Wind Industry Digital Landscape Review

A study in collaboration with
The Offshore Renewable Energy (ORE) Catapult

accenture | CATAPULT Offshore Renewable Energy

Executive summary

Over the past decade, the growth and drive to reduce the levelized cost of energy (LCOE) of onshore and offshore wind generation had resulted in a digital revolution in the industry. Although onshore wind capacity was almost 600 GW at the end of 2019,[1] offshore wind capacity was only 29 GW,[2] leaving ample room for future exponential growth. For operational wind farms, the share of operations and maintenance (O&M) is increasing its share of levelized cost of energy (LCOE) beyond a third of the lifetime costs[3] prompting a greater focus on cloud platforms and digital application capabilities for O&M processes to reduce costs while improving production.

Wind operators need to achieve high levels of performance across all O&M processes, using multiple interdependent systems. It is common to see custom-built solutions on legacy systems, but their adequacy is largely unknown. Larger players have developed in-house capabilities using big data and advanced analytics to raise performance levels across multiple technology types. This requires heavy investment in strategic platforms favoring custom solutions, rather than off-the-shelf applications.

To understand the current digital landscape and explore industry challenges and trends, Accenture and ORE Catapult interviewed 11 leading onshore and offshore wind players. Leveraging deep industry experience, we identified six main O&M use cases including:

- Alerts, alarms, warnings and faults
- Troubleshooting and minor corrective maintenance
- Failure prediction and major component replacement
- Scheduled maintenance
- Wind power curve analysis and production losses
- Production forecasting

The use cases were selected based on operational significance.

The current digital landscape was assessed based on these O&M use cases, focusing on areas where significant improvement in digital capability is desired. By addressing challenges such as lack of site connectivity, non-standard approaches to alarm management and data access issues, operators can uncover value to lower costs and increase profitability.

Considerable value can be unlocked from O&M data, applications and the system landscape, which support the decrease in LCOE by reducing costs and improving production. Across the six use cases, digital opportunities were identified. Additionally, overall recommendations include:

- Wi-Fi installation and 5G to improve connectivity between wind farms and the operations center.
- Linkage to IEC standards to standardize alarms, tags, faults across OEMs, asset models.
- Sensor analysis and inspection to ensure accuracy of measurement.
- Investment to advance domain and analytics expertise to predict asset health threats.
- Right domain expertise during handover period at end of warranty.
- Defining rights to data at contract negotiations.
- End-user centricity and change management approach.

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Introduction

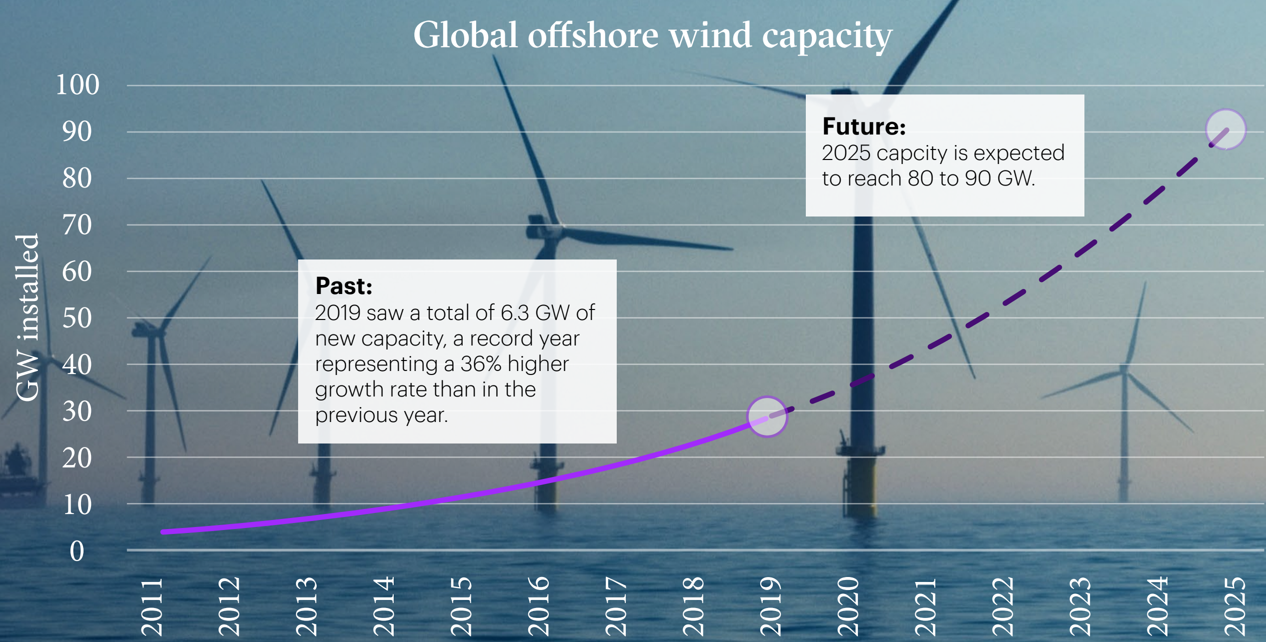
Global onshore wind installed capacity has grown significantly over the past decade, from 178 GW in 2010 to 594 GW in 2019.[4] Behind solar, offshore wind is the world's fastest-growing source of renewable generation, with global capacity at 29 GW in 2019.[5] Additional markets are opening up to offshore wind investments or increasing existing capacity goals on a monthly basis. Despite large project sizes and high growth rates, offshore wind currently only represents approximately 5% of global installed wind generation capacity.[6] However, future projections expect the size of offshore wind to triple in the next five years, with a major driver being rapidly falling LCOE, making the technology accessible to more markets. Many of the LCOE improvements to date have been driven by increased turbine sizes, reduced capital expenditure (CapEx) and growth in capacity factors.

For operational wind farms, the share of O&M as a percentage of LCOE is increasing beyond a third of lifetime costs,[7] which varies based on numerous factors, including longer planned asset life and production optimization strategies. This puts pressure on operators to look for ways to improve operational performance to remain competitive. The major determining actor is digital capabilities, where some of the major players can attain high annual return rates of up to 20% to 30% for their most profitable offshore wind sites.[8] Other key determinants are subsidy, distance to shore and turbine model; however, strong digitally capable operators could exploit benefits from all these factors.

Operations control centers and their associated processes and systems are increasingly important as offshore wind assets become larger and more remote. New developments in process innovation and digital tools continue to differentiate leading operators from the rest of the players.

Given the increased use of digital technologies and the myriad advantages of cloud platforms with greater processing power and low data integration, processing and storage costs, the past few years have brought an emergence of many different platforms, technologies and services geared toward renewables and O&M activities.

Figure 1. Projected near-term offshore wind growth rates; exponential growth.



Source: Accenture analysis.

Survey methodology

The study for this report builds on secondary research, including insights from 11 leading onshore and offshore wind companies, to better understand current trends for the digital landscape, challenges and opportunities for further improvement. The study participants operate wind farms globally, but with prominent activities in the United Kingdom and its coastal region. The O&M activities of the wind farms are either managed and executed by the original equipment manufacturer (OEM), or managed in-house by the owner/operator using a mix of in-house staff and contractors. The four steps of the study's approach investigate the digital landscape across six use cases.

Participant portfolio information

151 GW of renewable generation capacity managed by participant organizations

An average **asset age of seven years** in study, but spanning from newly commissioned to post-subsidy

A **wide range of ownership models**, from consortium to sole ownership

Study approach

ONE	TWO	THREE	FOUR
Onshore and offshore wind industry experience and leading practices research	In-depth interviews with onshore and offshore wind asset managers, owner/operators and OEMs based on use cases	Validation of industry challenges and key takeaways with Accenture and ORE Catapult industry experts	Drill-down into recommendations for the industry
Output: Questionnaire on onshore and offshore wind digital landscape	**Output:** Comparative digital landscape with focus on a single representative wind farm in the company's overall portfolio	**Output:** Report	

Scope: Applications supporting O&M use cases

The study covers the applications and data used in O&M, with a focus on six use cases, which represent select areas with the most potential influence on site operational and financial performance. The use cases set out in Figure 2 are common for all operators regardless of site characteristics and O&M strategy, yet the methods and sophistication for delivery vary substantially.

Figure 2. Common O&M use cases.

- **Alerts, alarms warnings and faults**
- **Trouble shooting and minor corrective maintenance**
- **Failure prediction and major component replacement**
- **Scheduled maintenance**
- **Wind power curve analysis and production losses**
- **Production forecasting**

Applications and systems used in O&M landscape

O&M requires multiple, interdependent systems to deliver the use cases, and these are central to operators' ability to achieve high levels of performance. The study reviewed five key areas to cover the range of technical categories (see Figure 3).

Figure 3. Components of the O&M landscape.

1. Sensor and data inputs

Secondary SCADA

A secondary SCADA is a data historian and visualization tool that integrates with the raw SCADA data. This monitors and controls the physical processes ongoing within the wind turbine system and comes with the turbine.

Weather tracking

Systems that are used to track weather characteristics and assessing the accuracy of the systems.

Additional condition monitoring systems

Additional sensors and collection mechanisms on major components, such as vibration sensors on gearboxes, strain gauges on foundations.

2. External data / tools

Industry benchmarking

Any comparison with competitors in terms of either costs or technical performance such as availability or failure rates.

Production forecasting

Tool and process currently used to calculate production forecasting for the wind farm.

3. Work execution

Worker scheduling and deployment

A system or tool to schedule maintenance and inspection work on turbines including workers, equipment and vessels to optimize workload.

Vessel and personnel tracking

Control room view for tracking all personnel and vessels (marine coordination).

Spare parts and supply chain

The system or process used for inventory management (spare parts, warehouse management and supplier management).

Asset equipment record

History of all components within each turbine, history of parts repaired or replaced, and location of this data (in CMMS or other).

Work order management (CMMS)

A maintenance management system provides a structured approach for the planning and monitoring of a sequence of O&M tasks. The intention is that a work order is opened for each individual piece of maintenance activity and each work order will have a unique identification number.

Figure 3. Components of the O&M landscape (continued).

4. O&M record

Service and inspection records

System or process for storing and managing the service or inspection records for the wind farm.

Outage logs

A log of the cause of downtime and the impact in terms of cost and production.

Operations log

A log of on-site activity including information such as turbine release status.

5. Digital infrastructure

Cloud/on-premise/ hybrid digital infrastructure

Cloud-based infrastructure provider used for main O&M processes.

Considering the components of the O&M landscape, participants set out their approach to O&M processes, identified areas of particular focus for their companies, and outlined challenges with the current digital landscape. Insights emerged into the way in which digital challenges manifest themselves in day-to-day O&M processes (see Figure 4).

Figure 4. Insights into the O&M landscape.

1. Sensor and data inputs

Secondary SCADA

In-house systems

Regarding secondary SCADA, there were several different providers mentioned in this space, including Breeze, Bazefield, Schneider and OSIsoft PI. However, many in-house custom-built solutions also operate in this area.

Weather tracking

A key driver of successful operations is accurate weather forecasting. This impacts on production, prediction, work order planning and minimizing unbalancing costs.

	Wind	Waves & Tides	Percipitation	Lightning	Fog	Humidity	Snow & Ice
VisualEyes (Met Office)	✓		✓	✓			✓
MeteoGroup	✓	✓		✓			
Breeze	✓		✓				
StormGeo	✓	✓	✓	✓	✓	✓	

Additional condition monitoring systems

There is high focus among study participants on additional monitoring systems such as strain gauges, gearbox monitoring, oil analyses and misalignments on, in particular, yaw and blade pitching systems.

Area	Strain Surges	Gerbox	Oil Analysis	Vibration Diagnostics	Yaw Misalignment	DTS (Cables)	Stucture and integrity monitoring	Condition Monitoring
Survey Output		Moventas	Moventas Gastops	Gram & Juhl Moventas	WindESCo			RES

Figure 4. Insights into the O&M landscape (continued).

2. External data / tools

Production forecasting		Disconnect between O&M and commercial team managing production forecast. Varied approaches using OEM power curve to create an operational power curve on an annual basis based on real data. Varied approaches to weather prediction, estimating downtime and use of outage plans.
Industry benchmarking		Benchmarking is not commonly supported through system features, instead being handled externally through reliance upon industry group and consultants, namely Webs, Sparta and McKinsey.

3. Work execution

Worker scheduling and deployment	In-house systems	There was a range in the responses where OEMs complete work scheduling and deployment, and operators log transports. There was a significant amount of manual processes with in-house capability.
Spare parts and supply chain		The following are vendors used by survey participants: SAP, Q-SYS and eMaint.
Vessel and personnel tracking		Various sea-planner, site-planner and marine traffic planners for vessel monitoring and GPS tracking were used by survey participants.
Asset/work order management (CMMS)		Several large vendors were mentioned, including SAP, IBM Maximo, Breeze and eMaint. Also manual processes with outputs captured in Excel, SharePoint, and Dropbox.

4. O&M record

Service and inspection records		Typically manual processes with outputs captured in SAP, SharePoint, Word, Excel and PDF.
Outage logs	In-house systems	Standard industry applications using Breeze, Excel, Power BI, as well as using in-house capability.
Operations log	In-house systems	Standard industry applications leveraging Breeze, Epilogue Systems, SharePoint and custom developments.

5. Digital infrastructure

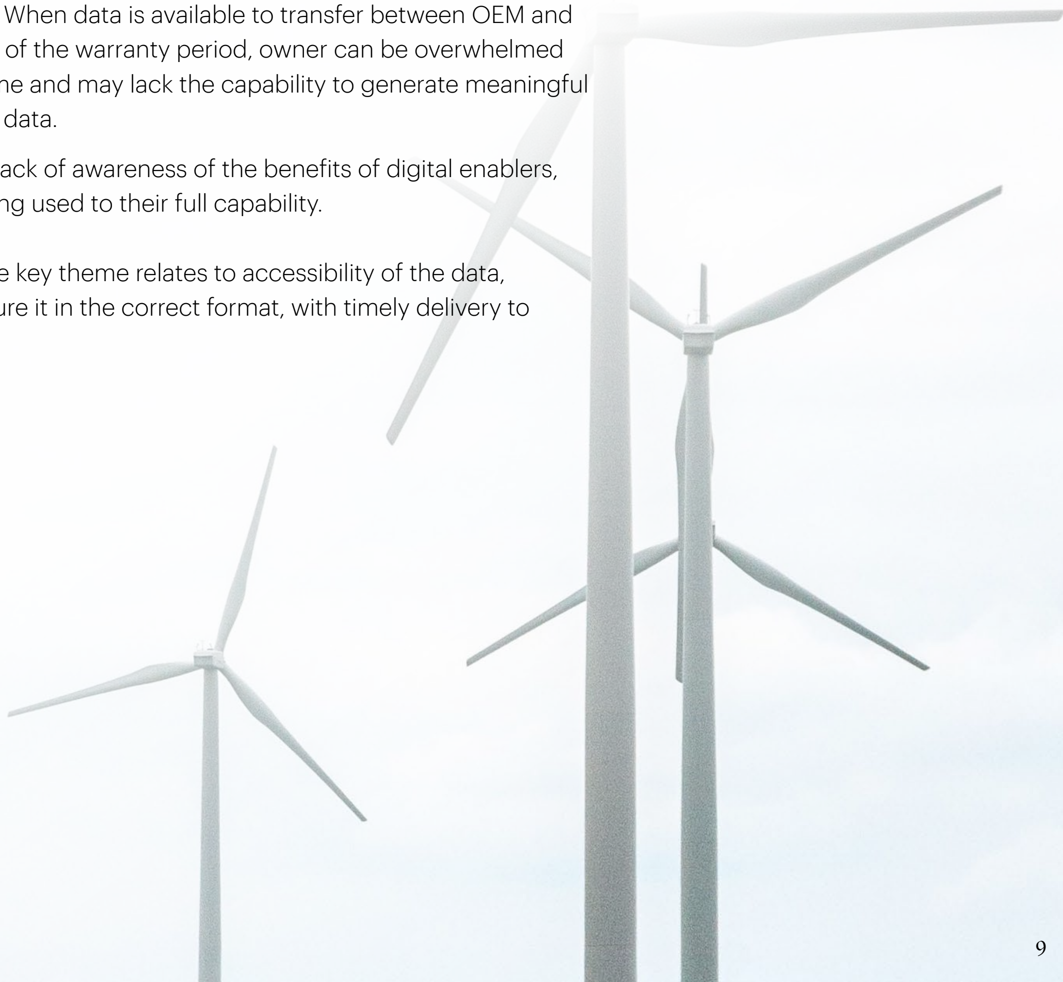
Cloud/on-premise/ hybrid digital infrastructure		There was no standard architecture or service provider emerging. Most operate in a hybrid mode with on-premise SCADA systems and utilize cloud services for data visualization.

Challenges

There are several challenges to improving the value to O&M from data and the application/system landscape itself. These cover connectivity, alarm standardization and the accessing of data. The scale of the challenges is dependent upon factors such as OEM provider, site location and legacy landscape. These challenges impact all players across the industry to varying extents.

- **Connectivity:** Breaks in connectivity between the wind farms and the operations center impacting on health and safety risk, work execution, quality of data collected and cybersecurity.
- **Standardization of alarms/faults:** Lack of consistency of alarms, tags, faults across OEMs, asset models, reports and benchmarking.
- **Calibration of equipment:** Lack of frequent calibration of sensors and alarms, or defined methods and processes in place to measure, analyze and report accuracy.
- **Use of sensors:** Lack of overall understanding of the importance of some sensors, resulting in sensors not being used to full potential, or combined with other data to predict and assess asset health.
- **Access to data:** Owner unable to obtain data from the OEM, and a lack of clarity on the rights to data.
- **Volume of data:** When data is available to transfer between OEM and owner at the end of the warranty period, owner can be overwhelmed by the data volume and may lack the capability to generate meaningful insights from the data.
- **Value unclear:** Lack of awareness of the benefits of digital enablers, and tools not being used to their full capability.

To gain data-driven insights, the key theme relates to accessibility of the data, and having the ability to structure it in the correct format, with timely delivery to the appropriate user.



Digital system significance for O&M use cases

The study participants were asked to provide their views on whether enhanced digital tools would have a significant impact on six O&M key use cases. Part of the consideration was the current status of the digital landscape, and identification of where further improvement potential could be found (see Figure 5). Figure 6 provides a breakdown of the assessments across all participants. Although digital technologies were viewed as improving the processes in the six use cases, the most significant improvement opportunities were the following four use cases:

- **Alerts, alarms, warnings and faults**
- **Troubleshooting and minor corrective maintenance**
- **Failure prediction and major component repair**
- **Production forecasting**

The reported percentage covers the applicable proportion of all participants' responses regarding the degree of improvement potential in the area.

Figure 5. Impact of enhanced digital systems on key O&M use cases.

● 73%
◐ 27%
○ 0%

Alerts, alarms, warnings and faults
A lot of analysis is manual. Automation of processing for outage analysis and linking to standards makes significant improvements.

● 55%
◐ 45%
○ 0%

Troubleshooting and minor corrective maintenance
There are unstructured data inspection reports and challenges in communications with the site, resulting in lost knowledge.

● 100%
◐ 0%
○ 0%

Failure prediction and major component replacement
Failure prediction is currently analyzed mainly for hard to replace, expensive components. The appetite for failure prediction analysis is growing beyond major components.

● 45%
◐ 45%
○ 10%

Scheduled maintenance
There are unstructured maintenance reports with manual processes which are not analyzed in a systematic way following inspection and maintenance.

● 36%
◐ 55%
○ 9%

Wind power curve analysis and production losses
Good power curve standards, with a difference in approach to its update. Lack of consistency of calibration of sensors and alarms.

● 64%
◐ 27%
○ 9%

Production forecasting
Typically teams work in silos and the advantages of regularly updating of the production forecast are not fully appreciated.

Figure 6. Breakdown of the assessments across the study participants.

Participant						
A	●	◐	●	●	●	●
B	●	●	●	●	◐	◐
C	●	●	●	●	◐	●
D	◐	◐	●	◐	○	●
E	◐	◐	●	●	◐	◐
F	●	●	●	◐	●	●
G	●	◐	●	◐	◐	●
H	◐	●	●	◐	◐	○
I	●	●	●	◐	●	●
J	●	●	●	○	●	●
K	●	◐	●	●	◐	◐

● **Significant Impact:** Significant improvement/transformation of the process from better digital systems.

◐ **Minor Impact:** Minimal improvement on the process from better digital systems.

○ **No Impact:** Better digital systems will have no impact on this process.

What follows is a deep dive into each of the six use cases, covering overall review, key observations and current tools in place.

Digital improvement scoring

- ● 73%
- ◑ 27%
- ○ 0%

Use Case:
Alerts, alarms, warnings and faults

Use case overview:

Analysis of types of alarms and faults to understand trends/patterns that will feed into equipment health analysis, work prioritization, and response time guidelines to minimize lost production and costs. The control room will monitor and decide how to respond to alarms and warnings. Performance engineering team understands the cause and relationships between alarms and faults. Asset management and O&M teams identify and prioritize follow-up actions.

Respondent overview:

- **OEM-managed:** OEM monitors and responds to alarms—wind farms have little visibility of this in real time, but would like better transparency. They often have some systems in place for retrospective checking.
- **Wind farm-managed:** Control room systems monitor alarms and first responses are determined from the control room. Some use secondary SCADA for alarm classification.

General observations:

- Assessed by participants as a significant opportunity for digital impact.
- Lack of standardization of alarms, and significant differences across OEMs and turbine platforms is a significant barrier to innovation.
- There are differences in turbine, sensor and SCADA generations for the same OEM, leading to challenges with scaling beyond a single wind farm.
- Automation of manual processes will have a greater impact on time spent on alarm classification identification, in particular for larger sites.
- More severe turbine stops are escalated for investigation, and taking learnings from these non-restartable stops is a challenge.
- Integration between new and legacy systems is key, but is currently an obstacle.
- More advanced operators are integrating advanced monitoring, classifications and recommendation for common failure modes.
- Some packages support linking alarms and alerts to standards (avoiding the need and knowledge required to do it manually).

Technology/systems:

- Breeze/Bazefield/OSIsoft PI
- Tableau/PowerBI for visualization
- In-house custom-built tools to analyze

Digital improvement scoring

- 55%
- 45%
- 0%

Use Case:
Troubleshooting and minor corrective maintenance

Use case overview:

The process of remote and on-site investigation of an incident to improve corrective maintenance, reducing downtime and increasing production. The operations team monitors plant performance, remotely investigates an incident notification, coordinates a field inspection and processes any subsequent work order activities.

Respondent overview:

- No consistent approach to either troubleshooting or conducting minor corrective maintenance across survey results.

General observations:

- Assessed by participants as a significant opportunity for digital impact.
- Inconsistencies between the input of alerts, alarms and alignment to fault hierarchy, causing issues with scaling beyond initial wind farms.
- Some issues with connectivity to the wind farms causes problems with digital systems in the field, such as accessing real-time data and expert advice.
- No industry standards for work records and maintenance reports.
- Some use of communication and collaboration platform that combines workplace chat, video meetings file storage and application integration, and mobility for connected worker elements and access to offline manuals.

Technology/systems:

- MS Teams/Mobility/iPads
- Matterport for interior turbine scanning

Digital improvement scoring

100%

0%

0%

Use Case:
Failure prediction and major component replacement

Use case overview:

Use of condition-based monitoring tools and algorithms to understand the risk of major component failures within pre-specified failure-length windows (and the conducting of a major component replacement project at an optimal time to reduce downtime, decrease maintenance activity and costs, and increase production).

Respondent overview:

- **OEM-managed:** OEMs provide diagnostics and onsite visits, then scheduling and coordinating major component replacement. Owners are consulted, but have little visibility of this in real time. All respondents noted that they would like better transparency, and often have some secondary diagnostic systems for verification.
- **Wind farm-managed:** Control room systems monitor alarms, and first responses are generated from the control room. Some use of secondary SCADA for alarm classification.

General observations:

- Assessed by participants as a significant opportunity for digital impact.
- Currently, failure prediction appears limited to vibration analysis and temperature trending on the drive-train components, as they are the most expensive to replace. There is appetite to apply similar techniques on smaller components that fail more often, such as pitch systems and power electronics.
- Some failure prediction analysis is outsourced as part of the condition monitoring system that has been procured. However, most respondents are very interested in doing much more of this in-house.
- Integration between new and legacy systems is key, but is currently an obstacle.
- More advanced operators are looking to build or buy advanced monitoring applications with automated fault classification and recommendation engines for common failure modes.

Technology/systems:

- Breeze/Bazefield/OSIsoft PI
- Tableau/PowerBI for visualization
- In-house custom-built tools to analyze

Digital improvement scoring

- 45%
- 45%
- 10%

Use Case:
Scheduled maintenance

Use case overview:

Optimally incorporate the annual service tasks as specified by the turbine OEM, and balance of plant activities into the annual plan for subsequent service scheduling to reduce downtime and maintenance costs.

Respondent overview:

- For many respondents this is a very manual activity, including downloading information from work order management system, and viewing in several different custom-built tools.
- Scheduled maintenance reports are often filed without further analysis due to time constraints.

General observations:

- Many respondents see how digital technologies can help in this space.
- Using advanced analytics on written reports to derive insights is not currently available.
- Different OEMs have different standards, so it is difficult to scale across wind farms.
- Additional time is taken to facilitate offline availability of turbine documentation.
- Service records are stored, but not further analyzed.
- Operator doesn’t have visibility while OEM is conducting maintenance.
- All information is stored in unstructured formats such as PDF or spreadsheet format.
- Lack of (internet/phone/satellite) communication between technician and office poses health and safety risks.

Technology/systems:

- SAP/Breeze/Bazefield/OSIsoft PI/PowerHub
- PowerBI/Tableau/Excel for visualization
- Dropbox/SharePoint
- In-house custom-built tools to analyze

Digital improvement scoring

36%
55%
9%

Use Case:
Wind power curve analysis and production losses

Use case overview:

Creation of a sufficiently accurate power curve for each site or turbine. Evaluates expected versus actual power curve to identify and quantify issues, and understand the causes of unit/site underperformance to correct this performance, prevent future underperformance, and minimize lost production and costs.

Respondent overview:

- Large operators conduct much of this work in-house using custom-built applications, but there are scaling issues due to standardization and contracts differences.
- Many operators were happy with current insights from manual solutions, but would like to have more automation.

General observations:

- Good standards around power curves (IEC 61400 12) and operative states (IEC 61400 26-1).
- Lack of standardization for error classification and ambiguities in alarm definitions lead to differences in the approach for their application.
- Different approaches where some take power-curve readings and others revisit and update the power curve. This is dependent on the participant, stage in the lifecycle and contractual arrangements.
- Secondary validation of wind measurements from site (e.g., anemometer) are used to confirm the power-curve reading, especially where it is OEM maintained.
- Lack of consistency in the calibration of sensors and alarms lead to varying confidence in the readings.
- Many were happy with current process as this is a standard offering within the industry.

Technology/systems:

- Breeze/Bazefield/OSIsoft PI/Bitbloom (Sift)
- SQL/R/Python/MATLAB/VBA
- In-house custom-built tools to analyze

Digital improvement scoring

- 64%
- 27%
- 9%

Use Case:
Production forecasting

Use case overview:

Optimize forecast accuracy (month and year ahead) for decision making on portfolio and individual assets performance to optimize revenue (e.g., defining and meeting generation target).

Respondent overview:

- Significant variation in forecasting approaches based on weather conditions, from some respondents using pre-construction calculations and others revising on an annual basis to eventual monthly reviews.
- Some respondents see that production forecasting is important and should be carried out in a less siloed approach, but it is managed by a separate department.

General observations:

- This is seen as being important for the future, where wind generation may be subject to widespread curtailment requests.
- There is a siloed approach between operators and energy management teams to production forecasting, often not seen as being a responsibility for the wind farms.
- Updating the production forecasting varies greatly between companies—from monthly to once every few years.
- Only 55% of the respondents update their pre-construction production forecasting.
- The advantages of regularly updating the production forecast are not fully appreciated and and some view that it does not outweigh the cost, including resource requirement.

Technology/systems:

- SQL/R/Python/MATLAB/VBA
- MERA2/ERA5/Vortex
- Wind Gemini/WindESCo

Key takeaways

From across the six use cases, there are key observations that cover the current role of digitalization in O&M, common industry challenges, future opportunities in contracting, and O&M as-a-service.

1. Most respondents agree that digital will have a big part to play in failure prediction, alerts and alarms, production forecasting, and troubleshooting.

2. Standardization of alarms, tags, faults across OEMs by linking alarms to IEC standards reduces the requirement for the development of custom solutions.

3. Larger operators are using big data and advanced analytics to build their own platforms to address use cases across multiple technology types, and are invested in these as strategic platforms.

4. There is an opportunity for third parties to provide O&M insights as-a-service, capable of running within the operator's environment.

5. All respondents have custom-built solutions in place that are adequate, but most would like to develop further capabilities.

6. Improvement of connectivity between the wind farms and the operations center will reduce the health and safety risk and improve efficiency during maintenance, the quality of data collected, and cybersecurity.

7. The integration of disparate data, including unstructured and semi-structured data, across the O&M processes, would add significant value by providing a rich context for any analysis. However, this is currently almost nonexistent due to poor data quality and lack of a data engineering skills set.

8. Many respondents stated that they had an appetite to learn from previous actions and information, including alarm responses and service records to improve O&M processes, but they are finding it difficult due to lack of both time and user-friendly digital tools.

9. Data owners, including owner/operators and OEMs, are reluctant to share data and the valuable insights that can be derived. Instead of supplier models, third parties should consider partnership models where data ownership is clear, and software/tools are developed collaboratively.

10. Future wind farms will have more yield-based O&M contracts exacerbating data and connectivity challenges. The expectation is that revenue-based O&M contracts are on the horizon, with further requirements on the O&M provider.

Recommendations

Considerable value can be unlocked from O&M data, applications and the system landscape, which support the decrease in LCOE by reducing costs and improving production. Some key industry challenges can be addressed by:

1. **Wi-Fi installation and 5G:**
Focus on improving connectivity between wind farms and the operations center will reduce impact on health and safety risk, efficiency during maintenance, quality of data collected, and cybersecurity. This challenge is exacerbated for offshore developments due to their location and the development size.

2. **Linkage to IEC standards:**
Lack of standardization of alarms, tags, faults across OEMs, asset models, reports and benchmarking can be addressed by downtime allocation at asset model level to IEC standards.

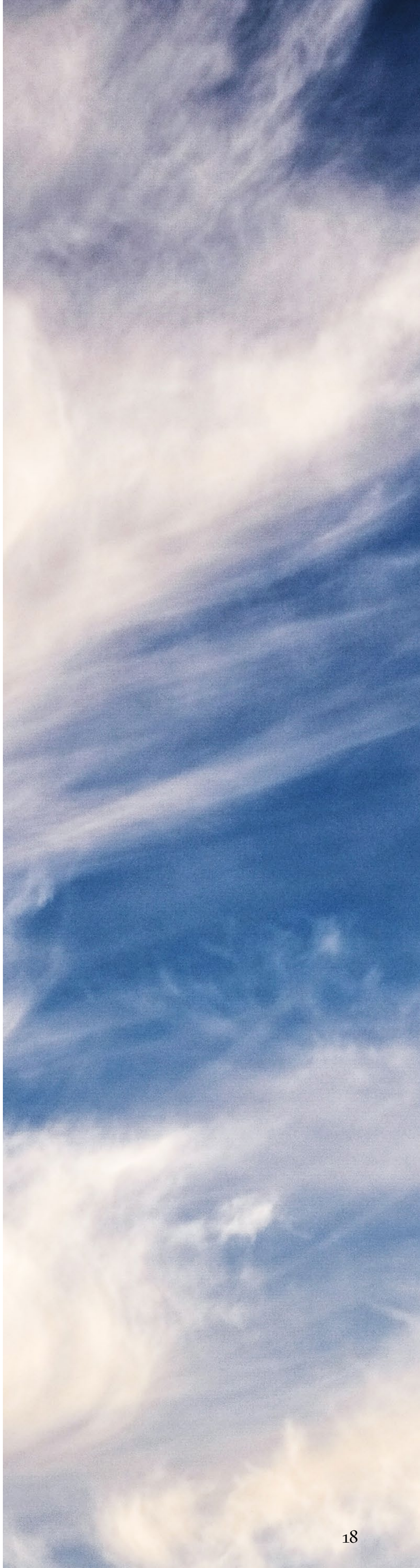
3. **Sensor analysis and inspection:**
Identifying sensor drift, regular inspections and inference from secondary sensors can overcome the lack of frequent calibration of sensors and alarms, or defined methods and processes in place to measure, analyze and report accuracy.

4. **Analytics:**
Investment to advance domain and analytics expertise can alleviate the lack of understanding of the importance of some sensors that are not being used to their full potential, and support the combination of data from multiple sources to predict asset health threats.

5. **Insights from data:**
When data is available to transfer between the OEM and the owner at the end of the warranty period, the appropriate domain and analytics expertise can mitigate the lack of understanding when generating insights from data, as well as the feeling of being overwhelmed due to the volume of data available.

6. **Rights to data:**
Defining data transfer at contract negotiations, with transparent overview of liabilities and rights, can lessen the challenge of obtaining data between OEM and owner, and a general understanding of the rights to data.

7. **End-user centricity:**
An end user-focused change management approach can support awareness of the benefits of digital enablers, the cost benefit analysis, and adoption of full capability of tools by end users.



Conclusion

Harnessing performance insights from O&M data is a differentiator for wind operators. Success hinges on investment to overcome challenges with connectivity, alarm standardization and accessing data. There are tremendous opportunities for market participants to stay relevant and excel in the industry by further developing their digital capabilities across O&M processes, for optimal delivery or management of service providers.

The current digital landscape is mixed, with larger players building in-house digital capability while others favor standard applications. An emerging trend is that third parties will provide O&M insights as-a-service, capitalizing on over a decade of domain expertise, and increasing data fluency and transparency within the industry.

References

1 Installed capacity of onshore wind until 2019 "Wind Power," International Renewable Energy Agency, © IRENA 2019, www.irena.org.

2 Installed capacity of offshore wind until 2019 "GWEC: Record 6.1 GW of new offshore wind capacity installed globally in 2019," Contify Energy News March 19, 2020, http://global.factiva.com.

3 Accenture project experience.

4 Installed capacity of onshore wind until 2019 "Wind Power," International Renewable Energy Agency, © IRENA 2019, www.irena.org.

5 Installed capacity of offshore wind until 2019 "GWEC: Record 6.1 GW of new offshore wind capacity installed globally in 2019", Contify Energy News March 19, 2020, http://global.factiva.com.

6 Renewable Energy Capacity Statistics 2019, International Renewable Energy Agency, © IRENA 2019, https://www.irena.org.

7 Accenture project experience.

8 Accenture analysis of the offshore wind industry, estimated and market dependent.

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Accenture is a global professional services company with leading capabilities in digital, cloud and security. Combining unmatched experience and specialized skills across more than 40 industries, we offer Strategy and Consulting, Interactive, Technology and Operations services – all powered by the world's largest network of Advanced Technology and Intelligent Operations centers. Our 506,000 people deliver on the promise of technology and human ingenuity every day, serving clients in more than 120 countries. We embrace the power of change to create value and shared success for our clients, people, shareholders, partners and communities. **Visit us at www.accenture.com**

About the Offshore Renewable Energy Catapult

ORE Catapult was established in 2013 by the UK Government and is part of a network of Catapults set up by Innovate UK in high-growth industries. ORE Catapult is the UK's leading innovation center for offshore renewable energy.

Independent and trusted, with a unique combination of world-leading test and demonstration facilities, and engineering and research expertise, it convenes the sector and delivers applied research, accelerating technology development, reducing risk and cost, and enhancing UK-wide economic growth.

Active throughout the UK, ORE Catapult has operations in Glasgow, Blyth, Levenmouth, Aberdeen, the Humber, the East of England, the South West and Wales, and operates a collaborative research partnership in China. **Visit us at ore.catapult.org.uk**