improve operations, bring down costs and increase uptake. Moreover, the more systems that utilize digital twin technology in the future, the more valuable data will be available to guide designers in creating optimal designs.

All images courtesy Miros

CATCHING THE (MIROS) WAVE

Real-time, cloud-based wave monitoring helps offshore operators perform more efficiently and safely, as Jonas Røstad, Chief Commercial Officer, explains the premise behind 'Sea States as a Service.'

By Greg Trauthwein

Necessity is the mother invention, and Miros started in 1984 as a 'geeky science project' to provide better sea state data for platforms in the North Sea – which at the time relied on buoys; buoys that provided good data but were 'maintenance hungry.'

Born was a solution that was nurtured with the Norwegian national oil company Statoil (now Equinor), to create "the first prototypes of this wave radar, which was put on oil producing platforms in Norway and gave the same parameters as wave buoy would give out," said Røstad in an interview at the company's Oslo headquarters earlier this year.

Nearly four decades later, Miros has evolved into a technology company that specializes in measuring the ocean surface, providing sensors and systems for environmental monitoring to the offshore and maritime industries, including wave and current monitoring as well as oil spill detection.

Offshore Wind Efficiency

"Today, typically, offshore wind projects use weather forecasts, but what we can do is to give the actual sea state at any given point," said Røstad, helping, for example, vessel operators in the offshore wind sector cut wasted vessel trips and increase safety.

"They start on the trip, and when they get out to the turbine, it turns out that the wave height is too high, so they have to make a U-turn and go back, which can also lead to turbine downtime. What we do is give real-time wave measurement within the [wind farm], and maybe mix it with the weather forecasts. It's all about maximizing the weather window."

In fact, on some really large offshore wind farms with diverse bathymetry, wave conditions can vary significantly at different points in the wind farm. In such a dynamic and fast-changing environment, absolute accuracy is always an issue, but Røstad points out that Miros' instruments are "the only DNV-certified wave measurement device(s) on what they call the Alpha factor."

A big value proposition for the Miros solution is the fact that the sensors feeding data to the system are dry-mounted, not in the sea and directly exposed to saltwater, significantly reducing maintenance.

Once installed and operational, they simply shoot the data stream up to the cloud, making the information easy to access for anyone with proper credentials. The layout of the sensors is unique to each wind farm, dependent ultimately on the layout of the farm, water depth, and bathymetry.

"[Via a pair of case studies] we have found that if we arrange these sensors right, then we can reduce turbine downtime by 1%."

Jonas Røstad,
Chief Commercial Officer, MIROS

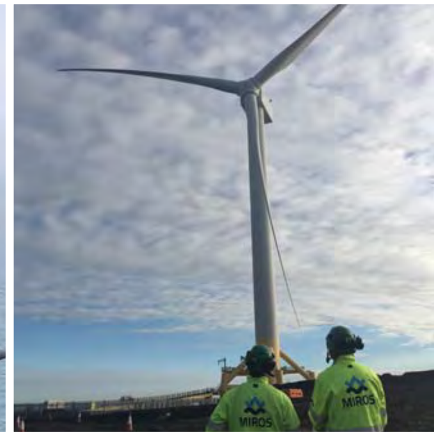
MARINE TECHNOLOGY TV
Watch the interview @ https://youtu.be/3fZyS1jP8dk

Naturally there are savings to be had on the vessel side, too. In a study with ORE Catapult in 2019, Miros found that by utilizing the data from its wave sensors, CTVs and SOVs saved up to 5% of fuel and CO2 emissions, too.

Studies are one thing, real-world operations another, and earlier this year, Subsea 7 awarded Miros Group agreements to install its internet of things (IoT) dry-sensor WaveSystem on three of its pipelay support vessels to deliver accurate wave measurements via Miros' cloud-based graphical user interface (GUI) Miros.app.

As part of three 3-year contracts and project requirements for the monitoring of wave and current to a water depth of 10 meters, WaveSystem will be installed on Seven Waves, Seven Rio, and Seven Sun vessels, and the deal will see Subsea 7 gain access to Miros Cloud services delivering real-time sea state data.

On awarding the contract, Filipe Salvio, Operations Manager at Subsea 7, said, "the cloud-enabled WaveSystem onboard our three pipelay support vessels allows us to deliver the best service to our customer independently of offshore



weather conditions. This system provides us with accurate wave, current, and speed through water data granting us to work safe, precise, and highly effective at all times".

According to Røstad, Subsea 7 aims to use its system as a competitive advantage: "Subsea 7 wants to promise their clients that they can work more hours than the competitor. With knowledge about the sea state, they can work more hours because they take away that uncertainty."

The other thing is that Subsea 7 can link this to external systems, like dynamic positioning, for example, to check if they can increase the working limits of the vessel based on real data. "So if you have limits and with experience from the data and how the vessel moves, they can actually change the limits to a higher number based upon the real-time data. Every vessel that has a limitation on the sea states [in which it could work] would benefit from this."

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