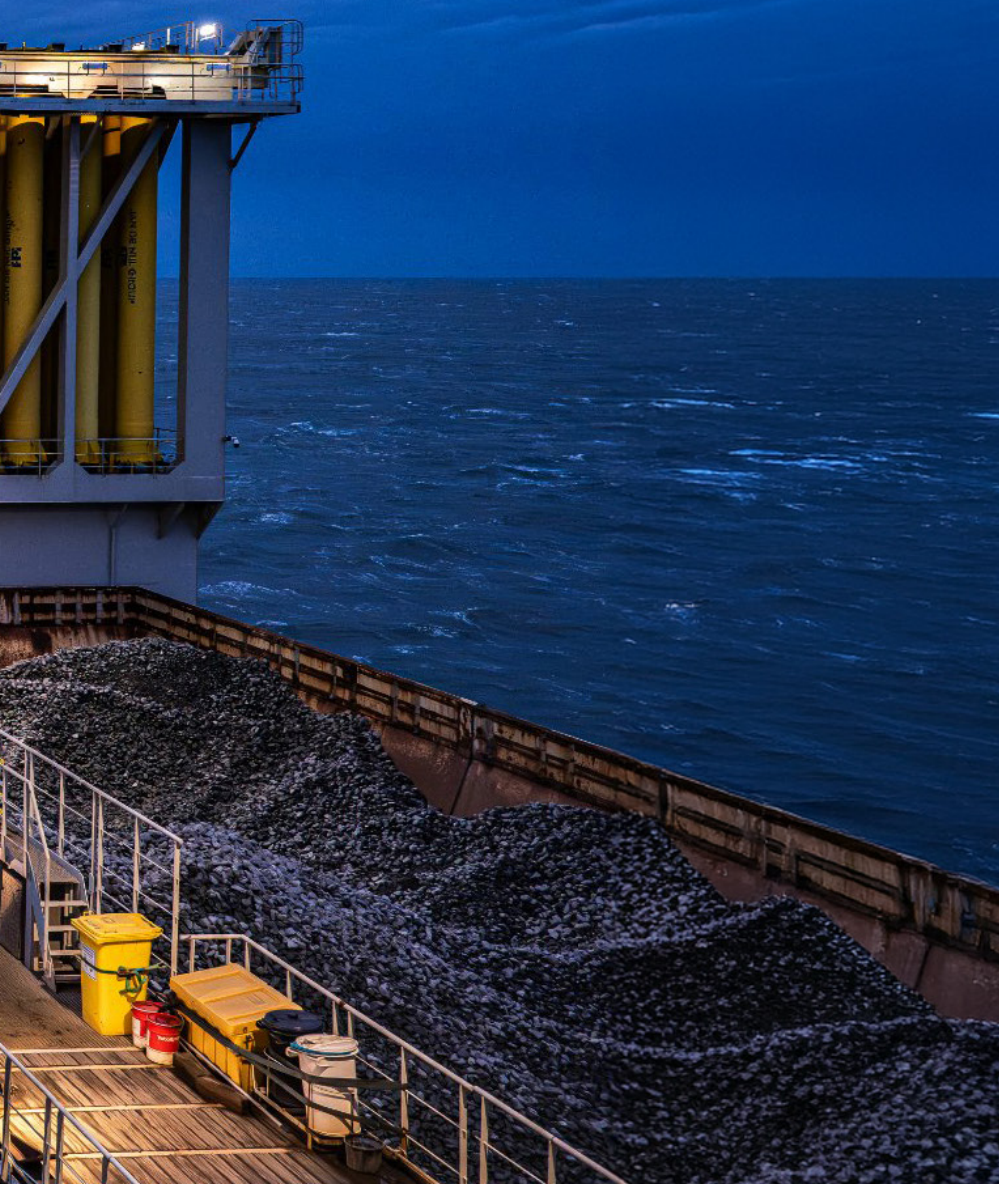


Beyond ‘under construction’: tracking offshore wind progress turbine by turbine

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‘Under construction’ tells us little about what is actually happening across an offshore wind farm. Tracking individual turbines through different stages of deployment and commissioning can reveal construction progress, installation patterns and the changing state of a project over time.

For decades, offshore wind maps have answered a relatively simple question: where is the infrastructure? Yet offshore wind farms are constantly changing. Foundations are installed, turbines are erected, cables are laid and assets move through multiple construction and operational stages. A single project boundary and development status can no longer capture that complexity.

A project status is useful for providing a broad market view, but it does not necessarily describe activity on the seabed. Understanding construction progress requires moving from the project level to the asset level. The objective is not simply to say that a wind farm is ‘under construction’, but to understand how construction is progressing across the individual turbine locations.

Consider a 100-turbine project that is classified simply as ‘under construction’. That status provides little insight into whether five turbines have been installed or 95. It does not reveal installation rates, construction sequencing or how activity is progressing across the site.

However, construction information is currently fragmented. Evidence comes from different sources, dates are incomplete and project announcements often report only headline progress, limiting the information available on individual turbine activity.

Knowing which turbines are currently installed can be particularly useful for project developers, as even a small number of installed turbines on a neighbouring project can begin to introduce wake effects that influence wind flow and energy yield assessments.

Determining when a turbine changes state is often an exercise in evidence gathering rather than direct observation. No single source provides a complete answer. Vessel automatic identification system (AIS) data can indicate installation activity, Notices to Mariners provide information on planned operations, satellite imagery offers independent visual confirmation and developer announcements help validate key milestones.

Each source, however, has limitations: vessel proximity does not necessarily confirm a particular activity, Notices to Mariners often describe planned operational windows rather than exact event timestamps, satellite imagery can be restricted by cloud cover and acquisition frequency and developer communications rarely provide turbine-by-turbine dates.

Combined with existing spatial datasets, these sources can be cross-checked to build a more reliable turbine-level history than any individual dataset could provide alone.

Once these observations have been validated, the next challenge is deciding how to store them without losing earlier stages of construction.

Maintaining only the latest turbine status creates an important limitation: every update risks overwriting part of the asset's history. By preserving historical states instead, spatial data becomes more than a snapshot. It becomes a record of project evolution, enabling analysis of construction sequences, installation rates and the time taken for assets to move between stages.

Once turbine events are recorded alongside dates, a wind farm can effectively be replayed through time. The map becomes more than a display of assets; it becomes a tool for analysing how construction progressed, where activity occurred and how installation strategies evolved across the site.

Historical construction data can reveal how quickly different developers install turbines, which installation strategies deliver the fastest progress and how weather or vessel availability influences construction campaigns. More importantly, it provides the context needed to understand how a project reached its current state rather than simply recording the outcome.

East Anglia THREE provides a useful example. The figure shows the same project at three stages of construction between May 2025 and September 2026. On 15th May 2025, most turbine locations remained in the Planned state, although installation activity had already begun at several positions.

By 23rd April 2026, foundation installation was still ongoing across parts of the site while the first turbines had already been installed. By 14th September 2026, all foundations had been installed and turbine installation was more than halfway complete.

Viewed as individual project updates, these snapshots simply show construction progressing. Viewed together, they reveal something more interesting: construction does not advance uniformly across a wind farm. Different turbine locations move through different stages at different times, creating a spatial pattern of activity that a single project status cannot capture.

Preserving those turbine-level transitions makes it possible to reconstruct the physical build-out of a wind farm, analyse installation sequences and compare construction approaches between projects. Without this historical record, much of that information is lost as each asset advances to its next stage.



1: East Anglia THREE construction progress map

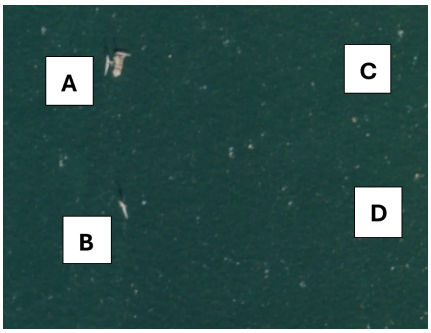


2: Sentinel-2 workflow for turbine orientation

The same approach also enables construction performance, installation strategies and project delivery timelines to be benchmarked across the industry.

Tracking does not stop once a turbine has been installed. As the heavy lift and construction vessels move on, operators begin testing and commissioning individual turbines before the project becomes fully operational. Continuing with East Anglia THREE, we looked more closely at some of the first turbines installed to see whether satellite imagery could reveal anything about this transition.

Using Sentinel-2 imagery, TGS | 4C has developed a visual interpretation workflow assisted by a large language model (LLM) to review repeat observations between April and September 2026. The process combined manual image inspection with LLM support to identify turbine features, compare successive acquisitions and estimate changes in apparent rotor orientation from blade geometry and, where visible, turbine shadows. Some of the clearest examples are included below.



3: Initial observation

As projects grow in size and complexity, understanding how infrastructure changes through time will become just as important as knowing where it is located.



4: Four-date sequence

Sentinel-2 was not designed specifically for monitoring individual wind turbines. However, the increasing size of modern offshore turbines means that rotor, nacelle and shadow signatures can sometimes be resolved under suitable atmospheric and viewing conditions. This creates an opportunity to extract additional information from imagery normally associated with much broader Earth observation applications.

In this first observation, turbine installation was still progressing across the site. Turbine A was being installed, Turbine B was already in place, and Turbines C and D remained at foundation stage.

By 22nd April 2026, the two installed turbines already appeared to have different orientations. Turbine A was estimated at approximately 22.5°, while Turbine B was closer to 337.5°. By 1st May, however, both appeared broadly aligned at approximately 337.5°.

The early May observation also showed noticeable red, green and blue spectral fringing around the turbine signatures. Because Sentinel-2 records its visible spectral bands separately, movement of a rotor during acquisition could potentially contribute to this displacement. However, inter-band registration and viewing geometry can produce similar effects, so spectral fringing should be treated as a potential indicator of movement rather than proof that a rotor was spinning.

Twenty-three days later, the picture had changed again. Additional turbines had been installed, and the visible turbines were broadly orientated at approximately 120°. In an operational wind farm, turbines sharing a similar heading would normally be consistent with a common response to the prevailing wind.

Where turbines lie directly downstream of one another, that same wind direction can also determine which machines are exposed to wake effects, including reduced wind speed and increased turbulence.

Later observations also showed that turbines were not always aligned. In one example, Turbine B was orientated at approximately 22.5°, while Turbines A, C and D were closer to 120°. Turbines A, C and D also displayed noticeable spectral fringing, while Turbine B did not.

These differences do not reveal the exact operational state of each turbine, but they do provide useful clues about what is happening between installation and full commissioning. Before entering normal operation, turbines undergo testing of systems such as yaw control, rotor movement, braking, sensors and communications. During this phase, they may be aligned with the wind, parked, rotated or deliberately held in different positions while individual systems are tested.

Repeat satellite imagery offers an independent way to observe some of these changes from above. When combined with wind conditions, vessel activity, installation history, commissioning records or generation data, these observations could help track the transition from installation through testing and into normal operation.

Offshore wind has reached a point where a single project status can no longer adequately describe what is happening offshore. By combining geographic information system (GIS) data, temporal data and multiple evidence sources, the industry can move beyond static maps and build turbine-level records that preserve construction, operation and intervention throughout an asset's lifecycle.

As projects grow in size and complexity, understanding how infrastructure changes through time will become just as important as knowing where it is located. GIS has long answered the question of where; the next challenge is capturing what happened, when it happened and how the story of each asset unfolded.

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