PEAK WIND AND BCG

Unlocking Value Through Operations and Maintenance

Seven Levers to Boost Offshore Wind Profitability

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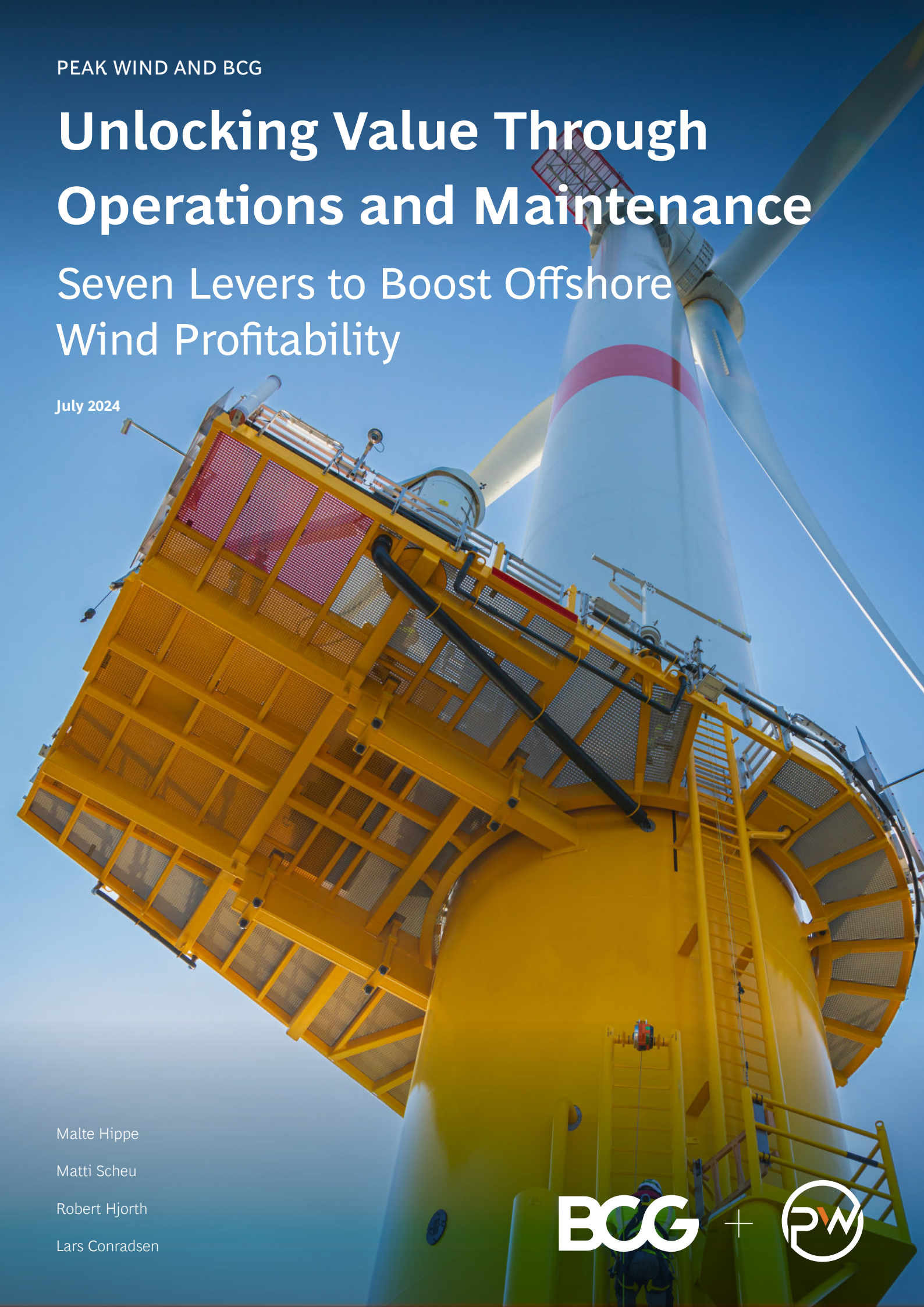

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This article underscores the pivotal role of operations and maintenance (O&M) in enhancing the operational performance and profitability of offshore wind farms. As these farms transition from supplementary green energy sources to primary energy providers, the emphasis on efficient O&M practices has become more critical than ever. Despite the traditional focus on expansion and timely project delivery, this article highlights the untapped potential in optimizing existing operational fleets for greater value creation. The evolution of turbine technology, coupled with a growing emphasis on revenue over mere production, necessitates a shift toward more robust predictive and revenue-focused O&M strategies. This shift is crucial not only for reducing operational expenditures and enhancing asset availability but also for adapting to market volatilities and achieving sustainable long-term asset management. By redefining operational practices and leveraging technological advancements, offshore wind farm operators can boost profitability, optimize energy production, and support the burgeoning role of wind energy in global energy systems.

Introduction

The offshore wind industry is currently experiencing a perfect storm that is impacting margins across the full asset lifecycle, causing executives to focus their attention even more on their pipeline and less on their ever-growing operational fleet. However, one should not disregard the considerable value creation potential in the Operations and Maintenance (O&M) phase. Operational performance of offshore wind farms represents an increasing proportion of the net present value of such projects, making efficient management critical to project success. Moreover, in many countries, offshore wind is changing from a supplementary green energy source into a primary source of energy. With that newly central role, the need for robust O&M practices delivering reliable and affordable energy is greater than ever.

We have identified four reasons for focusing on O&M improvement in order to boost offshore wind profitability:

1. Offshore wind CAPEX has declined more rapidly than OPEX and projects now have significantly longer lifespan expectations than previously. This means that operational performance constitutes an ever-larger proportion of the net present value of such projects.

2. Historically, offshore wind developers have prioritized expanding their pipelines and delivering projects on time, relegating operational efficiency to a secondary concern. However, as competitive pressure continues to increase, developers need to look at the significant untapped value remaining in the operational fleets of even the largest and most experienced developers.

3. Many of the O&M practices still followed today were introduced many years ago where wind turbines and projects were significantly smaller and lifespan expectations were shorter. Additionally, digitization and the use of generative AI have not yet reached their full value potential.

4. As offshore wind development increasingly shifts to a seller's market, coupled with an increasing talent shortage in that market, developing highly competitive O&M solutions — either in-house or strategically sourced — is emerging as an advantage. This not only enables owners to deliver compelling business cases and secure attractive returns but also facilitates access to critical technical data from operational sites.

As a result, today's offshore wind developers cannot afford to overlook the importance of refining their O&M practices. In doing so, they stand to unlock significant value, enhance project viability, and capitalize on emerging industry trends.

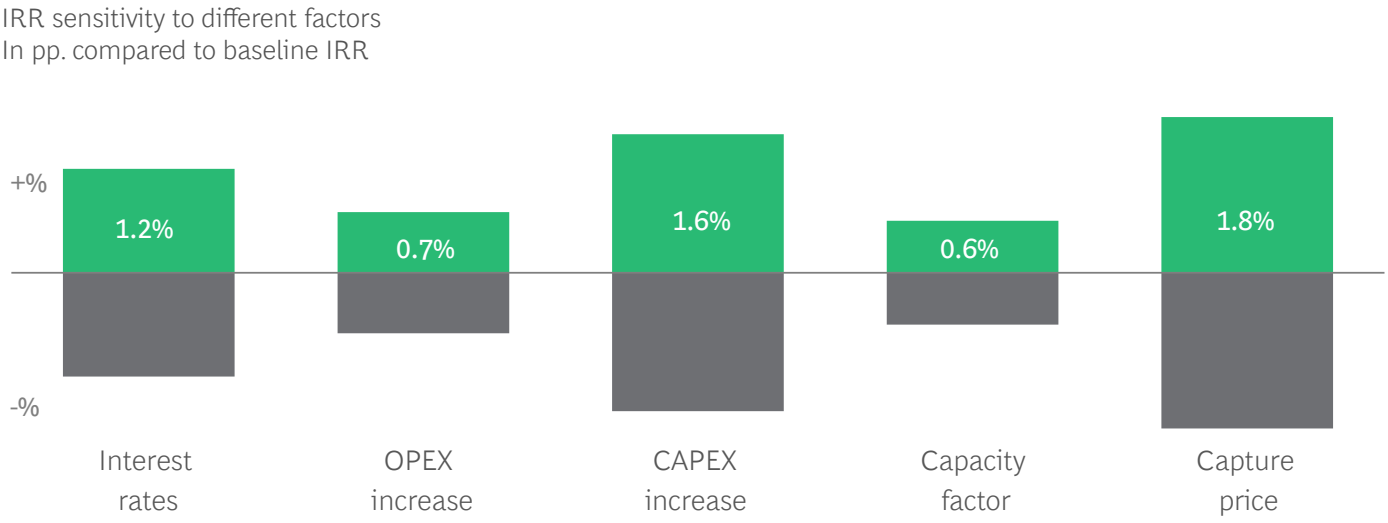
Unlocking value through O&M

Performance of offshore wind farms in the operational phase will impact the business cases of projects in several ways:

- Lower operational expenditure will lead to a reduction in LCoE.
- Improved operations will increase net energy generation by reducing corrective and preventive maintenance downtime and by increasing asset availability.
- Better awareness of market conditions allows the O&M teams to plan their work in a way that the asset can generate when power is most needed by the grid and thus create more value.
- Strengthened ability to identify and address issues early on is likely to have a positive impact on the lifetime of the asset.

A review of recent offshore wind business cases shows that the importance of a focus on revenue during the lifetime of the asset creates most value of the business case expressed by the internal rate of return (IRR). (See Exhibit 1.)

Exhibit 1. Showing impact on business case IRR assuming +/–10% change vs. base case (respectively for interest rates and capacity factor considering +/- 1% change vs. base case.)



How to create value in the operational phase

What is necessary to achieve strong O&M capabilities? We believe there are seven indicators of a mature and more future-proof O&M function:

1. Finding the trade-off between innovation and standardization
2. Moving from production-based to revenue-based availability metrics
3. Redefining fitness-for-purpose throughout all phases of an offshore project
4. Focus on continuously improving the production system
5. Better optimization of synergies across portfolio and O&M collaboration with neighboring sites
6. Designing data integration, learning models, and work processes to leverage predictables
7. Earlier focus on lifecycle management

1. Finding the trade-off between innovation and standardization

Over the past two decades, the offshore wind industry has called for an ever-increasing turbine size to continue pushing for lower LCOE. This tendency has led to considerable challenges in the operation of the assets as new platforms have less time to gather data before new larger models are introduced. The result is a rising threat of technical defects affecting both production performance and asset integrity, increasing pressure on operators to monitor the turbines to quickly rectify early signs of serial issues. To gather sufficient data for this, operators would benefit from pursuing a higher degree of standardization on their fleets; rather than choosing the largest turbine on the market, they could instead apply a platform strategy with less frequent updates, allowing for better understanding and managing of the technical characteristics of a given platform. Other advantages of such a deceleration in turbine size scaling include being better able to integrate SCADA data into control rooms to optimize performance on a larger dataset, the ability to share spare parts, as well as the ability to build more platform expertise among the maintenance teams.

Slowing down the rate of turbine growth could also hold benefits for the project developer. While in the past, conventional wisdom held that larger turbines are more production efficient and drive less maintenance per MW, these benefits are increasingly counteracted by rising turbine prices due to high material costs and the inability to industrialize manufacturing. Additional cost pressures are also introduced from the transportation and installation phase where demand is expected to surge for large-scale compatible installation vessels and ports, driving up day rates.

While a developer should not stop scaling its turbine sizes, there may be advantages to staying with a given platform for longer before changing. This approach would work well with long-term framework agreements on the procurement side, in turn helping operations define long-term technical capability roadmaps to service future assets.

2. Moving from production-based to revenue-based availability metrics

Power price volatility (short-term and seasonal) is prevalent in key offshore wind markets due to increased weather extremes, constraints on transmission infrastructure, geopolitical instability, and a growing proportion of renewables contributing to intermittency in supply. Many offshore wind projects operated or developed today will be exposed to this volatile market, for example, if they are operated in merchant conditions or without long-term power purchase agreements.

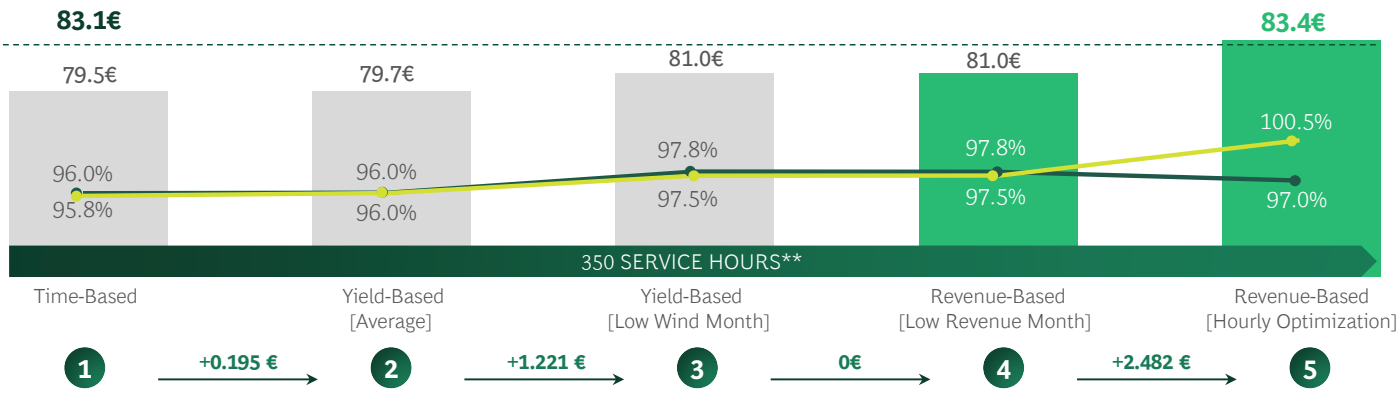
For operators, this means that it becomes increasingly important to steer when power is produced as opposed to purely maximizing production. The monetary effect can be in the range of millions of euros annually, when optimizing only the monthly scheduling for annual service campaigns, and even higher for an hourly optimization, with concepts such as “service during night”[1].

Exhibit 2 shows the results for a 600MW offshore wind project in Germany and in the UK with the levels of intermittency experienced in 2018.

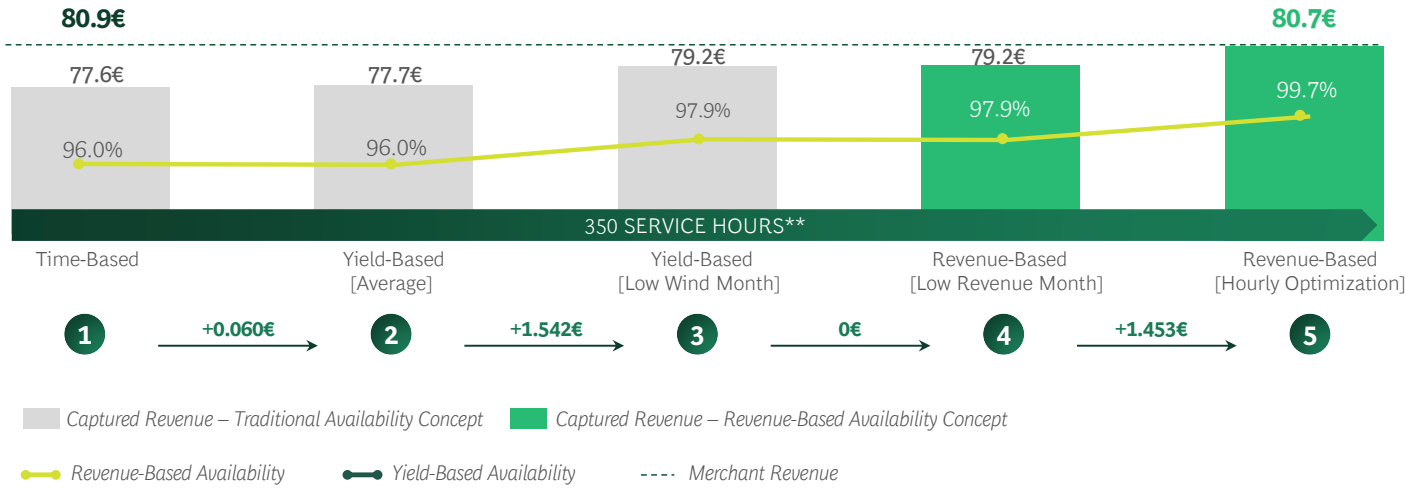
[1] “Zero subsidy – a need for a new availability KPI?”, PEAK Wind, August 30, 2023, https://peak-wind.com/zero-subsidy-need-for-a-new-availability-kpi.

Exhibit 2. Yearly revenue increase opportunity for an average size offshore wind project in Germany and in the UK

Germany (M€)



United Kingdom(M€*)



Note: *EUR conversion using average GBPEUR FX in 2018 of 0.8858. **Corresponds to a 4% time-availability. Corrective works are not included in the analysis (only scheduled campaigns).

Source: ENTSO-E Transparency, PEAK Wind analysis

The implementation of an operations system accommodating such market conditions and allowing harvesting of achievable upsides relies on project-specific conditions; however, some general key enablers for maximizing revenue over production are:

- Revenue-based availability as KPI in service and availability agreements with wind turbine OEMs and other contractors (for example, balance of plant, substations)
- Comprehensive understanding of site in context of the local energy system including relevant regulations (such as REMIT[2] in Europe), eventually incorporating storage technology (batteries, molecules, etc.)
- Accurate overview of historical electricity price trends and continuously updated figures of forecasted values (seasonally, daily, hourly) to enable optimized decision-making

[2] REMIT: Regulation on Wholesale Energy Market Integrity and Transparency

- Close and efficient link between energy trading, operations, and maintenance functions including required digital toolset

- Agile O&M system with the ability to respond to price changes (technician availability and flexible contracts with vessel/helicopter providers or in-house fleet, reliable transportation to enable service during opportune market windows), including a change of paradigm for personnel involved in planning and execution (who are traditionally focused on production maximization)

- Data-driven O&M system able to predict failures and consequently allow for optimizing timing of repair or replacement of components

By transitioning to a revenue-based focus, operators can unlock significant financial benefits in today's volatile energy market.

3. Redefining fitness-for-purpose throughout all phases of an offshore project

It is essential for offshore wind operators to control the fitness-for-purpose of their assets.

This means that systems will be operable at their desired performance levels throughout the intended time of use to generate expected revenues. Fitness-for-purpose can be achieved through diligent design, manufacturing, installation, commissioning, and maintenance practices. The latter includes integrity management for a system's reliability, supportability (enabling response to failure), maintainability (enabling short maintenance times), as well as performance management (enabling achievement of performance standards).

In recent years, particularly for sites exposed to volatile merchant markets, another parameter defining fitness-for-purpose is gaining importance: predictability. In the maintenance context, this refers to the ability of a system to accurately predict upcoming failures, in other words at what time which component is prone to failure.

This information and especially additional time between the first warning and failure can lead to big boosts in revenue. Recent scientific studies estimate 1 to 2 percentage points of availability gains through prediction[3]. In merchant environments, predictability further enhances the ability to produce when it's required rather than simply maximizing production (see "Moving from production-based to revenue-based availability metrics").

[3] Sofia Koukoura, Matti Niclas Scheu, and Athanasios Kolios, "Influence of Extended Potential-to-Functional Failure Intervals through Condition Monitoring Systems on Offshore Wind Turbine Availability," Reliability Engineering & System Safety 208 (April 2021): https://doi.org/10.1016/j.ress.2020.107404.

https://www.sciencedirect.com/science/article/pii/S0951832020308905

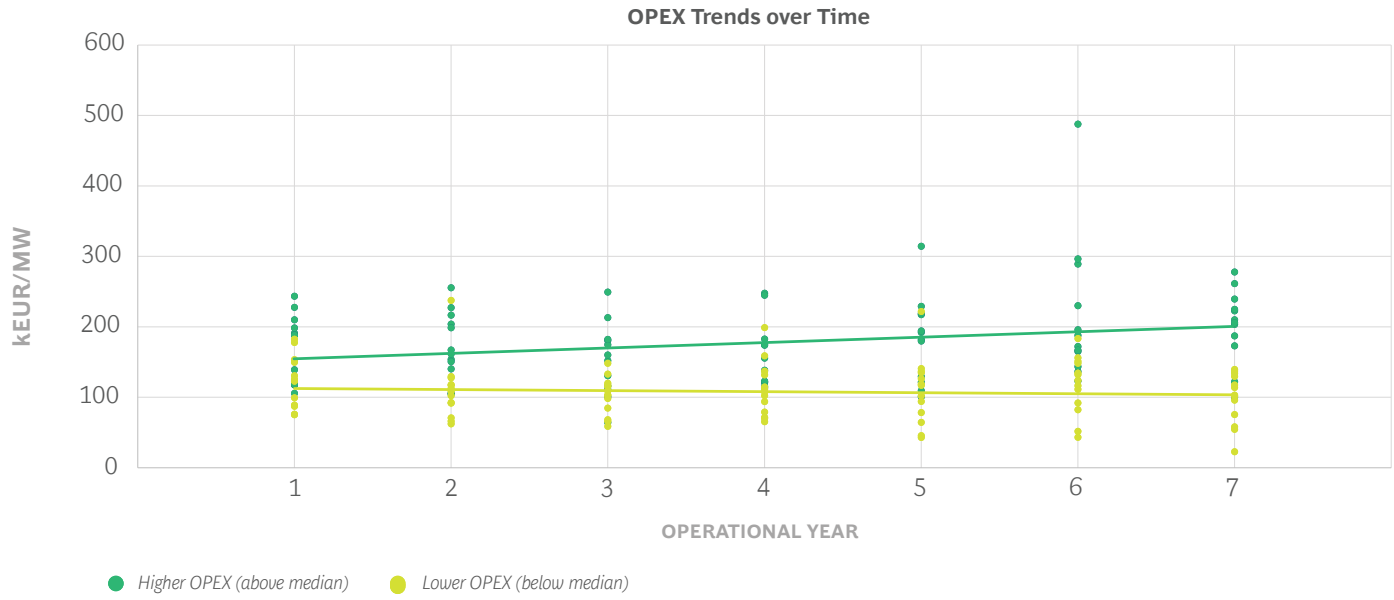
4. Focus on continuously improving the production system

Continuous improvement has proven efficient in many industries as a cost reduction and performance increase lever, with famous success stories like Toyota and GE attributing annualized savings of over $2 billion through Six Sigma alone[4]. In offshore wind, evidence indicates a correlation between overall operating expense (OPEX) levels and the ability to continuously improve the production system. In other words, the players able to reduce OPEX are generally also in the group of top performers (see Exhibit 3).

An evaluation of the first seven operational years of 27 wind farms in European waters has shown a clear pattern: wind farms performing above the median (those showing lower average OPEX over the seven years measured) are able to improve OPEX year over year; wind farms below the median show higher OPEX year over year.

The dataset analyzed for this study includes 27 wind farms (14 with below median performance and 13 with above median performance), 1,547 wind turbine generators (857 in the lower and 690 in the upper half), and an average per position installed capacity of 3.1 MW in the lower half and 3.8 MW in the upper half, representing different wind turbine models of all relevant offshore wind OEMs in Europe. The average year of start of production for all wind farms in the lower half is 2010 and 2012 for the upper half – thus no significant difference.

Exhibit 3. OPEX trends in kEUR/MW over the lifetime of 27 assets



Note: PEAK Wind, "OPEX Benchmark – An insight into the operational expenditures of European offshore wind farms," November 24, 2022, https://www.peak-wind.com/opex-benchmark-update-2022.

Source: PEAK Wind

The data is clear: wind farms with a focus on continuous improvement outperform their peers in terms of operational expenditure independent of asset age and size. Therefore, a commitment to continuous improvement positions wind farm operators for long-term success and cost reduction.

5. Better optimization of synergies across portfolio and O&M collaboration with neighboring sites

Physical proximity of offshore wind sites can offer significant OPEX savings potential as well as opportunities to increase revenue. Categories in which savings can be realized are typically:

[4] "Remembering Jack Welch and His Relation to Six Sigma," Six Sigma Daily, May 26, 2020, https://www.sixsigmadaily.com/remembering-jack-welch-and-his-relation-to-six-sigma.

- Offshore logistics (such as vessels or helicopters)
- O&M service execution (such as combined WTG and BoP service)
- Onshore infrastructure and ports (such as warehouses or O&M harbor build-out/operations)

Furthermore, synergy potentials across an individual portfolio can be realized even without sites in close proximity through:

- O&M contingency plans (such as cable repair concepts or emergency response)
- O&M organization (such as centralized operations and control centers)
- O&M procurement (such as standardized tenders or strategic partnerships)

Offshore logistics sharing alone, for WTG and BoP scopes for neighboring sites, based on bottom-up calculations, is estimated to save up to 30% of logistics cost, which translates into more than 100mEUR over the lifetime of a project of 1GW as an example. OEMs and developers have successfully implemented sharing across multiple sites: major turbine OEMs share resources across several service projects or implement a pit-stop concept using the same service operation vessel (SOV) for several sites. Leading developers also share their SOV between neighboring sites.

One OEM has further demonstrated a reduction in service time per turbine by up to 50%, if WTG and BoP service are combined.

A competitive environment and project-specific commercial agreements can make harvesting synergy potential challenging; however, other industries with similar characteristics, such as oil and gas, have demonstrated the potential of collaboration and synergy use in various cases. For instance, research published by the World Economic Forum attributed around one-third of cost-saving potentials considered feasible (calculated from the total expenditure per barrel) with OPEX improvements to collaboration[5]. The LCoE of offshore wind has the potential to be decreased through collaboration too and therefore to help the industry overall to succeed.

6. Earlier focus on lifecycle management

Some of the first wind farms are getting close to their initially planned end-of-life, at which point owners must be ready to follow one of four future paths: lifetime extension, repowering, running to failure, or preparing for asset decommissioning. All but the last option will benefit from early planning to ensure optimal performance from a lifecycle perspective, with lifetime extension having the largest scope of asset integrity considerations. Some operators are starting to apply for significant lifetime extension with regulatory authorities[6].

Considering the long-term performance and sustainability of wind farm assets, this of course requires a very thorough review of inspection and maintenance regimes. If operators want to avoid major peaks of replacement investment toward later life stages, the full lifecycle needs to be considered early on. With more and more wind farms operating outside of fixed revenue regimes, flexible trade-offs between short-term revenue opportunities and utilization of remaining lifetime become mandatory. One way of achieving this includes adopting a more preventive approach to maintenance of components that cannot reasonably be exchanged during their lifetime, such as towers and foundations, as well as choosing to reduce the power of a turbine under conditions where high loads are present, such as from wake-induced turbulence of neighboring turbines or deliberate de-rating in unfavorable market conditions. These actions can allow a wind farm to operate profitably for longer, supported by efforts to lower expenditure during late-life operations, such as applying lower O&M support prioritization and utilizing refurbished spares.

There are many benefits of a strong lifecycle focus within offshore wind O&M. Those capable of getting the most from assets over their lifetime are both able to capture more production and potentially lower eventual decommissioning costs, as the associated costs may be delayed to a time when decommissioning processes are more mature. Furthermore, applying such lifetime concepts allows the operator to build considerably more lifetime value confidence into their projects, allowing for more safe new project bidding.

[5] Muqsit Ashraf and Caruso, Pedro, "The Oil and Gas Sector Must Reinvent Itself. This Is How It Could Be Done," World Economic Forum, December 8, 2020, https://www.weforum.org/agenda/2020/12/how-to-reinvent-the-oil-and-gas-sector.

[6] Adrijana Buljan, "Five 20-Year-Old Danish Offshore Wind Farms Seeking Lifetime Extension," offshoreWIND.biz, December 11, 2023, https://www.offshorewind.biz/2023/12/11/five-20-year-old-danish-offshore-wind-farms-seeking-lifetime-extension.

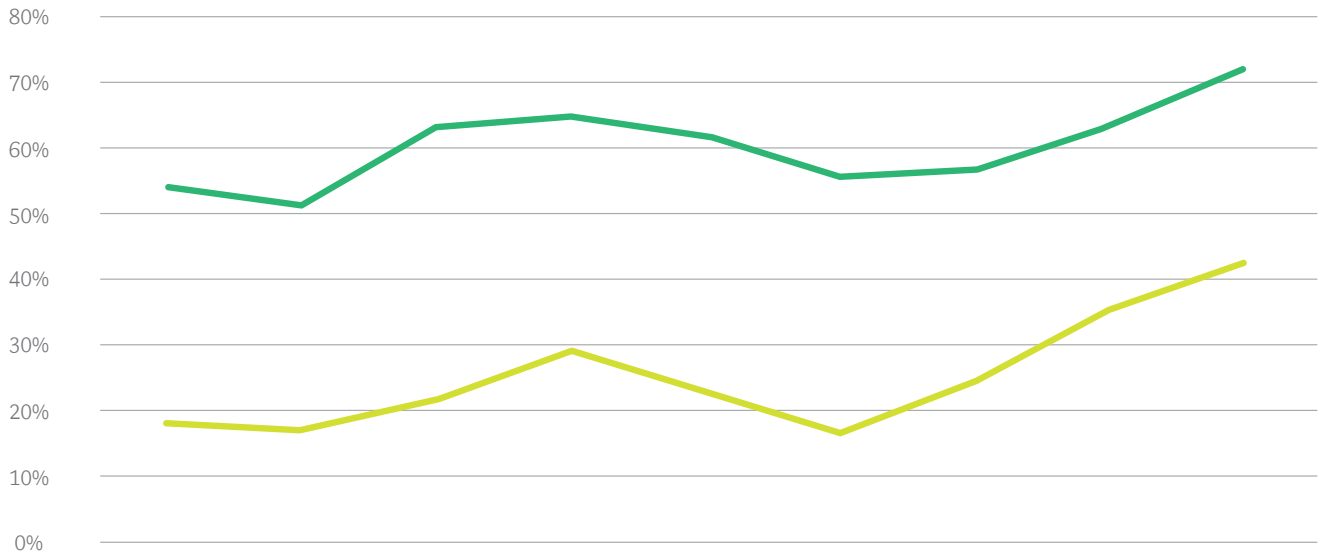
7. Designing data integration, learning models, and work processes to leverage predictables

Offshore wind farms are prime objects for data-driven performance optimization and predictive maintenance. They are by default equipped with ample sensors and other data-capturing units. The main difficulty that many operators still face today is capturing, storing, and utilizing all that data. And not all operators are fully taking advantage of the potential presented by the abundance of data, often due to lack of investment in sufficiently strong predictive programs as well as the absence of the right staffing environment in which to leverage the advantages of those programs.

Succeeding with predictive maintenance is not a trivial challenge and requires that operators work actively with both the technological and organizational aspects required. On the technical side, this includes not only the algorithms but also standardizing the data inputs from different sources, ensuring a clean and harmonized data layer for the algorithms to work on, considering the aspect of time to failure in models, linking to other historical data such as work orders, and integrating outputs to support the maintenance teams in scheduling, logistics, and spare part management. On the organizational side, operators must learn to trust the algorithm-generated alarms (while understanding that the quality of these will improve over time) and support the control room teams in using them through training and improving alarm prioritization.

Having strong predictive capabilities at the core of the control room brings considerable benefits. First, predicting major failures offers the opportunity to prepare for or even avoid entirely the events that for many operators can account for over 40% of production downtime. The market for jack-up vessels, which are often required for major component exchanges in offshore wind, is increasingly tight and vessels are often close to fully utilized (see Exhibit 4). Second, foreseeing or avoiding these costly events can result in considerable savings from fewer exchanges or rush orders if well integrated with maintenance planning and scheduling. Finally, having the digital infrastructure and the O&M organization tuned for predictive maintenance will position the company very well to benefit from future technology improvements that could improve both production cost and safety performance considerably over the coming years.

Exhibit 4. Utilization of jack-up vessels in Europe.



	2015	2016	2017	2018	2019	2020	2021	2022	2023
Total Utilization	54%	51%	63%	65%	62%	55%	57%	64%	72%
Utilization for O&M Work on Wind Farms	18%	17%	22%	29%	23%	17%	25%	36%	42%

Source: Sea Impact, https://sea-impact.com/

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PEAK Wind x BCG collaboration

PEAK Wind and BCG are collaborating on selected projects within offshore wind O&M and construction. The BCG Competence Center for Offshore Wind and PEAK Wind bring complimentary capabilities to the table that we seamlessly integrate to support our clients seeking to improve operational efficiency.

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