Weather at Every Stage: How Accurate Weather Data Improves Efficiency for Offshore Wind Farms

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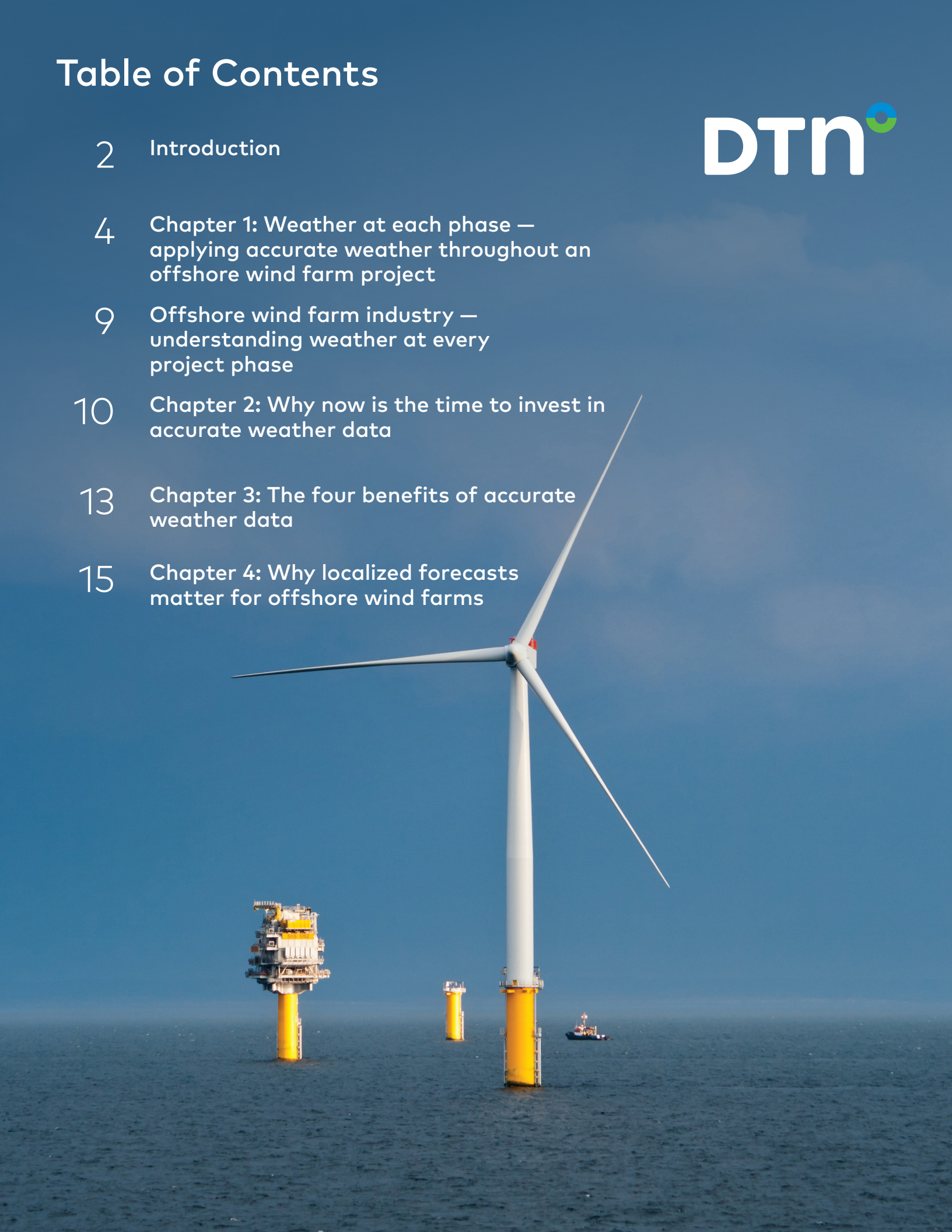
Table of Contents



Introduction

A combination of declining costs and technological advancements means that wind is now one of the cheapest modes of power generation available. As a result, it's anticipated the sector will grow significantly in the coming years, with international offshore wind capacity expected to increase from approximately 25 GW today to 164 GW by 2030. In 2019, the United Kingdom alone added 2.4GW of wind capacity, mainly achieved with new offshore installations.

But, as the offshore wind industry becomes more established, more wind farms are constructed farther away from shore. For example, Hornsea One, located in the North Sea, will be the farthest wind farm from shore in the world at 120km from the English coast.

The greater distance from shore presents new operational challenges related to the weather. Planners and operators must reconcile the difficulties caused by stronger winds and waves, while still facing the same problems that impact wind farms nearer to the coast: managing production and maintenance.

Since their inception, wind farms have been dependent on the weather. The geographical concentration of wind power, typically required for offshore wind farms, leads to increased wind speed variability. In the case of rough weather, this may lead to the sudden shut down of a whole wind farm.

These occurrences of extreme weather impact supply to the grid. Unless alternative sources are ready to take over power demands on short notice, wind farm shutdowns can leave national networks with a supply shortage. This means the pressure is on owners and operators to understand when this will occur and prepare.

And, when it comes to installation, operational maintenance, and decommissioning, the pressure is on teams to identify suitable weather windows to complete the work. Waiting for the required weather conditions for repairs and maintenance can lead to unnecessary expenses and reduced production times for wind turbines.

It's evident during extreme weather events that work isn't possible. Likewise, when conditions are flat and calm, it's apparent work can be performed. But when it's borderline — and it's tough to make a go/no-go call — reliable forecasts make the difference between the right decision and a wrong one.

This white paper will explore how accurate weather insights help at each stage of the offshore wind farm life cycle, the trends that mean the time for action is now, and why accurate weather forecasts are essential for utilizing weather windows for safe, efficient, and cost-effective operations.

Chapter 1: Weather at each phase

Applying accurate weather information throughout an offshore wind farm project

You may already know that offshore wind farms require some form of weather data during operations when knowing wind speed is essential for predicting power yields, and high winds mean turbines must shut down. But it has real value that can be unlocked throughout the entire project life cycle. From Front Engineering End Design (FEED) to decommissioning, accurate weather insights can help you overcome numerous critical challenges.

FEED Phase: Use weather data to establish the viability of wind farm sites

When identifying potential sites and assessing their viability, there are certain weather conditions and factors that need to be considered. The scoping process to identify potential offshore wind farm sites includes considering the likelihood of adverse weather and sea conditions, which could impact the economic viability of the site when operational. These requirements are based on alpha factors, with considerations like maximum wave height, wind speed, and wind direction components used in alpha factor calculations.

Based on the outputs of this analysis, the site's feasibility and critical weather considerations can be established. Not using a professional weather service can result in miscalculating weather risks: a potentially dangerous and expensive mistake at this stage.

For example, say the FEED phase conclusion is that during a year, wind speeds will exceed the maximum level allowed 15% of the time. This assumption is all well and good. It provides for 15 days of total downtime out of 100 days.

However, if the risk is miscalculated and maximum wind speeds occur more frequently, the downtime will increase. Almost immediately, this impacts the viability of the site, a situation linked to the decision not to utilize accurate weather data.

Investing in weather data during the FEED phase can reduce the risk of futile planning to a large extent. It provides confidence in the likelihood of unfavorable weather and sea conditions that can be reasonably expected at a site. It reduces the risk of investing too much time and effort into unviable sites and helps to maximize efficiency and profitability.

Development: Determine the size, number, and location of wind turbines — and above all, minimize associated risks

The development process differs by country. Often, it's government-led: the local government puts out a tender for preassigned sites. The developer (consortia) puts in a bid for that site based on their due diligence of the weather, asset, and financial conditions.

The partner identified for this stage is the developer. Their role is to determine the size, number, and location of wind turbines. Every consideration, from establishing how to get people back and forth during the project, down to which vessel to use, needs to be finalized.

The developer is responsible for assessing the site condition for maximum efficiency. They must understand the potential weather-related implications. A weather partner can help ensure the accuracy of this information. The developer also provides input for the social and environmental impacts of the site, which must be submitted for regulatory compliance.

A crucial part of this is recognizing the job restrictions due to the likely weather conditions and answering the following questions:

- What are the safety thresholds for all of the vessels?
- What are the conditions where work must be stopped?
- What contingencies should be put in place?

Understanding the site's likely weather conditions is key to answering those questions. During the development stage, weather experts help offshore companies analyze expected conditions, supporting planning for hiring and deploying crews for the project.

In addition, all the projects in Europe, Australia, Asia — and, increasingly, in America — are checked by a marine warranty surveyor, who uses DNV guidelines to establish project limitations. Weather experts can assist at this stage by explaining how they will approach the metocean environment for a particular project.

Installation — be safe and efficient, with accurate weather data

After approval, the developer prepares the site and gathers partners to assist in securing the manufacturing components for installation. Then, it's a shift to mobilizing teams and beginning work at the site.

The weather partner then focuses on supplying data for analysis and planning and forecasting conditions. They use the appropriate combination of external and internal metocean models to support near real-time monitoring of weather conditions during installation.

The biggest challenge at this stage is establishing the reliability of the available weather window for performing planned activities. This insight is essential to keeping operations on schedule, identifying appropriate weather windows, and ensuring crew safety.

Up to a third of the time during a wind farm installation is lost while waiting on weather conditions. The increasing size of turbines and their foundations exacerbate the problem. The opportunity to reduce costs by developing equipment and processes is substantial. However, while these innovations will undoubtedly come, installers still require accurate weather insights to identify suitable windows for work to take place.

Installers use forecasts to plan activities based on available weather windows. But there's two-way communication. The installer shares the weather window they require. For example, they need a 4-day window to complete a job. The weather partner can then make a recommendation based on the available weather data. They advise how to use the model data and avoid bad decisions made by misinterpreting it.

Often at this stage, the weather partner joins briefing calls. Their active role ensures that, after issuing the forecast, they can explain it in greater detail and their confidence in the outlook. The decision of whether to work or not will still lie with the installer, but the weather experts help identify when to start and stop work based on the conditions.

Operations and maintenance — access to the most reliable weather data ensures optimized processes at every stage

This phase typically lasts between 20-25 years. It is when the project starts generating electricity. There are two main roles for weather forecasting at this stage:

1. Identifying when conditions mean turbines can or cannot be operational
2. Determining when the weather will allow maintenance work to take place

In terms of the operational aspect, the underlying concern for wind farm owners and operators is to meet the expected power generation output. Site viability and profitability is heavily dependent on the power yield forecast, which is dependent on the wind forecast. Weather partners need to provide accurate wind data to enable precise power forecasts.

Alongside this, maintenance is required throughout the period to guarantee that wind turbines run efficiently and to prolong their lifespan. Wind farm maintenance is complicated, requiring both scheduled and ad hoc repairs. Often, crews need long windows for planned maintenance, varying by operation performed. While the ad hoc repairs can be quick fixes, depending on their nature, they may also require a long weather window. For example, when it involves jack-up rental or replacing a major component in the nacelle. Adverse weather conditions can also limit access to turbines and delay essential maintenance, leading to revenue loss.

Once a suitable weather window for maintenance work is identified, mobilization begins. The clock starts ticking. For the weather partner, it's now about monitoring the conditions, tracking any changes, and reporting back on their forecast confidence.

It's at this stage that companies need confidence in the weather data. If one forecast shows they have a 72-hour weather window, but other data sources show it will only be 60 hours, they need to know who to trust.

If they're not confident in the forecast that says they have the needed 72-hour window, they may decide not to do the work. If that forecast was ultimately correct, the missed work may be delayed until another weather window opens — sometimes weeks later.

These are tough decisions to make. Sometimes the weather window isn't there, but sometimes it is; they need to have trust in the data to keep projects on track. A lot of it is marginal, but it's also where they can make real gains during turbine maintenance.

Decommissioning — plan the best time to demobilize the asset

As the turbines come to the end of their natural life, the developer will decide whether to decommission or repower the site with new turbines.

As with installation, the biggest challenge at this stage is establishing the reliability of the available weather window to perform the planned activities. This information is vital in preparing crews to decommission the site. The role of the weather partner at this stage is very similar to their role during the installation phase.

Typically, if there's no plan to reuse the parts, minor damage to the assets is not important. However, developers are still mindful of any environmental damage and may intend to repurpose some assets on other sites.

If the site is repowered, the cycle starts again.

Planning and executing during the offshore wind farm life cycle is complex. Knowing the likely weather conditions at each phase puts the organizations involved in the best position to ensure projects stay on time and budget.

Offshore wind farm industry — understanding weather at every project phase

1	**End design (FEED)** (One-off) Offshore wind farm, owners & operators, engineering, procurement, & construction (EPC), contractors	**Focus** Budgeting, planning, asset management, & risk management.	**Weather challenges** Obtaining reliable information for efficient planning & budgeting.	**Weather service** Metocean services, planning platform, & project consultancy support
2	**Development** (1-2 years) EPC & subsea companies	**Focus** Pre-installation work, including subsea laying, foundation, cable laying, & trenching.	**Weather challenges** Accessing accurate weather data to establish when suitable weather windows for planned activities will exist. Ensuring work stays on schedule, while keeping crews safe.	**Weather service** Weather forecasting
3	**Installation** (1-2 years) EPC & original equipment manufacturers	**Focus** Installation on site, including piling (single, tripod, concrete), & turbine installation.	**Weather challenges** Accessing accurate weather data to establish when suitable weather windows for planned activities exist. Ensuring work stays on schedule, while keeping crews safe.	**Weather service** Weather forecasting
4	**Operations** (20-25 years) Trading groups maintenance	**Focus** Power generation & routine operational execution.	**Weather challenges** Utilizing wind forecasting for efficient operations & meeting the expected power generation output.	**Weather service** High resolution wind forecast, offshore weather forecasting, & decision support tools
	Maintenance (20-25 years) EPC & third-party contractors	Maintaining the OWF assets & routine checks.	Accessing reliable forecasts to plan maintenance activities, especially important as maintaining OWF assets is typically more economical than replacing. Ensuring safe access to the asset during the planned weather window period.	Weather & wind forecasting, tidal information, spectral data services, & current Information
5	**Decommissioning** (1 year) Owners & EPC	**Focus** Decommissioning &/or repowering the OWF site.	**Weather challenges** Planning the best time to demobilize the asset & keeping people safe during the available weather window.	**Weather service** Weather forecasting, verification services

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Chapter 2: Why now is the time to invest in accurate weather data

Whether working on a wind farm installation, planning routine maintenance, or planning to decommission a site, it's clear that weather conditions can impact the work. This situation has been the case since the very early days of offshore wind farms. As we explored in the previous chapter, it is not just about operations, the weather impacts every phase of a project's life cycle.

So why now? If the weather has always had an impact, why is now the time to invest? We've identified four trends that answer this question.

1. Wind speeds and wave heights are increasing

According to Science, the world's oceans are becoming more stormy. Over the last 30 years, observations note increases in average wave height and wind speeds — both of these are vital metrics for evaluating safety thresholds for offshore wind farms.

Depending on the precise level of wind speed, this could be a boon for the industry. A study published in Nature, reveals that global wind speeds since 2010 have recovered to levels last seen in the 1980s. Essentially, more wind means more opportunities for power generation — as long as it doesn't breach safety levels.

But, in the Southern Ocean, for example, average wave heights have increased by 5% or 30cm. If the trend sustains over time, it means that sea conditions would become more extreme, and consequently, make planning access to offshore wind farms a bigger challenge.

Take away: Wind speeds and wave heights are increasing. While this opens up more opportunities for power generation, it also increases the likelihood of conditions impacting installations, operations, maintenance, and decommissioning.

2. Reducing costs and accurately estimating power generation yields are essential to profitability

Accurately estimating the power yield from a site is essential for profitability. One offshore wind farm developer overestimated the power generation at their sites by up to 2%, which consequently knocked 10% from the value of the company's stock.

With very few offshore wind farm projects delivered on time and budget, the pressure is on the industry to reduce costs. The reputations of individual companies are affected when they do not adhere to cost estimates. But it also impacts the ability of the whole sector to secure investment, as it is perceived to be riskier than other investments. Focusing on reducing risks and mistakes could cut costs by up to 7%. By helping to identify safe weather windows for work, weather data can be part of overall cost reduction.

Take away: Accurate weather data supports accurate power projections that help protect profitability. It also helps reduce risks by enabling companies to make informed decisions on appropriate weather windows for work.

3. Managing company reputations and preventing false alarms

Deciding whether or not there is a suitable weather window to perform part of the project relies on confidence in the weather data.

If it's not clear whether the window exists or not because it's a close call, it's natural to want to consult multiple data sources. However, making the wrong call to work when conditions are not safe or canceling work only to discover the weather window was open after all, reflects poorly on a company's reputation. These false alarms also increase project costs, either from lost work or from preventable damage to assets and equipment.

Take away: Accurate weather data ensures greater confidence in decision making and prevents costly false alarms.

4. Sites are moving further offshore

The trend to develop more offshore wind farms means moving further away from shore to meet increasing demand. Prime locations close to the coast are mostly already occupied, which means the offshore wind industry has no choice but to build further away.

The key to making this happen is floating wind turbine technology, which is fast coming to the market, following successful prototypes. The first commercial installation off the coast of Portugal began transmitting to the grid in early 2020. The turbines in Portugal float 100 meters (328 feet) above the seafloor, which is approximately two-thirds deeper than the maximum depth of fixed offshore farms.

By enabling installations further from shore, floating wind turbine technology solves two of the industry's main problems. First, it removes opposition to installation on the basis they "ruin" the sea view. Second, it enables installations in deeper water, which is beneficial for countries lacking the continental shelf for shallow water installations.

However, there are challenges associated with this trend. Moving further from shore can result in stronger winds and larger waves. It's also possible that travel times to and from the site for installation and maintenance activities will increase. This situation is problematic because specialist vessels and equipment will need to be hired for longer, increasing the costs, especially if work overruns.

Chapter 3: The four benefits of accurate weather data

Smart companies involved in offshore wind farm projects are using weather data to make better-informed decisions that support operational efficiency and improve profitability. They do this because they appreciate the impact weather has on every phase of a project. They also recognize the four business benefits accurate weather data provides.

1. Avoid unnecessary weather-related downtime

What's the risk: In all aspects of the offshore wind farm project life cycle, there are specific safety thresholds. For all of the different tasks and vessels, there are different thresholds. For example, a ship operating as part of a turbine installation in the North Sea may have a wave limit of one meter. Above that threshold, work must be stopped and the ship must return to shore.

How weather data can help: The thresholds are precise, with clear cutoffs. Using an unsophisticated weather source makes deciding to stop or continue working harder because of the lack of confidence in the forecast. As a result, it means allowing for higher risk tolerance in the weather data. Consequently, this could result in more days where it's not possible to work, even though actual conditions allow for safe operations.

Professional weather services go through a complex modeling exercise, with different sources of data aggregated and then verified by experts. It creates one source of truth for the clients to assess the conditions with greater confidence.

2. Avoid scheduling changes due to the weather

What's the risk: Projects are broken down into chunks of work, typically based on the time needed to complete a section of work. If 72-hours is required to get a job done, from start to finish, an appropriate weather window must be determined.

After mobilization, if conditions change, shortening the window to 60 hours, then the crew will lose that window and need to reschedule the work.

How weather data can help: Accurate weather data helps uncover additional weather windows and ensures more accurate ones. In situations where the window is tight, reliable data can reveal conditions close, but on the right side of the thresholds. This allows the work to continue — without compromising safety. The impact can be huge. Not only can unnecessary scheduling changes mean the initial window is lost, it can be weeks before conditions allow for the next suitable weather window.

3. Prevent damage to equipment and the environment

What's the risk: It's no surprise that in bad weather, assets can be damaged, which has an impact on long-term profitability. However, accidents can also cause environmental damage.

How weather data can help: Complete weather data enables companies to avoid mistakes. It provides visibility into changing conditions, typically with a built-in threshold alarm, leading to improved safety at sea and reduced risk of equipment damage.

4. Prevent accidents and ensure safety, while maintaining confidence

What's the risk: Across all phases, safety in offshore wind operations is paramount, and all work should adhere to the highest safety standards. Adverse weather is a risk; crew members can be injured or even killed. But missing viable work windows can lead to two outcomes. Either the crew stays on-site and sees that conditions didn't break the safety thresholds — and subsequently lose confidence in the forecast. Or, they take action and move away from the site, only to discover the forecast was wrong. While this errors on the side of caution, it can lead to unnecessary increases in project costs and work delays.

How weather data can help: In extreme weather, it's obvious work isn't possible. The conditions are too dangerous. But when conditions are deteriorating, at what point does work stop? It's a difficult decision because stopping work early adds to project costs, and finishing too late is a safety risk. Confidence in the weather forecast supports the right call at the right time.

Forecast accuracy is vital for decision-makers on offshore wind farm projects. The more accurate the weather forecast is, the more confident people feel in making the tough calls. It's only with this level of accuracy that companies can realize the four benefits.

Chapter 4: Why localized forecasts matter to offshore wind farms

The type of service that weather experts provide is equal worldwide. While most of the offshore wind farm construction is currently focused on the North Atlantic, as technology develops and demand for renewable power grows, sites in other locations will likely be commissioned.

In terms of providing forecast data, it doesn't matter whether the wind farm is in the Gulf of Mexico, the North Sea, or the South China Sea. But, as you can imagine, the types of weather conditions can vary. This means that similar projects will have different requirements, depending on their locations — and have different needs from their weather partner.

Let's share an example that highlights one site's particular requirements. Picture an offshore wind farm located near the Belgian coast. Here, sandbanks can cause high or long waves to break early or induce waves to bend. As a result, these sea conditions make it harder to predict wave height. It is a real challenge for offshore wind farm operators in this region.

Historically, forecasts at this site have been up to half a meter off actual levels. This difference is because global wave models do not account for the impact of the local sandbanks. Consequently, this scenario results in challenges for vessels working close to their safety threshold, which makes it harder to predict when work can or cannot take place.

Meeting this challenge required a specific in-house metocean model, deploying an innovative approach. By coupling atmospheric forcing with in-house wave models, it not only looks at the conditions at sea, but also incorporates the atmospheric winds that drive the waves.

It also includes detailed tidal information, a prerequisite when working in shallow water. The model was calibrated both with local observations (in-situ) and remote data.

Different models have different strengths. Coarse models perform well in the deep ocean, but a more detailed model is required closer to shore.

In-house modeling can couple together different models: the output from one becomes the input for another. For instance, a regional WAVEWATCHIII model can be fed surface wind data computed by a regional WRF domain, of which both receive boundary conditions from a global grid.

Offshore wind farms planning operations in challenging weather conditions benefit from specific in-house models and combinations. In the case of this wind farm, a SWAN model, run on a high-resolution grid, can take spectral wave data from the regional WAVEWATCHIII, surface winds from WRF, tidal data from harmonic components, and ocean circulation data from Mercator and accurately capture the wave-current interactions over complex seafloor features. The resulting dataset provides unique insights into current and future conditions.

While these requirements are specific to one site, the approach highlights why local conditions need to be accounted for in the weather data — as well as the steps the weather experts can take to localize the forecasts.

Conclusion

It may sometimes seem like it's only a few hours gained here and there, but over the whole offshore wind farm life cycle, it adds up to real savings. Such gains come from the interaction with the weather forecast and the weather experts. Working collaboratively with meteorological experts can unlock insight that isn't apparent from limited weather services. And that's what it's really about, seeking out those extra nuggets of savings to ensure profitability.

We've shown the importance of accurate weather forecasting at every stage of an offshore wind farm project. This weather data enables owners, planners, developers, and operators alike to manage costs, keep projects on track, and ensure crews and assets remain safe.

Learn more at **www.dtn.com/offshore-forecasting-services**