Tracking in the wind

Extreme wind events are the biggest cause of failure and insurance claims for any PV plant, according to Thorsten Kray, Head of the Building Aerodynamics Department at Institut für Industrieaerodynamik GmbH, Aachen. For structural reasons, single-axis trackers are more prone to the issues than fixed-tilt structures. In this two-part series, pv magazine will examine the ways that wind impacts trackers and what EPCs and investors need to look out for, in addition to outlining a range of approaches from big tracker suppliers that were designed to mitigate wind-related damage.

"It is a fact that wind is the most common cause of damage"

When a massive summer storm or hurricane looms, many people are given pause for thought about their homes' wind resilience. To provide some extra assurance, regional codes like the American Society of Civil Engineers (ASCE) and Eurocode have added chapters that stipulate the gust pressure that buildings need to be able to sustain.

Owners of PV plants are similarly concerned about their assets. The Eurocode and ASCE have long been the go-to standards for the single-axis tracker industry. These codes, however, are not tailored to PV trackers; instead, the pressure coefficient requirements are taken from free-standing roof structures. In Europe, there is currently no ambition for a bespoke tracker chapter in the code, but in the United States, the ASCE update due for 2022 will likely be the first to feature such information. Current building codes — which take gust pressure requirements for mono-sloped free-standing roofs as the basis for tracker requirements — are broadly seen as insufficient. Yet the move to a bespoke code has still not been without controversy.

Array Technologies doesn't rely on active stow, so even when the tracker installation has not been finished, the system can prevent damage.

Photo: Array Technologies Inc.

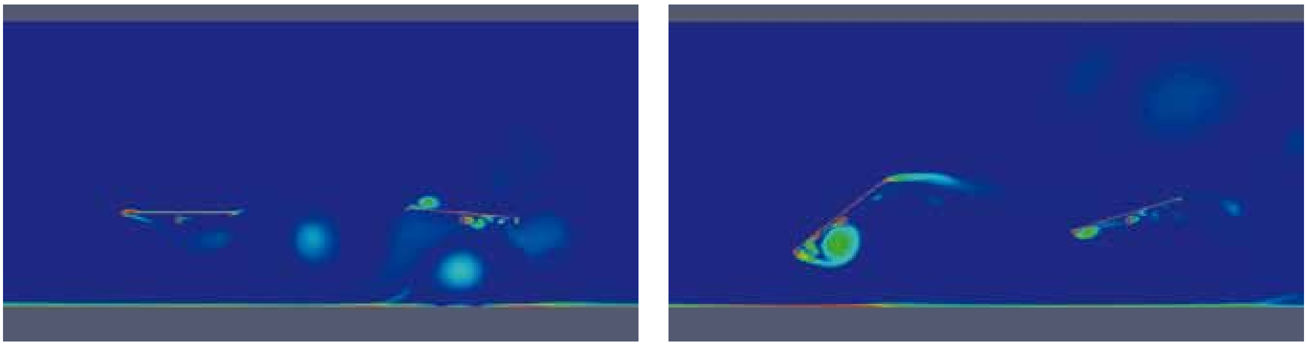
Achilles' heel

"It is a fact that wind is the most common cause of damage for photovoltaics systems in general," says Thorsten Kray, of IFI Aachen. With trackers, the problem is likely even more severe for structural reasons. By design, most trackers mount modules onto purlins, which are bolted only to central torque tubes, which allow the purlins to pivot as the torque facilitates torsional motion. The edges of the purlins and modules do not have additional support in most designs. By contrast, the purlins on fixed-tilt systems are mounted onto posts and rails along the edges of the modules, which makes the structure inherently stiffer.

The lack of stiffness around the edges leads to a range of fallacies about the structural requirements of trackers. Kray points to the difference between static and dynamic wind loads. A static model considers only static pressure, which is fine when the structure is rigid. If the structure can be subject to dynamic vibrations, which are excited by vortex shedding or gust buffeting, the static model omits inertia forces that can be the real culprit.

During heavy wind events, vortices are forming at the leading and trailing edges of the module chord. These vortices shed periodically. When they do so, they leave a low-pressure area at the point where they shed. The process repeats itself, with the vortices building up at the inverted edges of the modules. The solar industry describes this as "torsional galloping."

The instability is self-excited, as with each shedding the module swings to a higher tilt angle. Along the 50-meter table, the effect works to twist and bend the row like a DNA string, applying tremendous force on the posts and torque tube. Failing to factor in these forces could easily mean underestimating the wind load by a factor of two or three, Kray says. The worst case scenario that may occur is so-called "vortex lock-in." The pace of vortex shedding exactly matches the structure's natural frequency. If it does, it will continue to do so, unless wind speeds fall significantly below the wind speed that initiated the instability. If vortex lock-in transitions into tor-



Photos: IFI Aachen

Torsional galloping in a CFD simulation. The vortices push and pull the module row, causing the torque tube to experience torsional motion.

sional galloping, structural collapse of the mounting structures is much more likely to occur.

Silver lining

Following a series of catastrophic damage events to trackers in the field, manufacturers have been forced to react and reconsider the sufficiency of applicable building codes. "In my opinion it was only in the last years that companies have started to approach wind engineering laboratories, to perform wind tunnel testing," said Kray.

Two main approaches have been applied to avoid torsional galloping. In one approach, a manufacturer claims that in a storm event, the modules should be stowed in a horizontal position. The module row then lies in the wind like an airfoil and leaves a reduced surface onto which the forces can push. Because the air can pass the modules like air passes the wing of an aircraft, the pressure on the posts on which the torque tube sits, and the purlin on which the modules lie, is limited. This approach needs additional stiffness to mitigate torsional galloping. Soltec and Nclave are tracker suppliers that use this approach. Wind engineering laboratory RWDI, as commissioned by Soltec, has confirmed that this method works for the Spain-based supplier. In its bankability guidelines for trackers, DNV GL did not categorically rule out the approach, but it did warn that additional damping would probably be required.

The tracker suppliers deploying the second approach have their trackers assume a tilt angle of 30-52°, depending on the company, to avoid the wild excitation of forces when vortices are shed on leading and trailing edges. At a steeper angle, the modules stand more stable in the wind without excitation of upwards and downwards movements. Posts and purlins, however, will be the primary bearers of extreme wind loads. Manufacturers like Array Technologies and Nextracker, for example, claim this high-tilt angle approach makes torsional galloping less likely — a finding back by IFI Aachen and CPP, among other wind engineering labs.

Standards in the wind

Standards are extensively used in the solar industry for various purposes. Ingress protection levels, for example, are used for inverters, cables and modules. The number tells the customer, in a rather straightforward way, the degree to which an inverter, for example, is protected from rain and dust. While failures related to wind are the most common reason for damage to PV systems, people are questioning why there are no standards to sufficiently inform manufacturers, EPCs and project developers alike.

"It would be good to have a wind load standard that takes into account static and dynamic loads specific to single-axis solar trackers in its code," explains Kray.

However, this sentiment is not shared across the industry. Lucas Creasy, VP of Engineering at Array Technologies, for example, says that current standards provide an acceptable, sufficiently informative baseline. He does add, however, that manufacturers have still performed wind tunnel testing, including dynamic loads. The issue for Creasy is that ATI uses the code not only as a baseline, but takes into account a whole big range of other site-specific parameters that cannot feasibly be accounted for in a code. On the other hand, Eduardo de San Nichlás, Product Manager for tracker manufacturer Soltec, says that "codes should consider the structural singularities of the trackers." More details on this issue, including reports from plants that have survived hurricanes, will appear in the August edition of **pv magazine**. pv

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> *"Codes should consider the structural singularities of the tracker"*