EMPOWERING KNOWLEDGE TRANSFER IN OFFSHORE WIND

AUGUST 2019

WIND ENERGY SCIENCE

With nearly eight years of history rooted in the offshore and onshore wind energy industry, Wind Energy Science™ reach well beyond geographical and industrial borders in countries throughout the world. Our work and vision continue to expand with a research strategy that has given us one of the most comprehensive solution sets in the wind power industry. We champion clients from development to supply chain, from project management to value engineering and everything involved in the wind power business and its services.

Bringing Offshore Wind Greater Efficiency, Flexibility and Scalability

Companies and firms surveyed:

144+

Wind power companies, manufactures, consultants and research institutions

MARKET REseaRCH:

54+ Scientific publications on offshore wind between 2013 and 2018

involvement in

49 wind energy projects

44,000

Hours of research

INDUSTRY EXPERTISE:

300+

survey-responders worldwide

8 countries from around the globe

90+ wind power research projects

BOOSTING INNOVATION:

knowledge transfer

cost of energy

mitigation

81%

said we improved project quality and increased their knowledge

Wind Power Research Principles

Our passion is setting our clients up to succeed, each and every day. At all levels of our research platform, we are champions of our clients' research mission. Being a client champion means:

INSPIRING

A passion to act

We embrace innovation and speed as we break down barriers to drive our clients' business forward.

FOSTERING

A pioneering spirit

We think big and act confidently to reinvent the offshore wind power industry of tomorrow, seeing what's ahead and discovering new opportunities.

BUILDING

Trust in all we do

We build our business and our relationships on a foundation of openness, honesty, reliability and integrity while incorporating a risk and uncertainty discipline into everything we do.

EMPOWERING

Research

We empower and accelerate wind power research by developing unique data science solutions that break down barriers, foster collaboration and create new, bold possibilities of opportunity.

ENCOURAGING

Knowledge

We passionately and purposefully encourage a culture of knowledge sharing and openness to make a positive difference.

Fostering Innovation and Cutting-Edge Technology

At Wind Energy Science™, we foster the ideation and development of disruptive digital solutions that empower innovation and knowledge sharing in offshore wind technologies and project management. Our knowledge sharing iLabs are designed for knowledge sharing that facilitates innovation and shortens time-to-market on new applications or procedures. They further our efforts to create solutions and improvements that drive positive, rewarding relationships between wind turbine suppliers, policy makers, develops, stakeholders and research institutions.

Offshore Wind and Years Ahead

According to our analysis, wind power should become the leading power generation technology by 2030 to establish the effective decarbonization of the global economy. Our optimistic scenarios predict that offshore wind capacity can reach 100-120 gigawatts (GW) by 2030 as innovation in offshore wind technologies and methods continues. However, according to our research, offshore wind capacity could increase faster if new policies and regulatory framework improvements adopted to double renewable energy production.

Offshore Wind Innovation Outlook Survey

This Offshore Wind Technology and Project Management Survey aims to inform policy makers, wind turbine manufacturers, developers and other stakeholders about anticipated improvements in the next two decades that will make off shore wind competitive on a large scale. The information in this report aims to facilitate and incentivize the roll-out of policy actions and project management improvements. In addition, it assesses the progress towards achieving the objectives and suggests recommendations to maximize the effective implementation of the new technologies in the offshore wind industry.

OFFSHORE WIND LCOE KEY DRIVERS

Costs have fallen more than 40% in the 15 years since the first offshore wind farm installation. The levelized cost of electricity (LCOE) from offshore wind shows a cost decline from about €240 per megawatt-hour (MWh) in 2001 to approximately €60/MWh in 2030.

Some of the drivers that lead to lower LCOE in include:

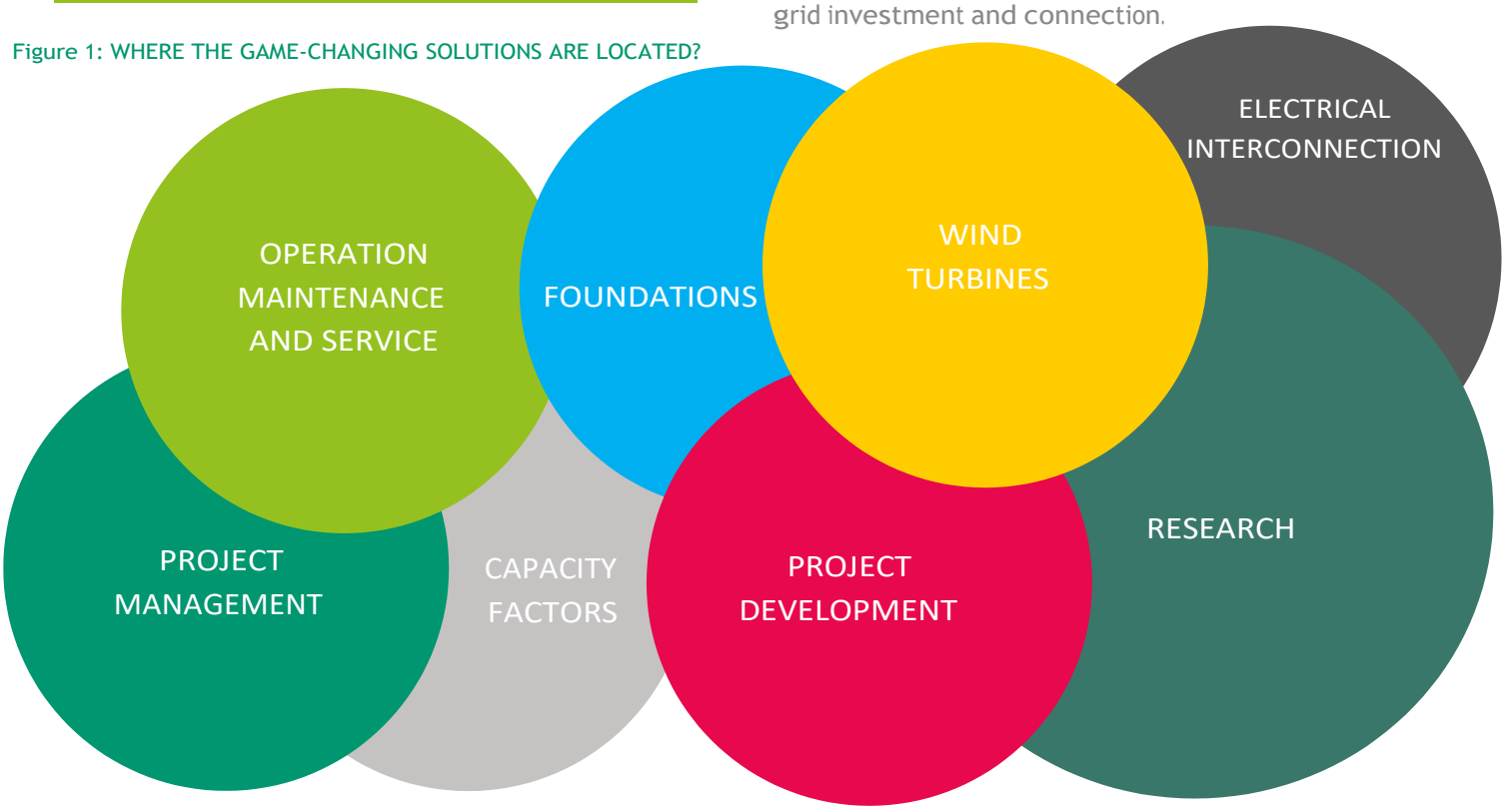
- Stronger wind resources, ranging from 8.5 to 10 m/s, which result in net capacity factors between 40% and 60%
- Closer proximity to the grid interconnect, which decreases the electrical infrastructure and maintenance costs
- Proximity to the land-based assembly area
- Proximity to shore-based port facilities, which minimizes installation, maintenance, and export system costs
- Shallower water depths, which minimize substructure costs.
- The cost of debt, the equity premium of the investors, and the share of debt and equity in a project all go towards the final value of the WACC.
- Operations and maintenance costs: Operational expenses consist of both fixed and variable costs and can represent up to 20%-25% of LCOE

Six Key Findings

The survey revealed that continued cost reduction, applicable research and support from policy makers are essential criteria to maximize the potential of offshore wind resources and to improve the industry as a whole. The survey revealed significant concerns about the efficiency and effectiveness of the current regulatory framework, project development, knowledge transfer and the challenges that offshore wind industry face:

1. **Half of senior wind power professionals think that the current regulatory framework must be updated and long-term policy schemes should be also introduced** with more than a quarter of those responding saying the need is more urgent, i.e., as soon as possible in the next two years
2. **Data Resourcing ranks as the top challenge** when managing project development and O&M risks, with worries over finding appropriately skilled human resources clearly beating other concerns.
3. **Access to finance is the major area of concern in terms of offshore wind power projects economic viability,** with almost 80 percent of those that responded saying that by providing credit support to the sector and make project data publicly available, the financing of offshore wind projects can be significantly improved.
4. **New pinch points to overcome supply chain and logistics challenges are emerging** with addressing availability of construction ports and installation vessels emerge as strategic actions.
5. **Support innovation, training and enhance synergies** are also often seen as big challenges now that great competition is considered as a driver to reduce offshore wind LCOE.
6. **The development of a fully integrated European electricity network with a politically backed master plan** is a critical concern, in order to ensure cost-effective grid investment and connection.

Figure 1: WHERE THE GAME-CHANGING SOLUTIONS ARE LOCATED?



KEY FINDINGS IN MORE DETAIL –SURVEY RESULTS

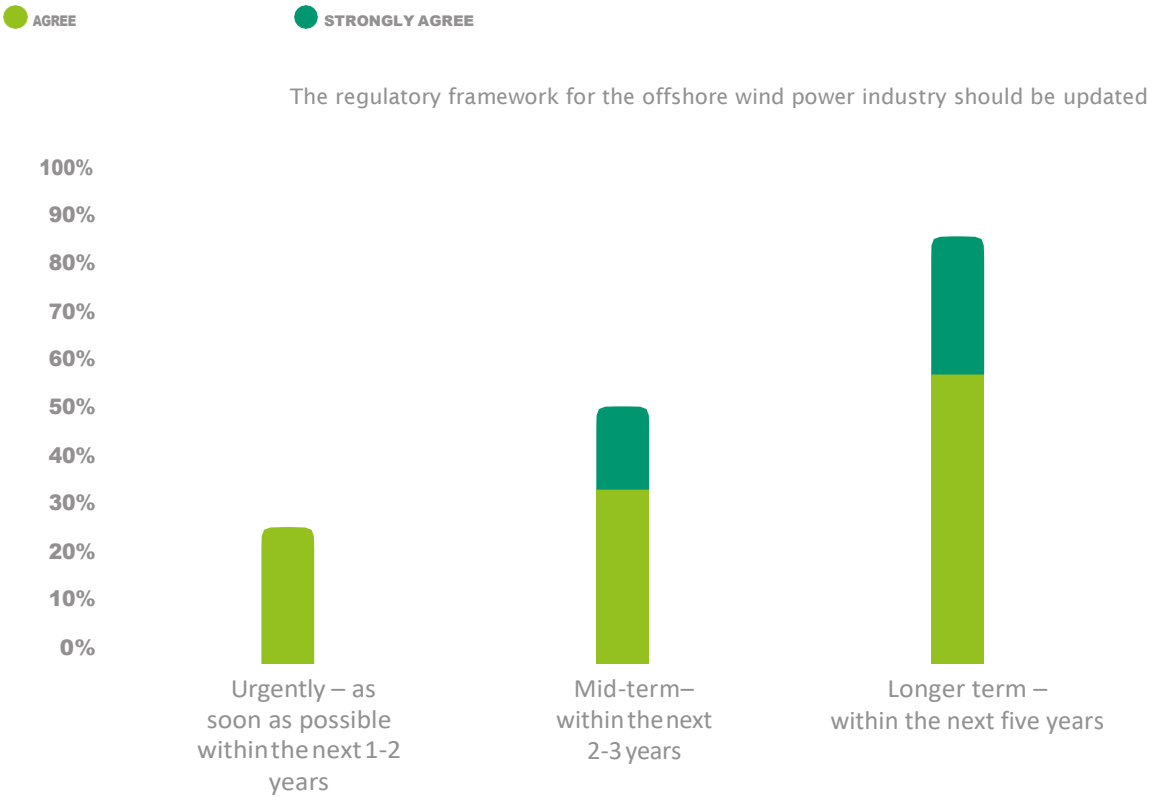
Regulatory framework updating More than a quarter of respondents said that the current regulatory framework must be updated and long-term policy schemes should be also introduced, with just over half saying regulatory framework updating is needed within the next five years (Figure 2).

Nearly all of those responding agreed that the regulatory framework and support mechanisms should be introduced in the longer term, with only one person thinking that re-development of the regulatory framework and new supportive mechanism were simply unnecessary.

The concern about the urgent need for significant changes in the regulatory framework is likely to be the result of significant improvements and cost of energy mitigation within a relatively short timescale.

Some respondents voiced particular concern about national pledges, regional synergies, and knowledge sharing, with one commenting that, "the offshore wind market is still policy-dependent, relying on public support schemes. According to our research outcome the EU should encourage ambitious national support mechanisms, with strong incentives that signal long-term certainty".

Figure 2: HOW MANY AGREE THAT THE REGULATORY FRAMEWORK AND THE CURRENT OFFSHORE SUPPORT MECHANISMS NEED TO BE UPDATED?

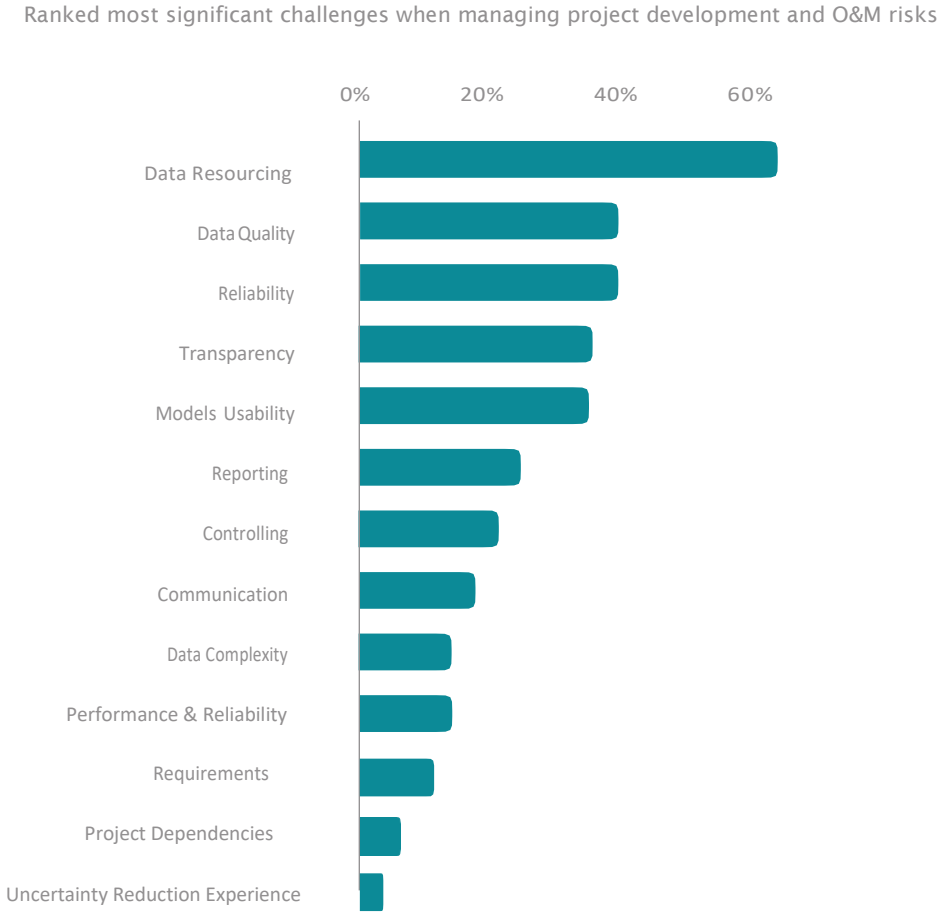


Data Resourcing – the most significant challenge when managing project development and O&M risks.

One of the most significant challenges that offshore wind power industry currently faces is finding the right resources to perform the modelling process, particularly O&M data, sources of risks, project development uncertainties and last but not least human resources, Nearly all the total sample (48 out of 54) named data resourcing as one of their most significant challenges and nearly two thirds ranked it as one of their top three challenges (Figure 3).

Data Resourcing is tough to get right because manufacturers, developers, stakeholders, traders and investors can find it difficult to corporate through knowledge sharing. In addition, despite of the plethora of the educational programs hire experienced staff with the required skills to handle and work with the data resourcing technologies is extremely difficult.

Figure 3: WHAT PERCENTAGE RANKED EACH FACTOR AS ONE OF THEIR TOP THREE RISK MODELLING CHALLENGES IN PROJECT DEVELOPMENT AND O&M?



Access to finance is the major area of concern in terms of offshore wind power projects economic viability

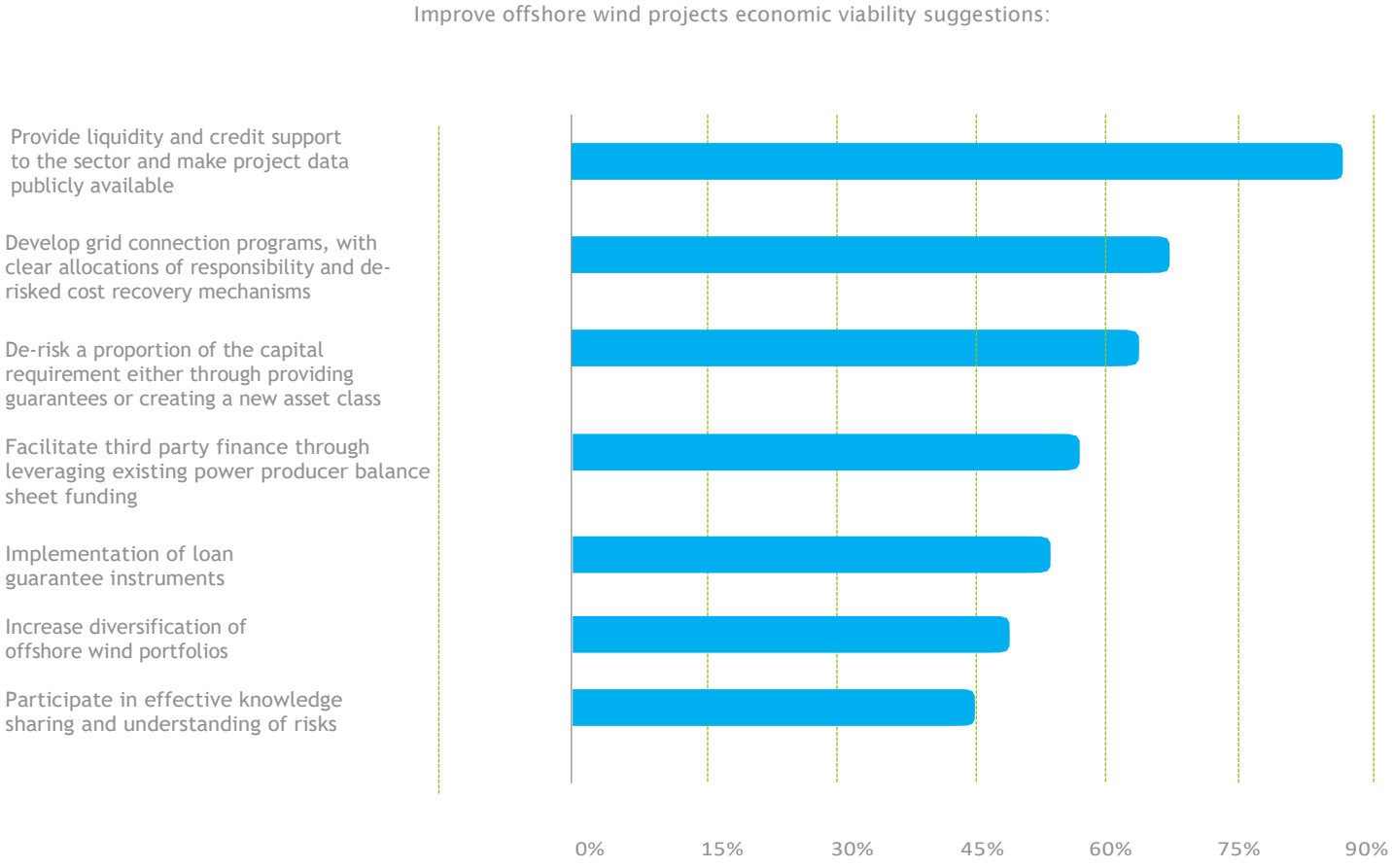
Seventy eight percent of those responding agreed that loan guarantee instruments can significantly improve the financing of offshore wind projects by dramatically reducing the risk for investors and almost 25 percent strongly agreed. Figure 4 shows the degree to which respondents feel the lack of efficient and effective financial initiatives to establish projects viability and reduce uncertainties.

The degree of concern over the effectiveness and efficiency of the financial initiatives is striking. However, the important phrase here is "stable, predictable and reliable incentives" with "long-term stability in pricing framework".

A clear financial support framework should enable investors and financiers to evaluate the economics during the initial stage of the project development. Any lack of long-term visibility on support and reliability of the prediction may affect investors' aptitude to Hight Return of Investment prospects. This is critical to preserve the appetite of current investors and attract new players to a sector demanding a holistic (as possible) understanding of project returns.

Third party capital providers are keen to ensure that policy makers keep offshore wind investments support scheme structure simple, reliable and "avoid ever-changing adjustments in the support schemes" to help them better assess cash flows over longer spectrums.

Figure 4: SUGGEST THE TOP PRIORITIES TO STAKEHOLDERS TO FACILITATE A BETTER FUNDING OF THE OFFSHORE WIND PROJECTS



New pinch points to overcome supply chain and logistics challenges

New pinch points to overcome supply chain and logistics challenges are emerging with addressing availability of construction ports and installation vessels emerge as strategic actions for the future offshore wind road-mapping.

The continual improvements of the offshore wind industry depend on the capacity to overcome supply chain and logistics challenges. In some European countries (UK, Denmark, Germany), offshore wind market development may be challenged not only by component problematic availability (WTGs, foundations, towers, cables), but also by a requirement for innovative construction facilities and state-of-the -art ports as well as advanced installation equipment and vessels.

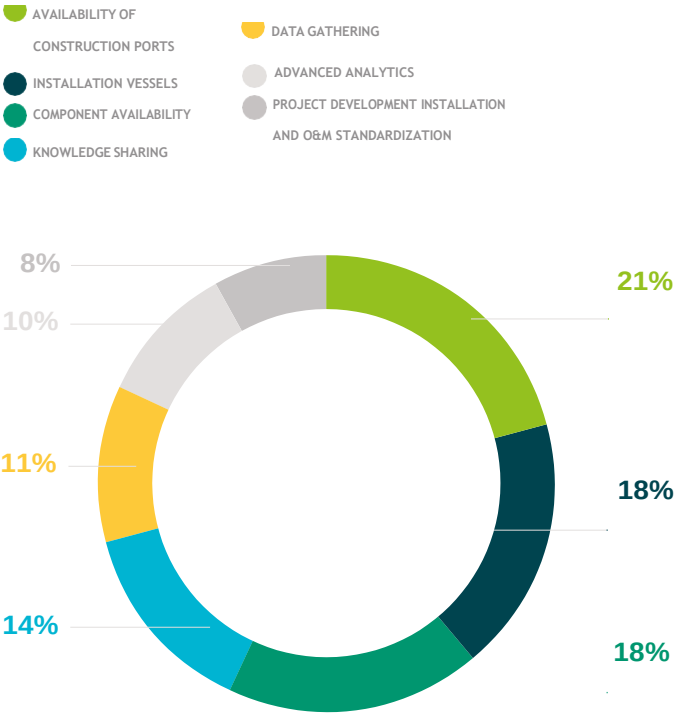
Compared to wind turbines, foundations represent a much more immediate supply chain opportunity some countries. Oil and gas industry suppliers have ample experience in offshore jacket foundation manufacturing that has already been transferred into the offshore wind sector.

However, “the transition will be easier for some than for others.” Jacket fabrication for an oil and gas platform, is a one off, rather than serial production where you're needing to build a wind energy plant of 50-1oo wind turbines. There is also still some uncertainty over whether developers will favor jackets, which can more easily be sourced in the EU or monopiles.

The availability of support services and capacity to install balance-of plant offshore assets such as substations and cabling are also significant for the responders.

Figure 5 depicts how it is likely to overcome supply chain and logistics challenges in the offshore wind power sector.

Figure 5: HOW IT IS LIKELY TO OVERCOME SUPPLY CHAIN AND LOGISTICS CHALLENGES IN THE OFFSHORE WIND POWER SECTOR?



Support innovation, training and enhance synergies are also often seen as big challenges.

Figure 6 illustrates the degree to which respondents agreed each of a range of key factors represents a significant challenge. Innovation and knowledge sharing are clearly the top concerns, but training and health and safety are also regarded as challenges.

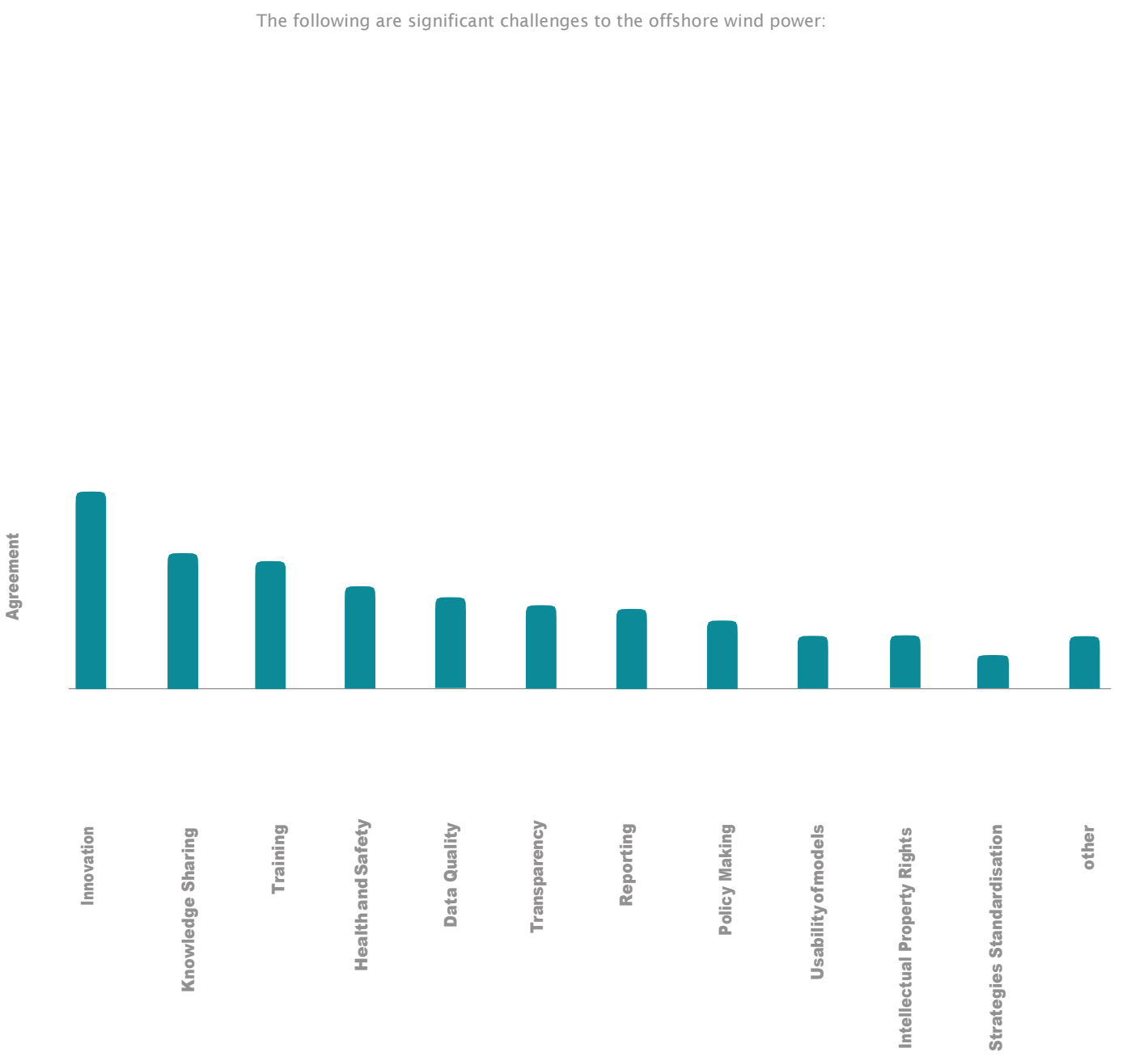
Indeed, many of the factors in Figure 6 represent an important challenge to some wind power professionals, while some other gaining relatively few votes.

FURTHER INFORMATION

We would welcome your comments on these findings. Please contact the author of this report at stavros@windenergyscience.com quoting Research, Project Management and Challenges in Offshore Wind Power Projects in the email subject line.

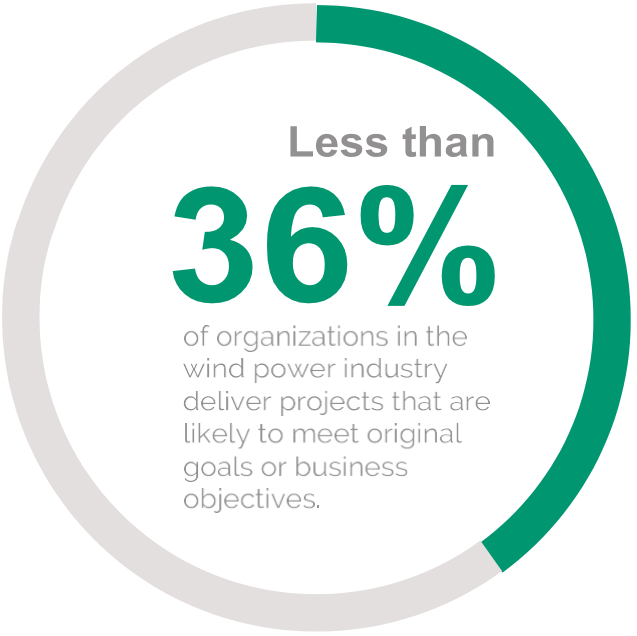
A forthcoming white paper will discuss the survey results and their implications in more detail.

Figure 6: WHICH FACTORS ARE SIGNIFICANT CHALLENGES?



Section Two: Optimizing the Project Management Function

In the last section of the survey, participants outlined the scale and scope of their project management structures and strategies, and their internal risk management operations. They then considered the initiatives they had, or were intending to undertake to standardize and prioritize these activities, and deliberated on the successes they had achieved so far.

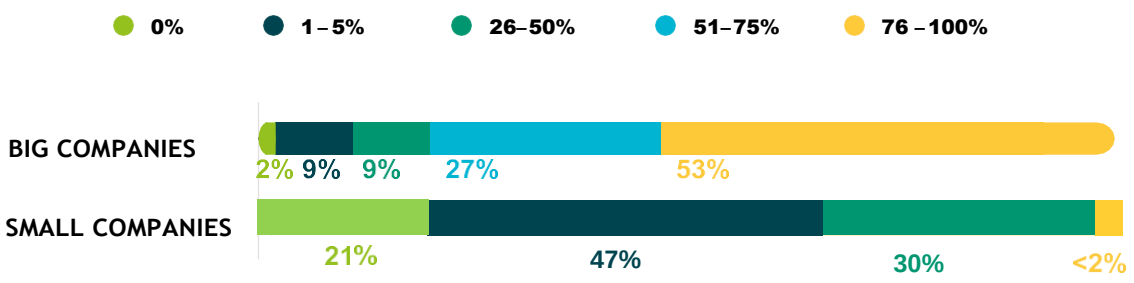


The crucial need to merge Change Management with Project Management

No project, especially in the wind power industry has 'constant state' as its objective, yet historically change management and project management have failed to effectively synergized. Offshore wind power projects have been entirely about delivering project outcomes on time and on budget. More than 75 percent of the survey participants agreed that it is usual a project manager to be capable of stimulating project deliverables that seem" out-of-alignment" to project objectives. However, the majority of them (70 percent) indicated that they "*do not expect project managers to deliver business value as a direct result of the project*". This means taking responsibility for not only what a project delivers, but also how those deliverables are implemented in the wind power life-cycle and how they could impact the business. To achieve that level of synergy requires change management to be integrated as a project requirement and the business impact to be stated as a deliverable.

Similarly, collaboration is challenging and resource-intensive for the offshore wind power industry given the large number of the external stakeholders, traders and parties involved. While smaller and less internationally diverse companies generally maintain a relatively small number of stakeholders, the problem occurs when the strategy shifts, as it often does, and the existing project objectives do not follow. To correct this significantly critical misalignment, organizations should establish a bottom-up process that continually defines the work processes, establishes and enforces new milestones and last but not least, links project outcomes with organizational strategy.

Figure 1. CHANGE MANAGEMENT IS INCLUDED IN THE PROJECT MANAGEMENT PROCESS (PERCENTAGE)



REQUEST THE FULL REPORT

You can request the full report and more details about these findings by sending an email to the author at: stavros@windenergyscience.com quoting, **Research Project Management and Challenges in Offshore Wind Power Projects** in the email subject line.

A forthcoming white paper will discuss the survey results and their implications in more detail.

Stavros Thomas is a wind power research engineer responsible for developing and executing strategic initiatives to mitigate the CoE for wind energy facilities and improve social acceptability. He is also the founder of the Wind Energy Science Research Group where he drives overall business strategy and execution in market research, KPI's evaluation and standardization of operational tasks.

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