INSTITUTE OF MARINE
Engineering, Science & Technology

OPERATIONS AND MAINTENANCE IN THE OFFSHORE RENEWABLES ENERGY SECTOR

In association with FUGRO

Foreword

The IMarEST is delighted to have partnered with Fugro in producing this insightful survey of global attitudes of engineers towards Operations and Maintenance in the Offshore Renewables Energy Sector. The role of offshore renewables is critical in the energy transition, and in delivering the national commitments to reduce emissions that are being made as part of the green build-back in a post-Covid world and ahead of COP26.

Offshore renewables is moving forward at an exciting pace, with larger wind turbines and floating offshore wind moving to commercial scale. The tidal and wave markets are developing and provide attractive options in some geographies, showing promise of commercialisation. Looking beyond the challenge of delivering the expected 234 GW of offshore wind by 2030 (Global Wind Energy Council Annual Report 2020), the operators and supply chain need to consider how to cost effectively operate and maintain the installed capacity.

This survey addresses key issues related to skills, technology, data, and health, safety and environment (HSE). The rate of growth of the industry and supportive technology creates new jobs, but readiness to accept this growth creates barriers – we need to understand the skills required to deliver both today and in the near future, as technological innovation delivers new requirements. The data requirements needed to inform safe decision-making, optimal operation and plant control requires consideration, along with the provision and sharing of data to support multiple end users and applications.

Presently there is a distinct gap between turbine manufacturers and wind farm operators with respect to understanding whether turbines are performing outside specification and requiring optimisation or being operated incorrectly. We need to address this urgently to ensure the wind resource delivers the watts. Digitalisation is here and will happen, and initiatives such as the IEA Wind Task 32 workstream on Digitalisation of Wind lidar offer an insight into potential application for resource assessment, wind plan control and forecasting for operational support.

Greater innovation can be challenging: gaining acceptance of novel technologies from the perspective of operator and certifying authorities is difficult. New technologies, particularly with respect to machine learning and AI, can be seen as a threat to jobs. The process by which we interface to these new technologies, and ensure expertise is unleashed and shared to enable future developments, will be critical. Underlying the above is the necessity to ensure that future innovation is delivered safely, with the well-being of the workforce paramount. The ability to reduce exposure to risk through new technology is welcome – the importance of quality of life has also come to the fore in a Covid-impacted world.

This report helps support the aims of the Offshore Renewables Special Interest Group, and is a welcome addition to the body of knowledge supporting its activities.

Dr Alice Goward Brown
Dr Mark Calverley
Co-chairs of the Offshore Renewables Special Interest Group

Alice Goward Brown, Co-chair of IMarEST Offshore Renewables SIG and Renewable Energy Consultant, Wood

Mark Calverley, Co-chair of IMarEST Offshore Renewables SIG and Director at Blue Ocean Consulting

About the Offshore Renewables Specialist Interest Group (ORSIG)

IMarEST Special Interest Groups (SIGs) are voluntary groups which operate to the benefit of a specialist field. The ORSIG provides a forum for those with an interest in wave, tidal or wind energy. ORSIG has several hundred members across the globe. Key issues are identified and the SIG promotes knowledge exchange and discussion forums to enable individual professional development and broader industry development. This is facilitated through webinars, workshops and an online discussion portal. The Group also undertakes academic outreach and early careers path development to ensure future professionals are ready to support the energy transition.

Data-driven maintenance strategy will revolutionise offshore renewables sector

Ivar de Josselin de Jong, Remote Inspection Director, Fugro

The transformation of the global energy market from traditional fossil fuels to offshore renewables is under way and moving at an unprecedented pace.

Fuelled by impressive technological advances and favourable government policies, the race is on to reduce carbon emissions. Offshore renewables are poised to become a major green energy source in what promises to be a historic transformation.

In 2018 offshore wind power accounted for 23 GW of energy globally and output is expected to increase to 94 GW by the end of 2026. This impressive 19% compound annual growth rate is not without its challenges as operators race to develop strategies for the operation and maintenance (O&M) of offshore assets with a service life of at least 30 years, while also delivering the expected energy output and return on investment for stakeholders.

Whereas offshore oil and gas is an established market, offshore renewable energy O&M is still very new, with only 20% of its infrastructure worldwide more than 10 years old. To succeed in this age of Industry 4.0, big data and AI, operators will need to be innovative and reconsider their O&M approach.

As turbines become more efficient, the cost of downtime will increase significantly, resulting in the need to switch from reactive to proactive, data-driven decision-making, supported by condition-based maintenance strategies. Analytic technologies are now prevalent in many industries, but they are only as powerful as their underlying datasets.

The successful transition to a proactive maintenance strategy will require a converging data approach – incorporating data from a variety of sources, such as structural monitoring, environmental and metocean data, as well as supervisory control and data acquisition, to develop a holistic, 360° view of the assets and the underlying infrastructure.

Condition-based maintenance strategies that rely on these converged data sources can be complemented by advanced remote and autonomous survey and monitoring solutions to increase asset uptime, ensure safer operations, reduce operational costs, manage the asset lifecycle effectively and support decisions about lifetime extension or decommissioning.

The journey to provide integrated cloud-based data solutions for the offshore renewables market has begun. Access to a data platform with best-in-class software that integrates and models real-time operational data and geo-data collected throughout the asset lifecycle will contribute to more efficient predictive maintenance plans, along with better and faster decision-making.

This strategy represents an important shift from traditional marine services to a data-driven, analytical and results-oriented approach that will help deliver the next generation of offshore renewable energy on a global scale.

Fugro welcomes partners who would like to collaborate on our vision and bring data-driven O&M solutions to the offshore renewable energy market. The development of this white paper in conjunction with IMarEST represents an initial step in this direction. We welcome and value your feedback.

Ivar de Josselin de Jong
Fugro

Executive summary

Renewable energy is gaining traction globally, particularly offshore renewable energy (ORE) as a growing sector aiming to support climate targets. As such there is a need to support more competitive projects that can allow development and expansion of this sector and support net-zero ambitions. But there are hurdles to growth, including slow build-up of networking and capacity in developing countries, a lack of government policies to support infrastructure, and limited financing for research and development (R&D) to improve the reliability of automation, zero failure design and standardisation in the operation and maintenance (O&M) phase of wind farms.

The sector itself has expressed concern that it is unprepared to integrate new tools and processes, particularly with respect to the human-machine interface and around the supportive services of insurance, health, safety and environment (HSE) policies and system standards. But more confidence is evident regarding the introduction of available, commercial technologies, such as cloud processing and data integration and storage, and communication infrastructure, such as low earth orbit satellites.

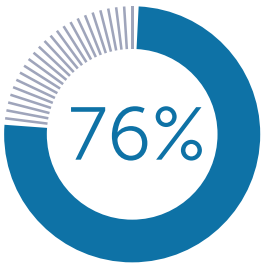
The skills outlook is evolving with roles expected to change significantly to handle these new technologies and processes. Data and coding skills are becoming increasingly important with ORE field service technicians expected to be multi-skilled and data interactive with a good understanding of operations and maintenance issues. While the ORE sector can benefit from skill transfer to support cost reduction, it must still invest in data integration solutions and upskilling its workforce – and potentially those in the hydrocarbon sector – to meet these changing demands. Otherwise, the ORE sector faces the real risk of a shortage of qualified people within the next 5-10 years.

Skills gaps aside, there is certainly a willingness to move forward and investigate and implement new technologies in the ORE sector. Rising technology stars include automated and remote processes, satellites, maritime autonomous surface ships (MASS), over-the-horizon connectivity, data learning, uncrewed autonomous vehicles, robotics, remote operations, augmented reality, Internet of Things, 3D printing and technology, blockchain, use of drones, 5G networking and crawlers, which are all expected to show the most growth in the ORE sector over the next 10 years. There is also great potential seen in the use of coupled atmosphere and ocean models to power a more sophisticated energy generation forecasting tool, with the caveat that many believe that weather forecasts are not yet accurate enough for optimal maintenance planning, and improved forecasting will have a noticeable impact on costs related to site inspections.

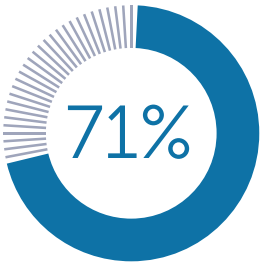
Overarching all the potential for growth and development of the ORE sector is the safety angle. Safety has to be designed and built into every new technology and process, and liability and legislation still needs to be addressed. Further development and enabling of uncrewed and remote operation solutions will be key to success here. Also, regulators and insurers have a large part to play in increasing confidence levels to allow traction of new ORE technologies.

Overall, there is still work to be done in the ORE sector to ensure the adoption and acceptance of robust innovation systems and processes that ensure safe and effective operations. But industry is embracing change and is making important moves towards achieving a more technology, data-powered and data-driven future.

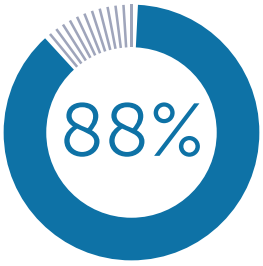
Results at a glance



view predictive maintenance as an effective tool to significantly reduce O&M costs



strongly agree that satellite observations will be increasingly used to support maintenance planning in the future

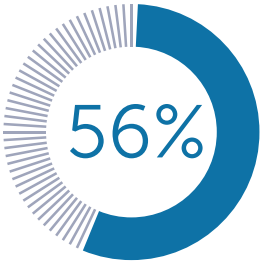


said that the introduction of automated and remote monitoring tools will have a significant impact on their organisation

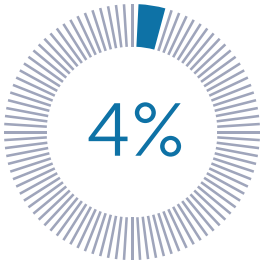
believe that the human-machine interface is unprepared for the introduction of automated and remote monitoring tools

Readiness and commercial availability of NEW TECHNOLOGIES are the main barriers to introducing automated technologies for O&M

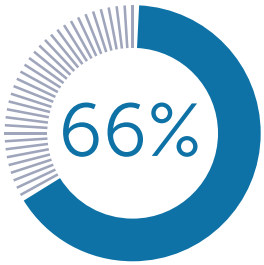
IMPROVED FLOW OF DATA and information between different project stages and parties is the GREATEST BENEFIT of having an information modelling tool throughout the asset lifecycle



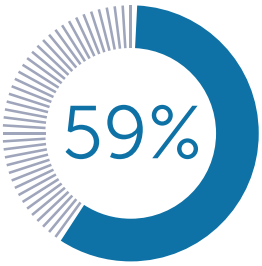
plan to use both risk-based and predictive modelling by 2024



will still be using a reactive maintenance model by 2024



expect automated cloud processing, machine learning and Artificial Intelligence (AI) to be the most important emerging technologies in the offshore renewables sector



saw a benefit in integrating supervisory control and data acquisition (SCADA) and balance of plant (BoP) data in a common database system

1: Technology

Automated cloud processing, machine learning and Artificial Intelligence – these are the technologies that hold the most potential for the ORE sector in the future, according to the IMarEST professionals. Drones came in a close second, with respondents no doubt encouraged by the sharp increase in remote inspections and surveys that drones piloted by crews have enabled over the travel-restricted Covid-19 pandemic.

Other technologies that show promise over the next 10 years include satellite imaging, over-the-horizon connectivity, quantum computing, augmented reality, sensor development, 3D technology, drone and crawler capabilities, and uncrewed aerial vehicles (UAVs).

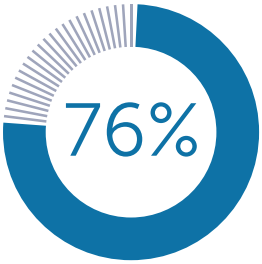
The benefits of adopting new technologies and digitalisation in the offshore renewables sector are wide ranging. Respondents noted the reduction of unnecessary tasks and labour and wasteful business practices, saving of both time and money, reduced dependency on humans, promotion of just-in-time decision-making and improved stock management.

However, there were some differing opinions on the usefulness of digitalisation in this sector. One respondent said that the data-driven approach "cannot replace experience", while another noted a shortfall between intention and implementation. A third urged companies to streamline the number of places where data is stored to fully benefit from digital tools.

Modelling tools and the introduction of automated component prognosis could, meanwhile, facilitate a reduction in the frequency and costs of inspections and operations and maintenance management. Most respondents believed that predictive maintenance is an effective tool to significantly reduce operations and maintenance costs and that the drive to improve the sustainability rating and reduce the environmental impact of operations and maintenance will prompt further innovation and investment in autonomous technologies. Respondents were less certain whether incremental cost reductions would be possible through the implementation of semi-autonomous practices.

In the workplace, the majority of respondents agreed that the introduction of automated and/or remote monitoring tools would have a significant impact on their organisation, while only 3% said that those tools would have no effect.

However, barriers to the introduction of new technologies remain, top of which is the readiness and commercial availability of new technologies. This is followed by cost, having a reliable evidence base for machine learning systems upon which to base predictions of actual and remaining life, and the ability to incorporate technician knowledge and experiences into condition-based monitoring systems.



agree that predictive maintenance is an effective tool to significantly reduce O&M costs

"Responses reflect what we see in the supply chain, where developments around remote and autonomous data acquisition systems, cloud-based data processing, analysis and digital twin solutions are rapidly taking shape. Clever combination of these main enablers will form the ultimate answer to offshore O&M market needs in the coming years."
Ivar de Josselin de Jong

Modelling tools and introduction of automated component prognosis could facilitate a reduction in the frequency and costs of inspections and O&M management. With regards to emerging and autonomous technologies in offshore O&M, to what extent do you agree with the following?:*

76.32%	Predictive maintenance will be an effective tool to significantly reduce O&M costs
72.37%	The drive to improve the sustainability rating and reduce the environmental impact of O&M will prompt further innovation and investment in autonomous technologies
61.07%	There will be increasing investment in and use of augmented reality and no-touch of subsea structures (e.g., deployment of advanced camera systems, sensor systems, and uncrewed subsurface vessels to help to reduce the cost as opposed to diver-based operations)
60.93%	Remote operations will significantly improve health and safety of offshore teams and reduce risks
60.93%	There will be increasing investment in and use of non-visual, non-destructive testing inspections of surface structures (e.g., composite wind turbines)
49.33%	The industry will see a differentiation between topside and subsea maintenance to enable more contractors to bid for the full package within RFQ/ITT (as opposed to 1 or 2 work packs within a larger RFQ/ITT)
48.99%	Incremental cost reduction is possible by implementing semi-autonomous practices

*Respondents were asked whether they agree, somewhat agree or disagree with these statements – the above percentages show those who outright agreed

What are the main barriers to introducing automated technologies for O&M?
Listed below in order of importance

1. Readiness/commercial availability of new technologies
2. Cost [training; specialist equipment/technology changes etc]
3. Having a reliable evidence base for machine learning systems upon which to base predictions of actual and remaining life
4. Ability to incorporate technician knowledge and experiences into condition-based monitoring systems
5. Effective management of the human-machine interface

2: Future skills

With autonomy and digitalisation progressing in the offshore renewables sector, roles in the marine engineering industry are changing, some more so than others. As a result, the industry will need to re-evaluate the skills its workforce needs to meet the demands of the sector in the future, a challenge shared across the blue economy.

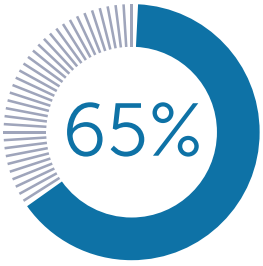
Respondents advised increasing digital skills and remote-control training to keep pace with progression. Supplementing the IT skills of marine engineers was a popular suggestion from respondents, with system integration and logic, cloud computing, data science and programming languages all noted. Robotics was another area with which marine engineers were urged to increase their familiarity.

One respondent summarised: "Technical skill acquisition will be highly needed in the marine industries and academic research environment to understand the automated built marine machines and the robotics language usage." Another added: "The role will need to evolve to use new tools. The tasks will remain but be done through a combination of man and machine." However, one respondent feared that a lack of necessary upskilling could lead to a huge shortage of qualified people in the sector.

The offshore renewable industry does have the option to draw on skills transfer from other offshore industries, which could help to fill knowledge gaps. For example, an offshore oil and gas engineer could easily be employed in the offshore renewables sector, one respondent pointed out, although there is a need for more cross-training between disciplines. An area of skill transfer where emerging offshore renewable energy technologies can benefit is the supply chain. To survive downturns in one offshore industry (i.e., oil and gas) supply chain services should be mobilised to support emerging industries. There has been a major effort towards this, and many companies today supply both sectors. There are also national nuances to navigate, for example the UK Offshore Wind Sector deal requires higher local content, while the US has made a commitment to drive jobs with a green economy, which includes offshore wind.

There are also great synergies between ship marine engineers and electrical engineers and those in the offshore world, another noted: "There is a huge abundance of skills in the offshore sector and most would be directly transferrable."

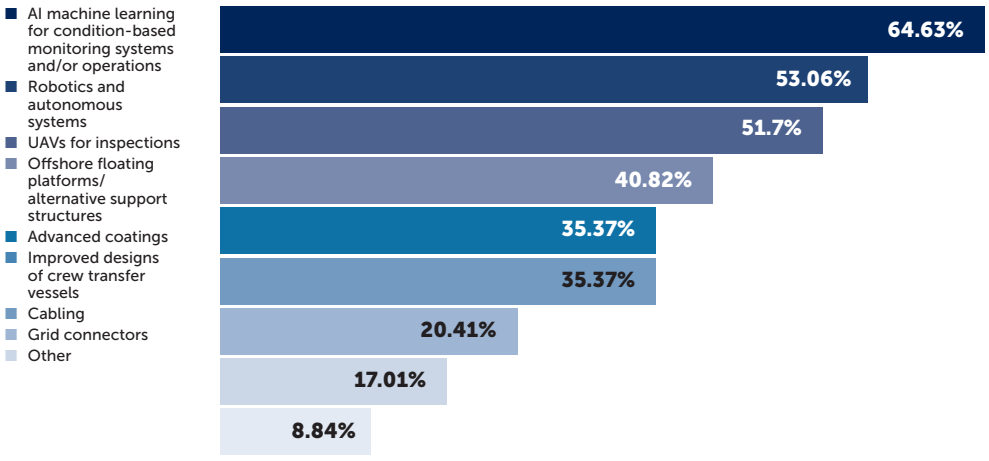
The offshore renewables sector has been criticised as slow to learn from other offshore industries, but this is improving with increased transfer of personnel between industries.



see AI and machine learning as key tools in future condition-based monitoring systems and operations

"We are facing a major transformation in the maritime business, with the rapid uptake of less carbon-intensive renewable solutions and a move towards uncrewed and autonomous operations. This shift in skill needs and change management process provides challenges and opportunities to the industry. Challenge in developing the right training programmes, building on existing skills and further developing the opportunity to work in a safer onshore environment and benefit from a better work-life balance."
Ivar de Josselin de Jong

What new tools do you see your organisation needing or benefiting from? (Please select all that apply)*



*Respondents were asked to select all options that applied

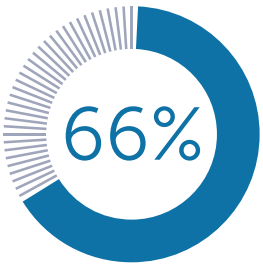
3: Health and safety

Safety must not be forgotten in the rush to adopt new technologies, to adapt current roles and to create others to meet the tech-focused demands of the future in the offshore renewables energy sector.

While there is agreement that health and safety considerations should be front and centre of every decision made on the sector's future, there is a fear that these are being overlooked.

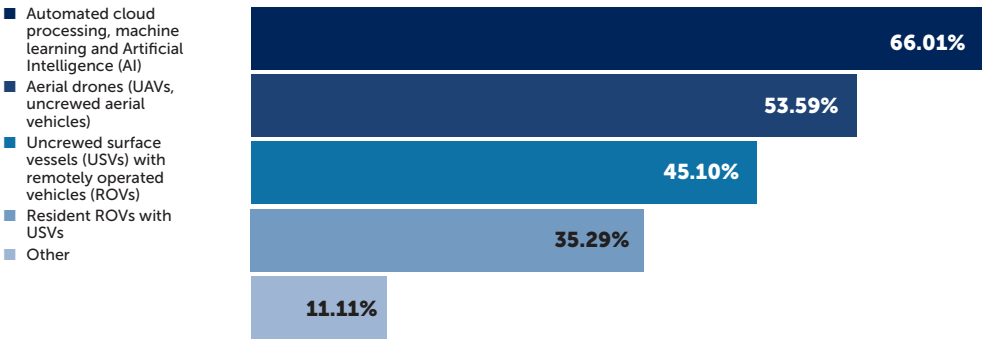
A common argument for remote technologies is the benefit of removing risks to people working in hazardous environments, and while this is a typically accepted view this survey also raised concerns on additional risks that new tools themselves present. For example, respondents were not certain that evolving roles effectively address health and safety risks for marine engineers. Those surveyed gave a 61/100 average rating, revealing that more needs to be done to mitigate health and safety risks faced by today's and tomorrow's marine engineers. One pointed out that health and safety issues are not being integrated into the development of new roles. There was also a fear raised that technology is progressing faster than current training systems can cope with.

And while it is believed that the industry is 'fairly prepared' when it comes to introducing automated and/or remote monitoring tools, there were mixed responses when it came to considering how successfully technologies address safety concerns for marine engineers. One respondent commented: "The emerging remote maintenance tools are an aid to diagnostics but don't supplant the necessity for a human in situ survey, especially related to critical safety and infrastructural equipment." Another said: "There's still a lot of work to be done to ensure a robust system with high safety features."



view automated cloud processing, machine learning and AI as the emerging technologies that will be most important to the offshore renewables sector

Which emerging technologies will be most important to the offshore renewables sector? (Please select all that apply)*



*Respondents were asked to select all options that applied

"A safe operational roll-out of remote operations technologies will require a global, standardised development of a completely new operational framework that involves new legislation, operational procedures and the development of new accredited training programmes for future operators."
Ivar de Josselin de Jong

4: Data

The benefits of data collection no longer need to be laboured, but there is still work to be done in convincing the offshore renewables energy sector of the gains to be made with improved analysis and increased sharing of relevant data.

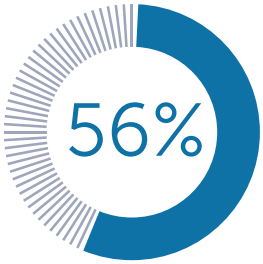
In considering the key benefits of lifecycle modelling tools, over a quarter of respondents viewed improved flow of data and information between different project stages and parties as the greatest benefit to using information modelling throughout an asset's lifecycle. A close second was informing predictive maintenance strategies to reduce the need for repairs and to prolong the operational life of the assets.

Yet despite clear advances in predictive modelling, reactive maintenance was still the preferred model for 4.6% of respondents. More positively, asked to look ahead three to five years and the percentage of respondents that envisaged using both risk-based and predictive modelling grew to 56%. But a small percentage expected they would stick resolutely to reactive maintenance. Looking to the future, the development of verification schemes is expected to cut costs by reducing the number of breakdowns and/or maintenance costs.

An overwhelming majority of respondents saw a benefit in integrating supervisory control and data acquisition to control industrial processes locally or at remote locations and balance of plant data on supporting components and auxiliary systems in a common database system. One respondent expanded that such an integration allows surveyors to determine the ratio of prime movers to their auxiliary support systems for the purposes of determining energy consumption. Another commented: "By thinking ahead and combining data in a smart way, overall design and operational costs can be optimised. There is no point in only optimising maintenance if this increases construction and fabrication cost significantly."

Another pointed out that integration pulls all data into one place, which in turn enables informed decision-making.

Those surveyed were asked to detail which type of operations and maintenance model or approach they currently use in their organisation. There were two clear winners: 36% use a continuous cycle of inspection and maintenance, while a further 36% pair risk-based and predictive modelling. Digitalising O&M strategies could mean breaking away from constant manual inspection and maintenance to a more predictive, risk-based approach.

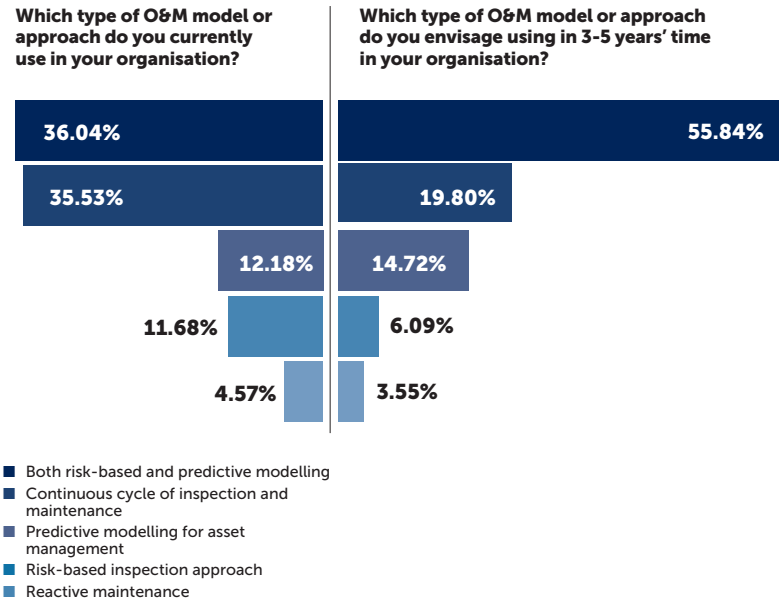


expect that they will use a combination of risk-based and predictive modelling in 3-5 years' time

"We see the supply chain embark rapidly on this data integration journey. Cloud-based data solutions will facilitate a data-driven, analytical approach to developing condition-based maintenance strategies for O&M in the offshore renewables market."
Ivar de Josselin de Jong

What are the greatest benefits of having an information modelling tool throughout the asset lifecycle?
Listed below in order of importance

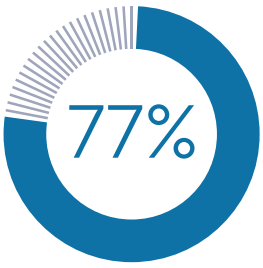
1. Improved flow of data and information between the different project stages and parties
2. Informing predictive maintenance strategies to reduce need for repairs and prolong operational life
3. Reducing frequency and costs of physical inspections
4. Improved data processing capacity to enable traceable data-driven decision-making
5. Integration of weather forecasting and metocean data to optimise O&M planning



5: Metocean data

Metocean and weather forecasting services should, in theory, allow for better planning and reduced costs by maximising time effectively when working at sea. However, despite recognition of the importance of these services, there was uncertainty among respondents considering whether metocean data will in reality improve efficiency. Some of the barriers noted included criticism of weather forecasts that are not yet accurate enough for optimal maintenance planning, concerns that improved forecasting will not have a noticeable impact on costs related to site inspections, and the prohibitive costs of a large network of onsite sensors today. But on the upside, the majority of respondents agreed on the usefulness of fixing onsite metocean sensors during installation.

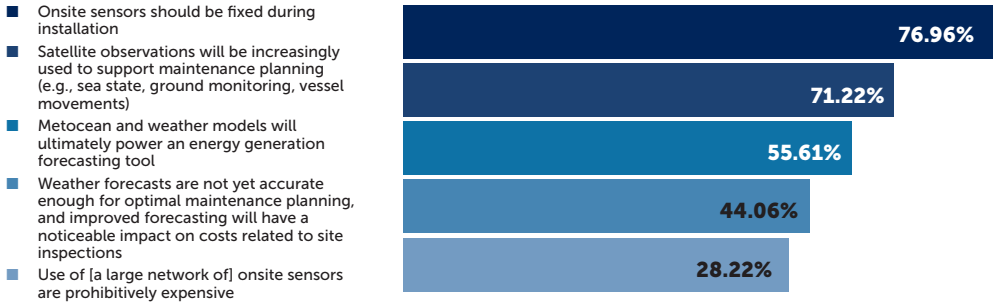
Diving into the role that metocean observations and measurements will play in future offshore developments offered up some interesting insights. One respondent pointed out that "better forecasting will enable more efficient switching operations between fossil fuel or wind generated power stations for national grid operators, allowing for better planning to include downtime for maintenance." Another commented: "Onsite real-time metocean data will always have precedence over predicted data and will be invaluable for operations and maintenance in future projects." On the flipside, one respondent warned against moving too soon with systems that do not deliver which will only hinder the roll-out of technology. A second pointed out that while these observations are useful, they "will not contribute nearly as much as other techniques that contribute to predictive maintenance".



believe that onsite metocean sensors should be fixed during installation of power production infrastructure

"Integrating the day-to-day 'geo-data' domain, (as described by metocean data), with real-time operational data will dramatically increase the insights available in support of the O&M teams that need to make well-informed, data-driven, condition-based O&M decisions."
Ivar de Josselin de Jong

Better understanding of the relationships between metocean data and power production and maintenance could improve efficiency of O&M. To what extent do you agree with the following?*:



*Respondents were asked whether they agree, somewhat agree or disagree with these statements – the above percentages show those who outright agreed

Extend, repower or decommission? You decide

With an eye on the circular economy, respondents were asked whether the offshore renewables energy sector should be more focused on asset extension, repowering or decommissioning. Those surveyed were split on whether to pursue asset extensions or decommission with proponents for the former citing improved ROIs, lower carbon footprints and maintenance of familiarity with operating systems. Those favouring decommissioning pointed up increased efficiency of newer assets and the comparatively greater environmental impact of older assets. Addressing the choices, one respondent said: "One of the main challenges will be acceptance. Methods need to be tried and tested before being widely commercially applied. Many warranties/insurers will be wary of new technologies and techniques, without the backup of tried and tested methods, which makes the process very costly."

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