James Fisher
Asset Information Services

Offshore wind

A hierarchy of needs for symbiotic innovation

A part of
James Fisher and Sons plc
Marine Services Worldwide

Executive Summary

In a zero-subsidy world, driving efficiencies must surely become a priority.

In this, first of a series, James Fisher Asset Information Services (JF AIS) explores how new forms of collaboration are helping shape an industry beset by unsystematically monitored, managed, and maintained equipment.

In doing so, consideration is given to a hierarchy of needs for offshore wind, a strategic lens through which the current state of the industry can be objectively viewed. Looking forward, it sets out a practical path starting with data acquisition, collection, and aggregation, continuing towards machine learning and artificial intelligence, for the industry to collaboratively unlock efficiencies and long-term profitability.

> **European leaders have committed to reaching a 32% renewables grid contribution by 2030.**

Sean Huff
Group Digital Director

Bill Bellew
Innovation Manager

Introduction

Clayton Christensen, guru of innovation over the last 20 years, posits that there are two kinds of innovation: disruptive innovation and sustaining innovation (1995, 2013, 2015).

According to Christensen, disruptive innovation changes the shape of industries overnight in a very jarring, sweeping fashion – Uber cab company is a good example in which the entire business model of a long-standing industry experienced a foundational shift in one moment. On the other hand, Christensen offers that sustaining innovation is a more derivative type of innovation designed to keep companies moving forward by improving and upgrading existing products and services. However, it does not typically disrupt an industry by introducing a 'game-changer' of the magnitude associated with disruptive innovation. While Christensen's is probably the most well-studied and well-developed viewpoint on innovation applicable during a healthy, highly competitive economic climate, recent extreme events on the global scene have led us at James Fisher Asset Information Services (AIS) to look for a third type of innovation that is better suited to evolutionary sustainment during periods of extreme uncertainty which has been called symbiotic innovation (Thomas & Wind, 2013).

In our context, symbiotic innovation is innovation based on partnerships and the synergies derived from them - rather than sweeping aside or crushing competition out of existence - in order to create enhanced economic sustainability, especially during a time of severe economic and social upheaval. JF AIS has engaged in symbiotic partnerships with a number of companies such as Brainnwave and Wirescan in order to realize data-driven projects that are more than the sum of their parts. In a COVID-19 world, this makes sense - in such times, we must leverage each other's strengths rather than exploiting each other's weaknesses.

> JF AIS is combining ideas gleaned from Maslow's hierarchy of needs with symbiotic innovation to seek opportunities to work with partners to provide offshore wind with a fresh approach to asset management, aiding the industry in climbing its own specific hierarchy of needs.

This is why, as Christensen also pointed out (2013), most innovation is derivative in some way, and symbiotic innovation is no exception in its approach to leveraging strengths. His example is Uber; Uber represents a change in an established industry's model for doing business in the transportation sector that is derivative, but in an innovative way – it is still a cab company, just with a twist that allows it to leverage a completely different set of strengths in the market space.

With these ideas in mind, we in JF AIS are choosing to focus our efforts on an industry that needs an 'Uber' approach: offshore wind. In doing so, we have chosen to combine ideas gleaned from Maslow's hierarchy of needs (1943) with symbiotic innovation in order to indicate an active seeking out of opportunities to work together with partners to provide offshore wind with a fresh approach to asset management, aiding it in climbing its own specific hierarchy of needs. From our point of view, the needs hierarchy is more easily and quickly scaled by cooperating, not street-brawling – and especially in light of the recent article in the press citing the desire on the part of the UK government to reduce offshore wind generation subsidies to zero over the next four years. **https://bit.ly/2XBdJkS**

A hierarchy of needs for symbiotic innovation

In a zero-subsidy world, driving efficiencies must surely become a priority.

Our observation and experience of the existing landscape of the offshore wind industry's evolution shows that significant and fast-paced growth has led to a vast array of challenges in the maintenance of core components and the driving of efficiencies into processes.

The quest for a reduction in industry-wide levelized cost of energy (LCOE), regardless of the specific calculus, has led to further growth in turbine sizes and an increase in wind farm asset distance from shore (Aldersey-Williams et al. 2019). However, this quest has left in its wake a vast array of equipment which is unsystematically monitored, managed, and maintained, in part due to multiple changes in ownership and poorly documented handover processes

Indeed, Warnock, et al. (2019) reached a resounding conclusion regarding the current state of play in their article "Failure Rates of Offshore Wind Transmission Systems" whereby:

> "It was found that all sites which have experienced at least one failure appear to have experienced a higher failure rate than that currently being used in industrial practices. This was this case for all types of technology currently being used in offshore wind transmission systems. When comparing the average failure rates of all offshore wind transmission systems, this research found that, as with the site by site analysis, the failure rate which appears to be being experienced offshore is higher than the figures being used in current industry practices. These findings suggest that there is a need for changes in industry practices."

Our analysis of core components such as the high-voltage (HV) network, foundations, blades, and the associated marine operations, has shown that nascent attempts to drive efficiencies into processes are occurring sporadically in pockets of the industry, but that an overarching strategic approach to creating a holistic understanding of the wind farm asset suite by owners and operators is yet to materialize. In many ways, this has resulted in the offshore wind industry's resemblance to a nationalized utility rather than a for-profit commercial undertaking. Reasons behind this lack of strategic evolution range from limitations arising due to ownership structure, to subsidy knock-on effects, to inability to generate a consensus on appropriate methods for calculating LCOE, to a range of other potential motivations around obscuring costs.

> "Our analysis has shown that nascent attempts to drive efficiencies into processes are occurring sporadically, but an overarching strategic approach to creating a holistic understanding of the wind farm is yet to materialize."

Technologically, we have generally observed that processes evolve and become automated due to their nature (i.e. path of least resistance to becoming automated), or because they represent a key area of focus or value (e.g. automobile manufacture via automated assembly line). The more data you have available from which to form reliable decision-making processes, the more actionable intelligence is generated – that is, information around which decisions can be made and appropriate actions taken. We tend to find that much of the offshore wind industry sits in an area of development where truly actionable intelligence is relatively rare, and we can chart step-by-step how it comes into being:

1. **Rudimentary data/information** – almost no knowledge of the asset
2. **Some data/information available** – e.g. aggregation of on-site test data with documentation
3. **Basic condition monitoring/diagnostics** – sensor data that provides binary output (good/bad)
4. **Constant data collection from multiple sources** – profiling asset behavior under a variety of conditions
5. **Remote monitoring for analysis** – using incoming data streams for data science analytics, potentially from numerous assets
6. **Predictive analytics** – decision support and campaign design around failure prediction

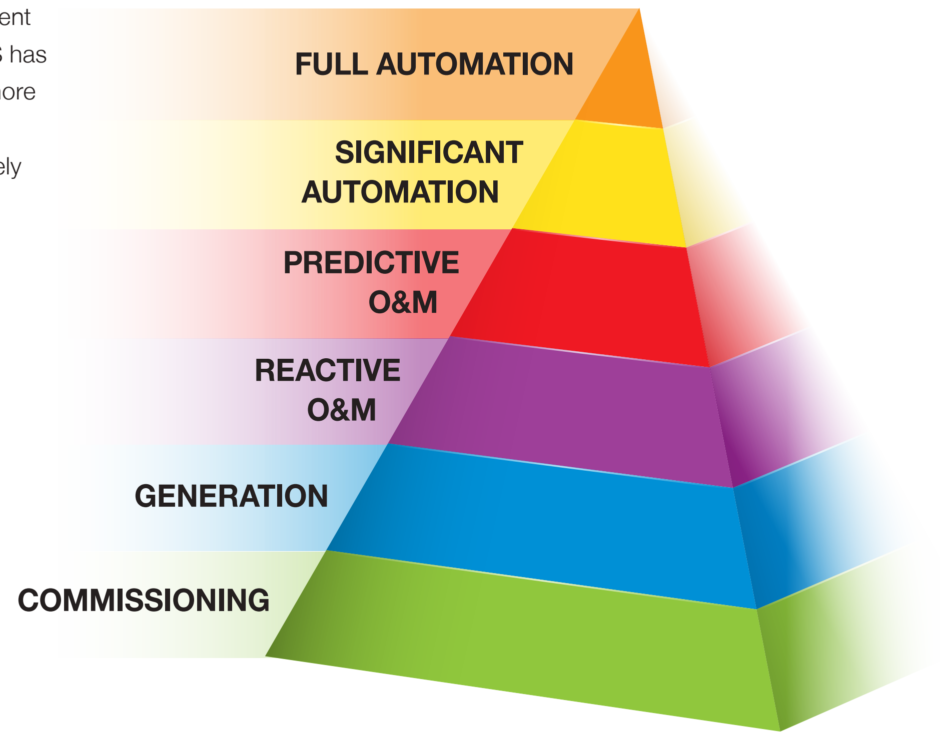
Hence, innovation in the industry, from our perspective, starts around step 4. Here, enough data begins to enter the pipeline that meets the 5-V criteria for data science: volume, veracity, variety, variation, velocity. Only once the 5-Vs are satisfied can we truly innovate by plotting our move from a reactive to a predictive model, and this move must be data-driven.

Maslow (1943) postulated that humans have basic needs that form the foundation of a conceptual pyramid upon which they can grow only by first satisfying those needs from the bottom up, in order of priority, from the physiological to the psychological and continually striving for a concept he called 'self-actualization'. For example, in Maslow's hierarchy, a person cannot engage in loving relationships (the third tier) until they have satisfactorily provided for their basic physiological needs (the pyramid's foundation: food, clothing, shelter, etc.) and their own safety (tier two: not getting eaten, mitigating obvious dangers, etc.). Only then can the human begin to seek out belonging within a group and the development of meaningful relationships with other humans. We believe in the abstract that the same is true for many industries that are at different stages in their paths to development. Some are very mature and some are nascent. Offshore wind, for example, is nascent compared to, say, shipping.

> "The more data you have available from which to form reliable decision-making processes, the more actionable intelligence is generated."

Offshore wind's hierarchy of needs

In an attempt to better understand nascent industry development, James Fisher AIS has developed a hierarchy of needs for offshore wind. The purpose is much inspired by Maslow's hierarchy of needs, to effectively help define a fundamental hierarchy, a progression that attempts to relate offshore wind's evolution from the most basic concepts through to its own version of 'self-actualization' realised in full automation.



Commissioning and generation

The root assumption in the foundation of the pyramid is that 'approval' and 'construction' are already givens, much like Maslow's hierarchy assumes the existence of the human as a vehicle for needs. The offshore wind farm has already been built, cables laid, and it is ready to be inspected, tested, and put into service. Also – as many of our customers have suggested - ideally at this point, all the data, documentation, and specifications needed to begin operations have been aggregated into a system where they can be accessed and used by those who will require them in a variety of capacities going forward. Accomplishing good data aggregation early on via agreements and data-sharing partnerships provides the foundation for symbiotic development and innovation in subsequent stages.

Thus, the first hurdle, analogous to satisfying physiological needs, is commissioning; no generation can occur if the asset has not been commissioned and the criteria for approval met. Likewise, it is not until generation begins that operating expense (OPEX) will begin to drive typical operations and maintenance (O&M) activities. Unlike Maslow's hierarchy (Ibid.), safety concerns in the form of HSE requirements have long-since been in place by this point. However, in keeping with Maslow, those will now change hands from constructor to maintainer, and HSE regulations are constantly under scrutiny and development throughout the entire asset lifecycle. If, however, information handover is poor between stakeholders, communication and data continuity are hindered and, in turn, hinder any successive attempts at symbiosis between partners down the line. In contrast, maintaining good data continuity across stakeholders and asset developmental stages can enhance symbiotically innovative opportunities throughout the lifecycle of the asset.

> "Maintaining good data continuity across stakeholders and asset developmental stages can enhance symbiotically innovative opportunities throughout the lifecycle of the asset."

Reactive operations and maintenance

Once generation has begun, there will be a need to engage in O&M activities using sets of processes for both scheduled and unscheduled maintenance, as well as emergency response. However, while prescribed maintenance does occur, observation has led us to conclude that the industry's current, immature level of evolution with regard to O&M leans firmly toward a reactive model: once a failure is indicated, an intervention is implemented. The reactive model is based on the idea that service providers to offshore wind tend to 'fly in to save the day' once something has failed rather than being able to engage in any sort of pre-outage failure prediction. This model becomes particularly acute as warranties expire across an asset, also revealing many discrepancies in lifespan expectations based on comparisons with onshore performance or lab test results.

Problematically, the reactive model is also predicated on condition monitoring, which, while better than no monitoring, is only one branch up the evolutionary tree from basic data aggregation (i.e. getting all your sensor data, reports, diagrams, operating manuals, inspection reports, and the like in one locatable place for use and reference). Condition monitoring can sound an alarm to tell you that something has begun to go wrong, but not necessarily when something will go wrong, which means that one's starting point is often on the back foot. Even if an asset has very sophisticated condition monitoring systems in place, the lead time for failure identification and location is generally not long enough to be able to efficiently and effectively prioritize O&M activities to pre-empt the event. With regard to the more costly aspects of O&M, such as contract vessel hire and replacement cable section procurement, short-notice costs can be staggering. In this vein, up-time sustainability has become key to avoiding heavy penalties over and above lost production and repair costs with industry-wide up-time requirements for the UK sitting at 99%.

Additionally, engaging in reactive O&M over time tends to lead to commodification of activities and a downward sloping revenue curve – it's unlikely, for example, that highly specialized service provision can become even more niche-oriented over time without losing additional market share in an already narrow market. Niche domain-expertise-driven service provision markets that may be dominated by only one or two players commanding premium prices for services will not remain exclusive for long, if (or when) others spot the near-monopoly advantage they hold. Therefore, as new entrants introduce lower price structures into the mix, the race to the bottom begins. And precisely here lies an opportunity for symbiotic innovation.

At James Fisher, we understand that each niche domain provider has value, but also that the value of multiple partners can be made greater than the sum of their parts by combining multiple niche offerings into a symbiotically innovated whole that allows learning to occur through data streams that cross-inform each other. One simple example of this sort of data synergy was developed with our partners at IBM to understand how cable load and temperature relationships can indicate free-span in subsea power transmission cables, leading to actionable intelligence about the asset that ushers us into the predictive realm. As mentioned earlier, if data continuity is maintained by good handover practices, it then becomes possible to apply data science techniques to allow complex analyses to occur that can lead to failure prediction, and not merely failure reaction, through a complex understanding of those symbiotic data relationships provided through partnerships.

> **"The value of multiple partners combining multiple niche offerings into a symbiotically innovated whole allows learning to occur through data streams that cross-inform each other."**

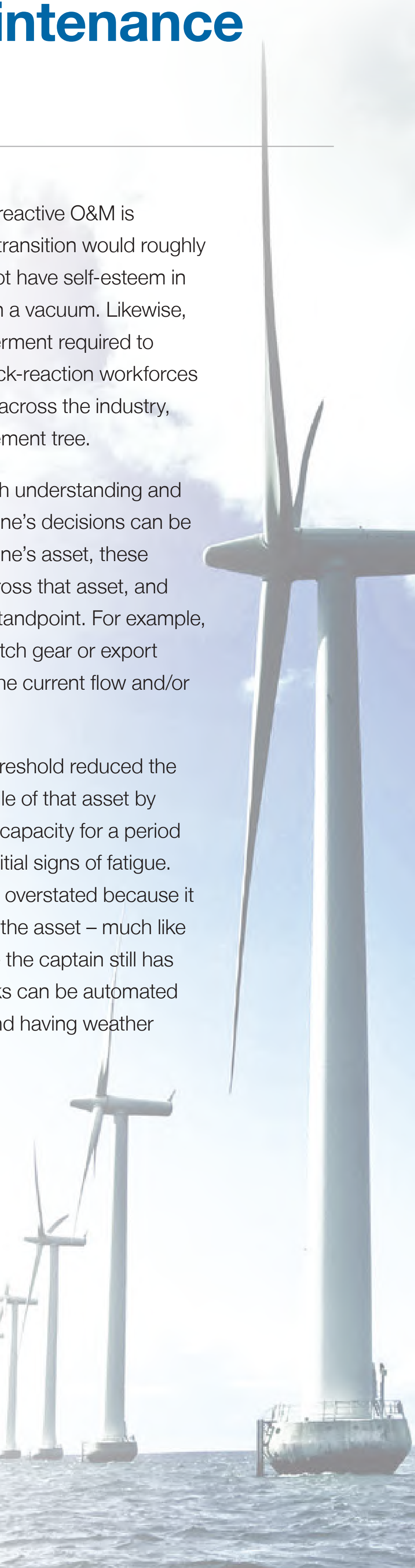
Predictive operations and maintenance and the management of risk

Once condition monitoring has been established, the reactive model put in place, and reactive O&M is ongoing, the need to enact data-driven processes becomes evident. For Maslow, this transition would roughly correspond to the move from 'love and belonging' to 'esteem', meaning that one cannot have self-esteem in the absence of a sense of love and belonging to a community – i.e. one cannot thrive in a vacuum. Likewise, an asset manager cannot experience the relative freedom of decision-making empowerment required to thrive if s/he is always on the back foot regarding O&M, and if constantly relying on quick-reaction workforces to put out the flames has become a necessity. Unfortunately, this is too often the case across the industry, and the remedies are to be found up the next evolutionary branch of the asset management tree.

Another consideration with regard to predictive O&M is the management of risk. As with understanding and analysing trends in any context, the more data one has, the generally better informed one's decisions can be – risk is no exception. As additional data begins to surface in various contexts across one's asset, these data sets can act in a synergistic way to continually better inform developing trends across that asset, and hence better inform the changing risk climate from a financial, physical, and personal standpoint. For example, simply understanding the rate at which a potential problem is developing in a set of switch gear or export cable can provide actionable intelligence to the asset manager, who can then reduce the current flow and/or reroute power in response, thus reducing overall risk to uptime.

In that example, being able to act decisively on the predicted crossing of a tolerance threshold reduced the risk of impending failure in that moment, but also statistically changed the lifecycle profile of that asset by potentially adding more stress onto another component – e.g. forcing it to run at 110% capacity for a period - which will then have to be similarly managed at a later time as it begins to show the initial signs of fatigue. The value of this sort of risk management from an O&M planning standpoint cannot be overstated because it allows maximum decision flexibility for the asset manager while reducing overall risk to the asset – much like how being high up in the crow's nest allows the lookout to spot the thunderstorm while the captain still has time to react to being caught in it. And over time, responses to consistently profiled risks can be automated for even additional saving – the difference between having a sailor in the crow's nest and having weather radar that provides automated re-routing of the vessel.

> "The value of predictive operations and maintenance cannot be overstated because it allows maximum decision flexibility for asset managers while reducing overall risk to the asset."



Predictive operations and maintenance analytics within James Fisher AIS

From a predictive O&M standpoint, James Fisher AIS has a wide range of capabilities that result from our symbiotic relationships with our partners. These relationships can provide the customer with the boost required to climb the evolutionary tree more effectively by using data to drive decision-making processes with help from data science techniques and analytics coupled with domain expertise and partnerships from areas that include:

- **Marine coordination systems for manifesting, HSE and certification, vessel routing**
- **Maintenance management systems for tracking plans and timelines**
- **High-voltage applications from the array to the onshore substation using LIRA, TDR, DAS, DTS, HVPD, and a variety of other data streams**
- **SCADA input to data models for production and performance**
- **Inspection systems for core components: subsea survey, blade inspections, foundation inspection, infrastructure integrity, rust/corrosion, vibration, etc.**
- **Intervention tools for planning and optimising intervention strategies**
- **Integrity testing and monitoring tools for varying frequencies of data collection**
- **Design Thinking and collection management processes for designing and optimizing data-driven strategy implementation**

Using data science and advanced analytical techniques along with domain expertise, the asset manager can begin to plan O&M activities in support of a long-term vision and strategy, not a short-sighted, stimulus-response model. For example, imagine the cost savings that could be gained, if one knew in advance that a primary transmission cable was going to fail 80-90 days from today based on the rate of change across a number of sensor and data inputs.

- **Vessel hire could be booked well in advance and tuned against hindcasted weather and sea state windows**
- **The asset's operating profile could be optimised to sweat out the last penny prior to de-energising it**
- **Equipment procurement for the repair cycle could be done more competitively along with technician hiring and any required certification and work permit updates for personnel**
- **O&M tasks could be more efficiently combined to create task synergies across locations for duration and type**

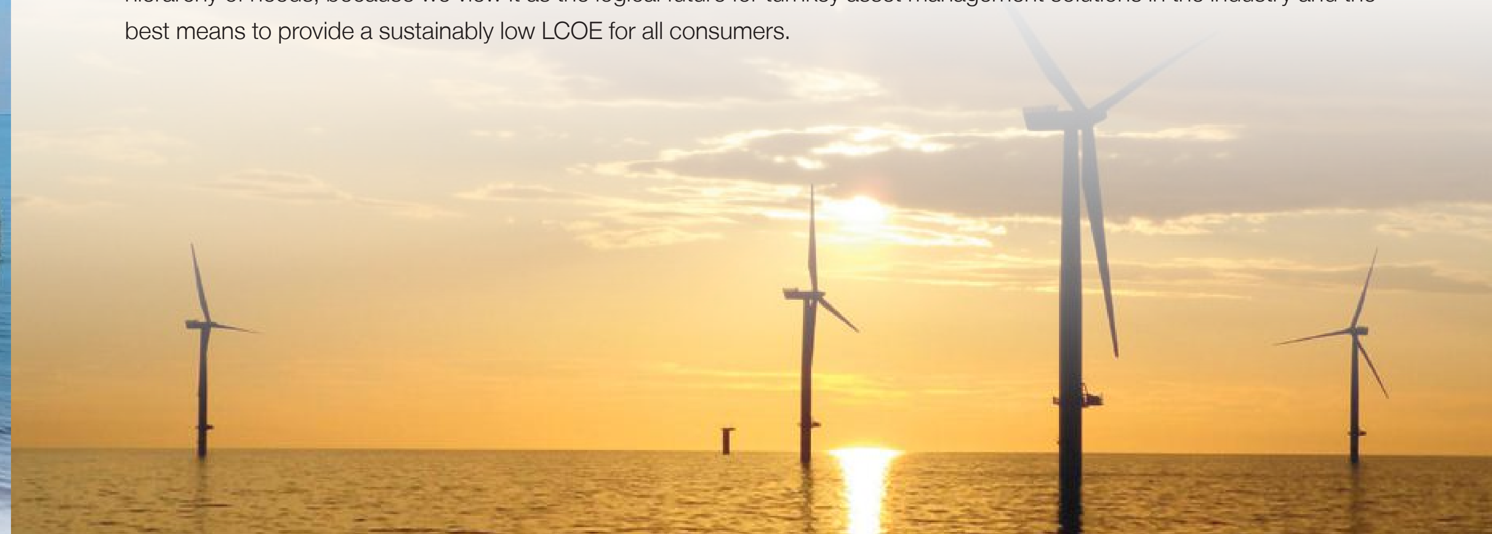
… even a partial list such as this is literally mind-boggling, and any advanced knowledge of failure and location provides the asset manager with the ability to exponentially improve how work is prioritised, costed, flowed, and executed, resulting in impressive cost savings and putting partial – and even full - automation within reach.

Summary: Significant and full automation

Once the benefits of predictive O&M have been realised and the cost savings have taken root, the move to significant levels of automation within the offshore wind industry is a strong consideration.

Though for now, fully automating asset management and O&M activities may seem like a blue-sky vision of the distant future, the foundation of our offshore wind hierarchy of needs pyramid lays the groundwork for striving toward just such automation within the industry. By starting with data acquisition, collection, and aggregation and continuing the positive trajectory into the application of data science techniques, automated processes will eventually be able to not only guide corrective actions, but also implement them based on sophisticated analysis of condition monitoring data, machine learning, and artificial intelligence. Once an action determination is made, it must be coupled with the robotics necessary to perform actions, thereby mitigating the need to regularly risk human safety far from shore. The process of evolution and automation of activities is not the path of least resistance. Indeed, there is often much resistance to change in organisations with high levels of inertia because that's "the way we've always done things." But as Warnock, et al. (2019) clearly stated: "… there is a need for changes in industry practices."

JF AIS is currently looking toward the horizon with a vision shared by our partners in symbiotic innovation in order to be at the leading edge of offshore wind asset management. In order to help in changing some of these industry practices and improve upon the way things have always been done. We are actively engaged in helping customers progress up the offshore wind hierarchy of needs, because we view it as the logical future for turnkey asset management solutions in the industry and the best means to provide a sustainably low LCOE for all consumers.



References

Aldersey-Williams, J.; Broadbent, I.D.; Strachan, P.A. Better estimates of LCOE from audited accounts—A new methodology with examples from United Kingdom offshore wind and CCGT. Energy Policy 2019, 128, 25–35.

Bower JL, Christensen CM. Disruptive technologies: catching the wave. In: Rebuilding your business model. Boston: Harvard Business Review Press; 2011. p. 201-230.

Christensen CM. The innovator's dilemma. New York: Harper Business; 2011.

Christensen CM, van Bever D. The capitalist's dilemma. In: The definitive management ideas of the year from HBR 2015. Harvard Business Review Press; 2015. p. 15-32.

Maslow, A. H. (1943). A Theory of Human Motivation. Psychological Review, 50(4), 370- 96.

Thomas, RJ, Wind, YJ (2013) Symbiotic innovation: getting the most out of collaboration. In: Brem, A, Viardot, E (eds) Evolution of Innovation Management: Trends in an International Context. New York: Palgrave MacMillan, pp. 1–31.

J. Warnock, D. McMillan, J. Pilgrim, and S. Shenton, "Failure Rates of Offshore Wind Transmission Systems," Energies, vol. 12, no. 14, pp. 1–12, 2019.

James Fisher
Asset Information Services

James Fisher
Asset Information Services

T: +44 (0) 1224 355 880

E: contact@jf-ais.com

W: www.jf-ais.com

V2