Learning from the past to secure floating offshore wind's future

How lessons from the oil and gas industry can support the floating offshore wind (FLOW) sector's sustainable development

Floating offshore wind has the potential to substantially increase access to an unlimited energy resource in deeper waters, and can play a crucial role in driving the world's transition to clean energy.

This paper examines the importance of adopting proven approaches from the offshore hydrocarbon sector to realise floating offshore wind's successful commercialisation, drawing on comparisons between the sector's current use of asset monitoring systems in pilot projects and the potential of the technology's full-scale application. Going beyond model verification, it analyses how the technology can secure platforms throughout their entire lifecycles; mitigating risk to stakeholders, supporting array upscaling, and delivering the levelised cost of energy (LCoE) benefits of digitalisation.

As part of the worldwide aim for net-zero, or carbon neutrality, European leaders have committed to reaching a 32% renewables grid contribution by 2030 – up from 17.5% in 2017. Recognising the limitations of fixed bottom offshore wind, floating offshore wind (FLOW) is increasingly viewed as an integral part of this initiative. With consistent high-velocity winds, operating in deep waters has the potential to uplift FLOW's capacity factor when compared with its fixed bottom counterpart. Illustrating FLOW's advantageous position, the International Energy Agency expects the technology to achieve cost-savings of 50% by 2050, outperforming fixed bottom winds forecasted 35% cost-reduction. This projection is reinforced by the multi-national energy company, Equinor, which predicts that FLOW will arrive at a competitive levelised cost of energy (LCoE) of €40-60/MW by 2030.

FLOW's promise has been accompanied by a surge of interest and investment, leading the Friends of Floating Wind, a group of technology developers and associations formed to promote the interests of FLOW, to set a target for the sector to increase its global energy output from 36MW to 5GW by 2030. The group contends that this growth rate is critical to building the economies of scale necessary for commercial viability. If successful, FLOW would power the equivalent of 12 million homes, more homes than there are people in London. To answer such ambitious expectations, there are over 50 FLOW projects at various stages of development, all of which are working to ensure that the industry's capability is equal to its demand. Drawn to the sector's achievements in Europe, there is growing interest in FLOW from Japan, South Korea and the US, with Japan alone investing over £830 million to date.

Conversely, before FLOW's exciting potential can be realised, the industry finds itself at a critical juncture as it prepares to transition towards full-scale commercialisation. With all eyes on FLOW in the overlapping spheres of government, media, finance and public opinion, the much-anticipated technology is more vulnerable to exogenous events that

could jeopardise its development and reputation than other, more mature forms of power generation. Therefore, stringent monitoring throughout FLOW's lifecycle beyond the initial research and development phase is critical.

Fortunately, the availability of trusted approaches from the hydrocarbon sector, as well as emerging digital innovations, can help the industry take every precaution, at every turn, to move forwards with diligence and confidence. Aligning with this aim, established asset monitoring systems from oil and gas can protect FLOW against the financial, environmental and health and safety (H&S) repercussions of structural integrity incidents, such as mooring line damage or failure. Extending beyond model verification for pilot projects, asset monitoring technology will be integral to improving risk management and reducing costs as arrays continue to upscale, enabling the industry to unlock FLOW's full potential.

Phase 1: Optimising pilot projects with asset monitoring

Before FLOW can transition towards full-scale commercialisation, it must first establish itself upon solid footings. Understanding this, industry leaders are continuously competing to design the most reliable platforms, giving rise to the diverse range of prototypes and pilot projects that we see today.

Asset monitoring has become a prominent feature in this pre-commercial landscape. The reason for this is epitomised in a recent research paper from the University of Strathclyde, which states that 'the better estimation of extreme forces and the distribution of fatigue loads will enable us to find more realistic, and thereby more economic safety factors that meet an acceptable probability of failure.'

By deploying asset monitoring, engineers can create detailed models that deliver this degree of insight. Drawing on complex data configurations – including environmental, oceanographic and mooring line tension and load data, these models simulate the performance of mooring systems and other critical platform components to validate their structural integrity, forecast their life cycles and optimise their design.

For instance, Strainstall's asset monitoring technology enabled model verification for Equinor's landmark Hywind project, the world's first floating offshore wind farm.

Case study: The Hywind project

Hywind deploys asset monitoring for design optimisation

Costing over £152 million, the Hywind project produces 30MW, powering an estimated 20,000 homes in Aberdeenshire, North-East Scotland. Standing 254m high and weighing 12,000 tonnes, the floating offshore wind farm must output power reliably while withstanding the harsh conditions of the North Sea. As one of the most challenging offshore environments in the world, the North Sea is typified by formidable waves and wind speeds averaging over 10 metres per second.

Completing a thorough analysis of asset load and fatigue life was critical to ensuring that Hywind's spar-type mooring arrangements could handle such conditions. To gain the data needed for verifying this, MacGregor Pusnes – the project's chain stopper supplier – sourced and equipped Strainstall's patented strain ring monitoring sensors.

With a resolution of 0.25% (of full scale), the strain rings were originally trusted by the oil and gas industry to provide highly accurate data for upstream assets, including FPSOs and semi-submersible platforms installed around the world. This technology can sense minute changes in mooring loads, while monitoring primary load paths in real time. This provides an increased understanding of the load placed on floating structures, helping to predict their fatigue life while informing a regime that includes predictive maintenance. Additionally, all data collected could be compared with modelled predictions, providing insights for future design optimisation, material reduction and value engineering.

Ultimately, the strain ring proved to be a reliable solution that helped to secure the Hywind project's successful completion; a project that has since outperformed expectations despite weathering frequent winter storms and the extreme conditions of a hurricane.

Strainstall's involvement with Hywind demonstrates asset monitoring's significance to the assured deployment of pilot projects. It also reflects how widely-recognised methods from the offshore oil and gas industry can help to protect FLOW projects from structural integrity threats, while reducing R&D and quality assurance timescales.

In partnership with First Subsea, Strainstall are now contracted to deliver a similar solution for the Kincardine Offshore Floating Wind Farm – the largest FLOW array to date.

Phase 2: Sustainable upscaling to meet emerging energy demands

Ensuring asset security for life

Hywind and other pre-commercial arrays only scratch the surface of floating offshore wind's capability. As 80% of offshore wind power available is in deep waters, the energy industry is increasingly keen to access this largely untapped potential. Against the backdrop of climate emergency, the technology's promise has been met with a growing demand for FLOW to upscale its operations and support the global aim for net zero. Doing so will require the size of turbines and the number of arrays to expand at an unprecedented rate.

However, as arrays become larger it is pertinent that industry combines swiftness with caution to achieve sustainable growth. Transcending the bounds of pre-commercial deployment, asset monitoring's risk management capability on a commercial scale is key to realising this. The Health and Safety Executive (HSE), a UK government agency, recently outlined the asset owner's responsibility for operating floating offshore renewable energy structures, stating that 'the duty holder shall ensure that an offshore renewable energy installation (OREI) and its moorings possesses such integrity, throughout its lifecycle, as is reasonably practicable to ensure the health and safety of persons.' It also advises that ''loads during operational conditions including normal operation, contact loads from access boats and temporary loads maintenance operations' should be monitored, along with 'environmental conditions, e.g. winds, waves, water depth, tidal and current conditions' to mitigate the risk of 'mooring line failure'.

While the HSE clearly assigns responsibility to asset owners for ensuring that suitable risk-management systems are in place, it is significant that it leaves methodology open to interpretation instead of mandating a specific approach. This may have led project leaders to view asset integrity forecasting at the initial research and development (R&D) stage as an appropriate response to public sector instructions, seeing predictive risk mitigation as offering an acceptable degree of assurance.

However, sophisticated modelled forecasts are still estimations by their very nature. To adhere to the HSE's instructions with the highest levels of confidence, owners should monitor FLOW arrays throughout their entire lifecycles. This approach is the only way to manage risk at an ALARP level, as it captures data across all stages of array development – from R&D and installation to operation and decommissioning. Doing so ensures that blueprints perform in practice against all eventualities, including mooring line damage.

As conveyed by the HSE's specific concern for mooring line integrity, compromises to mooring arrangements are a leading threat to the industry's ambitions to upscale into full commercialisation. Mooring line damage or redundancy can have considerable fiscal repercussions, as the emergency maintenance required to resolve this interrupts the array's steady output of energy and capital. More concerning still is the prospect of mooring line failure. Such incidents have the potential to take entire arrays offline indefinitely, while lost assets present a considerable hazard to other sea users.

Comparing FLOW with the hydrocarbon sector

In considering these ramifications, it is concerning that the FLOW sector has not followed in the footsteps of offshore oil and gas in its deployment of asset monitoring and sensor technologies as a given. Although mooring line issues for exploration and production (E&P) assets are severe, the hydrocarbon industry is more equipped to absorb the financial costs of exogenous events than FLOW. Despite this, asset monitoring is still deployed as standard in offshore oil and gas production. Even though FLOW is an emerging technology that sustains itself only on pre-commercial levels of investment, the sector appears to remain hesitant to adopt the same approach to risk mitigation.

While O&G has more severe environmental risks, FLOW operations pose their own unique threats that call for asset monitoring. Considering the arrangement of FLOW arrays, these are particularly vulnerable to mooring line failure. One malfunction can prompt a sequence of incidents that endangers the structural integrity of an entire wind farm. This threat only heightens as FLOW upscales in terms of size, value, and output to the wider power grid. While there is no definitive winner between spar, semi-submersible, barge or TLP (tension leg platform) in the race for FLOW optimisation, it is now a matter of priority for all designs to take every precaution when planning for mooring line safety. To this end, deploying load monitoring as a standardised feature of life-long operation can offer a heightened degree of security.

Monitoring qualitative value

In addition to protecting physical assets, the FLOW industry must consider an often overseen – but no less significant – challenge for its development. In the field of offshore engineering, the industry assesses quantitative data sets at painstaking lengths, yet qualitative factors are often left unobserved. In this vein, collective stakeholder confidence is integral to accurately evaluating the case for asset monitoring. Wind Europe alludes to this when it states that 'projects require significant investments and their bankability could be eased through financial instruments that address long-term uncertainty.' In line with this logic, industry confidence is not only shaped by financial instruments, but also by risk-management technologies. These foster their own unique form of qualitative capital, invigorating investor and stakeholder confidence.

For FLOW, it appears that technological advancement is no longer its highest hurdle. Instead, market perception has become a larger barrier to success. Asset monitoring's value is therefore not limited to measurable statistics. Rather, it is determined by the levels of confidence that risk mitigation can instil. This logic applies to FLOW's relationship with the insurance sector, particularly in respect to material damage, liability and loss of earnings. Deploying protective measures that span across the whole lifecycle of arrays can help to build

trust with insurers, which aids the negotiation of cover and premiums.

Fine-tuning commercial arrays for LCoE

Alongside its risk management capability, mooring line technologies have a prevalent role to play in LCoE. Wind Europe suggests that: 'FLOW cost reduction needs targeted R&I in mooring solutions' and the 'industry needs to reduce the cost of such key components as well as the related offshore operations.' In tandem with this aim, deploying sensor technologies such as load and condition monitoring can help reduce CAPEX and OPEX. On the one hand, these offer value engineering and material reduction benefits for improved cost-efficiency in platform development. On the other hand, the continuous monitoring of mooring lines and other critical components delivers data insights to enable lucrative asset life extension initiatives.

Phase 3: Enhancing efficiency and asset assurance through digitalisation

Collecting and analysing data is a prerequisite to realising the potential of FLOW through digitalisation. By emulating and adopting the hydrocarbon sector's digital approaches, FLOW stands to benefit from streamlining its operations.

According to Deloitte Insights, digital technologies that enable Internet of Things (IoT) applications could save over $500 million per year for large oil and gas companies (averaging 270 million barrels produced per year). Cost reductions of this scope are derived from health and safety advantages and efficiency improvements enacted by such technologies. Predictive maintenance, breakdown prediction, load measurement, condition monitoring, digital twinning, artificial intelligence and edge computing are just some of the technologies that can combine to form a safer and more efficient digitalised oil field.

Many of these technologies also contribute to the industry-wide aim for the automation of upstream operations. The underlying reason behind this movement is encapsulated by the RAND Corporation's 2016 study, which found that 80% of non-productive time (NPT) in Total's exploration and production operations can be attributed to human error. In response to this, the sector is gravitating towards digital technologies that enable the remote management of hazardous offshore production locations to maximise safety and minimise downtime.

As the challenges of FLOW and the offshore hydrocarbon sector bear a striking resemblance, it stands to reason that their solutions are equally comparable. Dr Conaill Soraghan, data and digitalisation team leader at ORE Catapult, found that 94% of participants in the offshore wind sector who

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took part in their research said they were not taking advantage of digital technologies, despite the significant performance increases of digitalisation and IoT. Dr Soraghn subsequently noted that 'concepts and techniques in areas such as big data and artificial intelligence are yet to have an impact in offshore wind, and that's something that needs to change if the sector is to embrace a more cost-effective future.'

In contrast to its fixed bottom counterpart, FLOW is in the unique position to realise this future. As a result of its pre-commercial status, digitalisation and IoT practices can be implemented from the outset. It is simpler to integrate IoT-style solutions from the beginning than to adopt them as retrofit, which can have the drawbacks of complex asset upgrades and time-consuming retraining programmes. If successfully harnessed from the start, digitalisation and IoT can offer a host of operational improvements, including real-time data sharing worldwide and a reduced need for costly offshore platform visits. These also facilitate the post-analysis of operational data to create digital FLOW arrays of superior safety, productivity and cost-efficiency. Digitalisation of this scope would position the industry significantly closer to its ambitious LCoE and net-zero targets.

However, taking advantage of automation and IoT technologies requires the mass stockpiling of the 21st century world's most valuable resource: data. To enable the remote management of arrays over globe-spanning distances, automated platforms will necessitate accurate dashboards that draw on myriad data sets, and must be able to interface with wind turbine generator SCADA systems. Mechanical load, met-ocean data, strain, meteorology, wave height, current direction, current speed, GPS location and a multitude of other data fields will all need to be gathered to convey an overview of events in sufficient detail, as well.

Yet data collection operations and dashboards of this complexity are not an idealistic aim set in the horizon of a distant future. On the contrary, this capability is afforded by current technology. For example, Strainstall's Integrated Marine Monitoring System (IMMS) is already able to provide data insights at this level of detail for offshore assets. Additionally, the wider James Fisher and Sons plc group of companies that Strainstall is part of is frequently innovating, developing and delivering IoT and digitalisation enabling technologies to high-assurance sectors worldwide, striding untrodden paths in the arenas of digital twinning and advanced telematics.

In considering the sophistication of current data capture and curation technologies, the only barrier to a digital tomorrow is our willingness to invest today. While doing so will take confidence and coordination, the safety, CAPEX and OPEX advantages of digitalisation far outweigh its challenges. However, achieving this will require project leaders to prioritise the implementation and utilisation of emerging digital methods in their FLOW developments. It is only through this approach that the data platforms required for effective IoT-style operations can be built. Organisations that take the initiative stand to gain a decisive competitive advantage over those that are reactionary in their attitude towards data collection.

Summary

As one of the most promising opportunities on the horizon for renewable energy, the upscaling of FLOW has the capability to be a major driver in the global aim for net-zero. However, as the industry begins to navigate the turbulent waters of full-scale commercialisation, it is becoming increasingly apparent that opportunity accompanies threat in equal measure. FLOW must not only live up to the pressure of its key investors, but will need to shoulder the world's expectations in the current state of climate emergency. Achieving this will require FLOW decision makers to proactively take advantage of risk management opportunities that mitigate threats to the sectors' sustainable development.

By mooring itself to the hydrocarbon sector's wealth of experience, the FLOW industry can harness today's technologies to realise tomorrow's promises. Asset monitoring will be integral to this achievement, particularly with its ability to deliver superior safety, risk-management and LCoE benefits throughout all stages of array operation. Building on its proven track record in oil and gas, real-time data from asset monitoring has the capability to go beyond concept verification to support the commercialisation and digitalisation of full-scale arrays; driving the industry forwards as it embraces a greener future.

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About us:

With over 50 years' industry experience, Strainstall is a leading developer of asset monitoring technology for a range of high-assurance markets.

Throughout our history, we have secured our reputation as specialists in engineering bespoke solutions for the unique challenges of our industry partners, particularly those that operate in harsh and remote offshore environments.

Our technology captures data in a host of applications, monitoring load, displacement, inclination, temperature, vibration, strain, water levels and other key parameters. When combined, this data provides a real-time overview of events to maximise the performance of assets, extending their lifecycles while enabling predictive maintenance.

We have supported some of the world's largest engineering projects, from Shell's Prelude FLNG to Orbital Marine Power's O2 tidal platform. Drawing on our offshore expertise, we continue to innovate in the emerging FLOW sector.