

# Climbing the Digital Maturity Ladder
## Data and Digitalisation in Offshore Renewables

**Peter van Heck** | March 2019

CATAPULT
Offshore Renewable Energy

## Summary

The emergence of big data and digitalisation as a transformer of the global economy has been one of the key industrial trends of recent years. In 2018, the Government's Industrial Strategy identified artificial intelligence and data as one of its four Grand Challenges, providing clear evidence of the technology's emerging importance and highlighting its transformational potential.

For the offshore wind, wave and tidal energy sectors, the technology provides endless opportunities for innovation. From reducing turbine downtime through predictive maintenance, to improving health and safety through better weather and wave height forecasting, the industry is still scratching the surface of the potential benefits.

This paper provides a high-level introduction to the digital revolution for professionals in the offshore wind, wave and tidal energy industries, and explores the key technologies being used and developed by the Catapult's Data & Digitalisation team to fully exploit the industry's opportunity.

## Headlines

- Offshore wind, wave and tidal energy companies can benefit from the lessons learned by companies in more digitally mature industries, such as information technology, finance and oil and gas.
- Digital maturity can be expressed based on the type of analyses performed.
- Analyses are either descriptive, diagnostic, predictive or prescriptive.
- Four key technology opportunities have been identified for businesses in offshore renewables that can lead to greater efficiencies, better maintenance and lower costs:

  Business intelligence (structurally transform raw data into meaningful, useful information)
  Performance analysis (diving deep into the data to determine, for example, why turbines underperform)
  Machine learning (using comptuers to find dependencies that can help to predict specific events or situations)
  Process optimisation (optimisation of processes by analysing end-to-end data).

- ORE Catapult's specialist Data & Digitalisation team has been established to provide expertise, deliver innovation projects to help the industry adopt big data and digital techniques and deliver business improvements for companies in the sector.

## Introduction

As demonstrated by the significant reduction in Contracts for Difference (CfD) strike prices, offshore wind power is now established as a mainstream source of electricity generation that is cost-competitive with conventional methods. The UK also has a world-leading marine energy supply chain that has the potential to achieve significant cost reduction.

Despite the significant progress made, there are still many challenges to be overcome in the design, operation and maintenance of offshore wind farms.

The reduction in CfD strike prices also means that for owner/operators, the margin to make a profit becomes smaller: a trend that is expected to continue in the coming years. In order to keep offshore wind farms profitable, costs have to come down even further.

With operations and maintenance (O&M) representing around 25–30% of a wind farm's lifetime cost, the industry's focus has shifted towards smarter maintenance and task planning, and more efficient spare parts management and logistics, in an effort to reduce expenditure.

Finding out where and how improvements can be made is one of the challenges in which data will play an important role.

In response to this industry-wide issue, ORE Catapult has established a multi-disciplinary Data and Digitalisation team, comprising experts in computer science, data management, mechanical engineering and marine technology. This valuable blend of the data science and engineering domain is often lacking in offshore wind and this new team is focused on supporting the industry increase digital maturity.

Furthermore, the digitalisation lessons learned can then be applied directly to the tidal and wave energy industries, which are currently less mature but will face the same issues in the future.

## The Data & Digitalisation Team

The Catapult's multi-disciplinary Data & Digitalisation team was established to address the main challenges in wind, wave and tidal energy data management, and to investigate and spearhead new ways of processing and handling data. Through the Crown Estate-commissioned Data Pilots project, the team is engaging in short-term projects that tackle data-related challenges in offshore renewables – for example, using machine learning to determine underperformance, determining causes of downtime by analysing alarm logs, and automating the generation and calculation of key performance indicators (KPIs).

## The Data Opportunity

Taking advantage of the opportunities offered by data and digitalisation can require significant changes for businesses.

For organisations in offshore renewables, taking advantage of the digital opportunity means overcoming significant barriers, including behavioural change and replacing outdated IT systems. The most basic steps in the digital transformation often require new ways of working: reviewing data, active condition monitoring and taking steps towards preventative maintenance, for example. Besides simply using data and actioning the insights that it can provide, making a business digital-ready also involves a transition to the use of digital hardware and software tools to improve operational processes: for example, the provision of Wi-Fi connectivity on wind farm sites, or automation of procurement processes to improve purchasing efficiency.

Offshore wind turbine generators are complex systems comprising thousands of individual components and sensors. The day-to-day operation of the turbine, combined with maintenance and logistics activity, generates huge amounts of data. These data contain the vital signs of the turbines and can be used for more than only control use – monitoring and interrogating it can provide many insights.

The transition to data-driven decision-making calls for a step-based approach. From looking at other industries where digitalisation is more mature, we can see four main stages:

1. Descriptive: finding out what happened.

2. Diagnostic: finding out why it happened.

3. Predictive: working out what is likely to happen in future.

4. Prescriptive: working out what needs to be done.

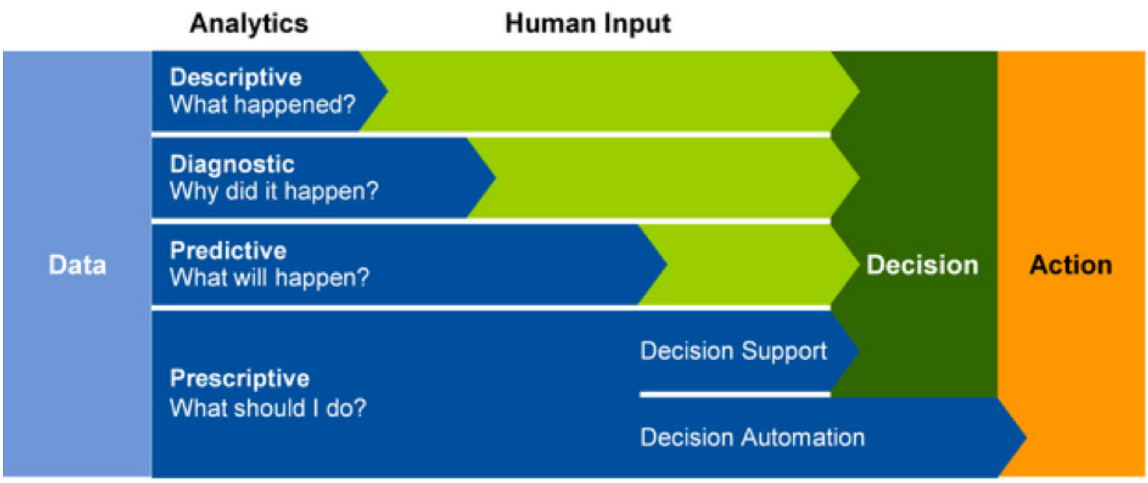


*Figure 1: Gartner's Analytic Ascendency Model*

Transitioning to a data-driven process is not only about putting these steps into place, but also about implementing a system where the full value of the data is extracted at each step. For example, most individuals and organisations will work with Key Performance Indicators (KPIs), which provide valuable descriptive insight.

However, different business functions require specific KPIs for them to be relevant and useful. For example, finance might be better served looking at KPIs related to invoicing, while a team manager might gain more benefit from work order insights. Defining more specific KPIs improves their actionability.

Improving analytics and becoming a more data-driven organisation comes with the benefit of reduced risk: decision-making informed by data is always more dependable and reliable than decisions made on instinct, anecdotal evidence, or estimation.

For example, turbine inspection schedules are planned because data indicates that they might need attention. This knowledge can then be used to equip engineers with the tools needed for specific tasks, creating efficiencies in logistics.

Offshore wind farms – and wave and tidal sites – are often extremely hazardous environments, creating significant health and safety challenges for the personnel deployed to carry out construction, survey, inspection and repair work. Technician transfer from crew transport vessel (CTV) to turbine is an ever-present challenge and so reducing the number of visits is crucial for employee safety and asset performance. Knowledge of what needs to be done and when could be obtained by utilising the data available.

## Potential Applications in Offshore Renewable Energy

The Catapult has identified four key technology opportunities for businesses in offshore renewable energy around digitalisation that our Data & Digitalisation team are focusing on.

**Business intelligence** offers techniques and best practice for active or real-time insight into what is happening with an asset. Integrating disparate data streams and determining which KPI's should be monitored – and what to do with the insights provided – improves knowledge of how assets are performing. It can be especially useful for determining underperformance, which can be the basis for deeper analysis and intervention. The results are very descriptive and need more input before they become actionable.

**Performance analysis** is a broad term for analysing asset performance data. These results can be descriptive, providing insight in what assets have been doing, but can also be diagnostic. Improving quality, speed and variety of analyses leads to a better understanding why assets perform as they do.

**Machine learning** takes performance analysis a step further. Where performance analysis relies on analysts to give meaning to the data, machine learning relies on dependencies in the data. While an analyst might focus on specific performance indicators, machine learning applies artificial intelligence to find and highlight trends in the data that analysts can then interrogate.

**Process optimisation** is a self-explanatory term that involves the optimisation of (business) processes. Data has the potential to take away assumptions and decision making based on gut feeling. Improving logistics and scheduling can lead to reduced costs and risk, improved asset availability and better working conditions.

Overleaf, we'll look at the technology opportunities in more detail.

### *Business Intelligence*

The market research firm Forrester describes business intelligence as "a set of methodologies, processes, architectures, and technologies that transform raw data into meaningful and useful information." Most offshore wind owner/operators are already familiar with these technologies as most, if not all, control rooms use a specific set of information to continuously check and respond to the working of all turbines. In addition, management will generally receive high-level monthly performance updates.

After assets have been in operation for a period of time, normal or expected behaviour becomes clear which allows operators to define targets and/or limits. These are monitored continuously and when a deviation occurs, can trigger updates or alerts. The technology offers all the necessary data architectures, means for calculation and several options for triggers. The analysts simply have to define how to aggregate incoming data into the final KPIs.

The first challenge here is to define useful KPIs and realistic (but also challenging) targets around metrics such as production, availability, intervention intervals, etc. With the industry developing quickly, norms improve rapidly. Benchmarking systems like the Catapult's System Performance, Availability and Reliability Trend Analysis (SPARTA) can be a tremendous help for finding the right KPIs and defining targets. The industry is expected to evolve and start using more standardised data streams, with standardised data architectures and KPIs supporting proven operations and maintenance (O&M) processes.

Actionability is another challenge that comes with business intelligence. While it is useful to know that a wind farm is underperforming, this information only becomes valuable if its operator can take action on this knowledge. Aligning maintenance and resource planning with operations and management by analysing which turbines or components display unexpected underperformance is one way to continuously verify if the work done is the most useful.

## *Performance Analysis*

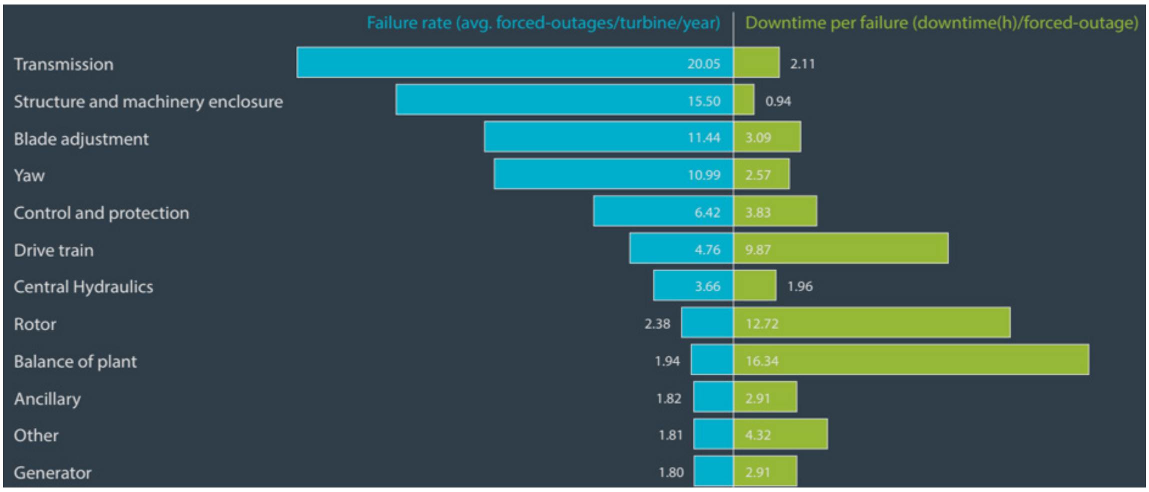


*Figure 2: Analysing performance by looking at failure rates and downtime per failure.*

Knowing that an asset under performs is one thing – but as discussed, the information alone does not change anything. Before an intervention can take place, we must find out the cause of the underperformance. Combining data from the Supervisory Control and Data Acquisition (SCADA) systems with event log (e.g. alarms), weather, National Grid and logistics data can reveal detailed insights into why things happened. Much of this data is already available to operators and used for day-to-day operations, but we see that the data can be utilised better by combing data streams and performing deeper analyses.

One of the industry's most significant challenges comes with turbine commissioning. If the sensors are not accurately configured, a turbine might suffer effects like nacelle misalignment. It is possible to determine certain types of misalignment using SCADA data and turbine positions, but if the sensors are not trustworthy, the data will not be either. Therefore, making sure the sensors are accurately configured is very important.

Analysing the performance impact of turbine maintenance and servicing is a good way to evaluate current maintenance strategies. The downtime, lost production and lost revenue of visits are all indicators on the direct consequences of a turbine visit. Reducing these metrics is a clear win, but more can be done. Before performing a fleetwide retrofit, a "before and after" performance analysis can be carried out on one or a few turbines. The results can then feed into a strategy that determines task priority. The insights can also help to consider and evaluate alternative maintenance strategies – for example, by looking at low revenue periods and focusing interventions at these times. Would it be advantageous to carry out more maintenance by doing it earlier and more frequently, at times when less revenue is generated?

Looking at when a turbine is not running at full performance is a good indicator of unreliable or failing components. The issue can be determined by analysing the frequency and inter-alarm times detailed in the turbine's alarm logs, which in turn narrows the fault down to specific components.

## *Machine Learning*

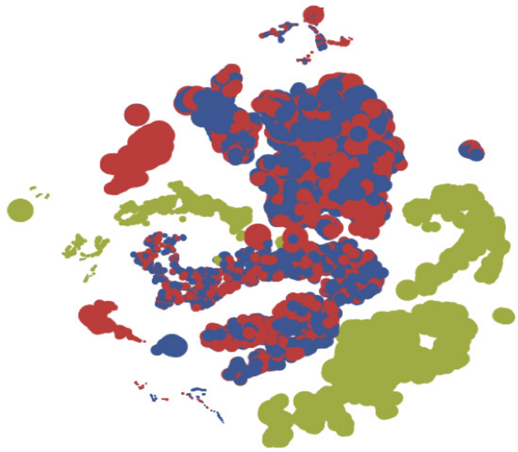

*Figure 3: Result of dimension reduction of SCADA signals by machine learning algorithms, showing two turbines performing similarly (red and blue) and one that is different (green).*

Each second of the day, every turbine generates hundreds of values that have a multitude of information hidden in them. The amount of data generated is too vast and too complex for human analysts to comprehend in real-time, so the help of computers is necessary. Machine learning is the process by which computers find dependencies on their own, and it can help to predict when specific events or situations might arise. For example, a model can be trained on the data leading up to a specific type of failure so that it begins to recognise patterns specific to that situation. That model can then be applied on the data coming from turbines directly, and it can be programmed to flag an alarm when that same pattern shows up again. In this case, the pattern found is an indicator for a fault that is likely to occur soon. This knowledge can be used to plan predictive maintenance, or to intervene before the failure occurs (preventative maintenance).

The challenges around machine learning include a lack of available data detailing events for training sets, algorithm selection, and how the results are interpreted. If the model is too generic, the results won't be better than what a human operator would see. However, if the models are too specific, new instances won't be recognised. Defining a scope that is broad enough to contain the complexity to add insights, but narrow enough to be able to work with the available data, is extremely challenging.

Besides scoping, the availability of quality data is also an issue. To make sure that the dependencies found by the algorithm are not a coincidence, sufficient data needs to be provided. Gathering the necessarydata is of critical importance, but can be extremely challenging due to its commercially-sensitive nature.

### *Process Optimisation*

Enterprise Resource Planning (ERP) data, work orders and authorisation/communication logs contain a plethora of useful information about how current business processes run and where bottlenecks are. Process mapping (defining the steps involved in a process) can give a good indication of how a process works for the majority of times, but is dependent on use case. Process mining – the act of creating these process maps from data – removes this bias. The resulting maps provide insight into what is done, potential bottlenecks, and how effort is spent throughout the process. Processes like "from fault to fix" (when a turbine goes down, until it is fixed) generate data in the form of alarm logs, work orders and resource usage. Looking at these processes and optimising their efficiency leads to more operational time and lower maintenance costs.

The challenge lies in gathering the data from multiple sources and combining these into one view.

Another challenge is in the fact that these processes often involve multiple business units. In other, more digitally mature industries, it has been found that process efficiencies can be uncovered by looking at the process from an end-to-end perspective, because handing over of work can be made more efficient. However, getting the disparate departments of a company to work together can be a challenge in any industry.

### *Conclusions*

Taking advantage of the opportunities offered by data and digitalisation will require significant changes for businesses and overcoming significant barriers. However, it is now clear that the application of data analysis can cut costs and help owner/operators make smarter decisions. Becoming a data-driven business can be achieved by climbing up the digital maturity model, which can be achieved by leveraging analytics capabilities from the descriptive and diagnostic levels through to predictive and prescriptive.

Implementing technogies like business intelligence, performance analysis, machine learning and process optimisation can also lead businesses in offshore renewable energy to greater efficiences, more optimised maintenance, and ultimately lower costs.

The offshore wind, wave and tidal industries have great potential to become more data-driven. Exploiting lessons learned from other industries to deploy the right digital innovations in your own company is the way forward. Whether you're a company just starting this journey, or well on your way in climbing the maturity ladder, the Catapult's Data & Digitalisation team can offer support.

***If you would like to know more about maximising the value of every data point generated by your own assets, or if you are a digital solutions provider seeking to break into offshore renewables, please get in touch.***

# Appendices

## *Author Profile*

Peter van Heck is a Data Scientist in the Catapult's Data & Digitalisation team. Combining a background in computer science with deep knowledge of wind farm data systems, Peter's primary focus has been on data architectures, data availability, and modern analytics methods including machine learning, process automation and business intelligence. Peter ensures that operational data from our assets and projects is readily available and is being analysed effectively to maximise its potential. Peter has worked together with mechanical engineers and asset analysts on- and offshore to deliver robust and actionable insights to owner/operators, SMEs and research partners across Europe.

## *Disclaimer*

While the information contained in this report has been prepared and collated in good faith, ORE Catapult makes no representation or warranty (express or implied) as to the accuracy or completeness of the information contained herein nor shall be liable for any loss or damage resultant from reliance on same.


## Offshore Renewable Energy Catapult

**Inovo**

121 George Street
Glasgow
G1 1RD, UK
T: +44 (0)333 004 1400

**National Renewable Energy Centre**

Albert Street, Blyth
Northumberland
NE24 1LZ, UK
T: +44 (0)1670 359 555

**Fife Renewables Innovation Centre**

Ajax Way
Leven
KY8 3RS
T: +44 (0)1670 357 649

**O&M Centre of Excellence**

Ergo Centre
Bridgehead Business Park
Meadow Road, Hessle
HU13 0GD