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# MITIGATING EXTREME WEATHER RISK

PART 2: Surviving High-Wind Events and Dynamic-Wind Effects  
with Differentiated Solar Project Design and Control Strategies

By Alex Roedel and James Butcher

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**By Alex Roedel and James Butcher**

Solar Support<sup>1</sup>, a specialist in solar asset storm restoration and remediation, reports that wind effects are the root cause of most weather-related damages to utility-scale PV power plants in a typical year. Though wind-related hazards are inevitable, catastrophic project losses are not. Stakeholders can mitigate these perils during project design via strategic product selection and specification.

As a leader in the global energy transition, Nextracker is committed to sharing its expertise and best practices for the benefit of industry stakeholders and strategic business partners. With nearly 50 GW of intelligent solar trackers fielded around the world since 2013, Nextracker is not only the top global tracker supplier for five years running—it is also uniquely qualified to speak to in-field reliability, performance, and risk mitigation.

In Part 1<sup>2</sup> of this two-part white paper, we demonstrated how project stakeholders can address site- and region-specific risk profiles associated with hail, flooding, snow, and extreme sand and soiling, as well as expedite plant restoration in the wake of damaging storms. Here, in Part 2, we provide actionable content that project developers, EPCs, engineers, insurers, and financiers can use to mitigate project risks associated with wind.

Wind-related solar project damages result not only from the high-wind conditions associated with extreme weather events—such as hurricanes, typhoons, and tornadoes—but also from dynamic-wind effects that occur at relatively moderate and frequent wind speeds. This is an important distinction, as projects that are unlikely to experience extreme wind speed may routinely experience moderate wind speeds capable of producing dynamic-wind effects.

Damage associated with low wind speed dynamic effects, in particular, demonstrates that reliable in-field operation over a 25- to 40-year service life is not a coincidence. Solar power plants that appear similar on the surface may have very different wind

**FOUNDATIONAL KNOWLEDGE** To learn how to mitigate project risks associated with hail, flooding, snow, sand and soiling, and plant restoration and remediation, see Part 1 of this two-part white paper.<sup>2</sup>



risk profiles due to differing technological features and capabilities. To mitigate wind-related perils, project stakeholders must understand the factors that account for these very different outcomes under identical weather conditions.

## A TALE OF TWO PROJECTS

In October 2018, a cluster of severe thunderstorms hit the Darling Downs in southeastern Queensland, Australia. The farming region, located on the western slopes of the Great Dividing Range, is notorious for its seasonal severe weather. It is also home to some of the country's largest solar farms. As the afternoon storms moved rapidly to the east, from Darby to Toowoomba, they passed two large-scale solar farms.

First in the storm's path was a 25 MW solar farm, fielded using Nextracker's one-module-in-portrait (1P) NX Horizon single-axis trackers. As the storm front approached, weather stations at the site fed real-time wind speed and direction data to a centralized data aggregation and monitoring platform. At the moment wind gusts exceeded a predetermined and site-specific threshold velocity, tracker controllers initiated a wind stow command. Inside of two minutes, roughly 1,200 Nextracker rows faced west into the approaching

*"At a minimum, owners and insurers need to ask for a simple explanation as to how companies are achieving lower cost without increasing risk."*

—David Banks, president, CPP

storm at a high tilt angle. When the winds died down, the project emerged entirely unscathed.

Directly next door, sheltered downwind and fielded using two-module-in-portrait (2P) single-axis trackers, a 55 MW solar farm suffered catastrophic losses. *pv magazine Australia* described the wreckage at this site<sup>3</sup>: "The piles onto which the trackers are mounted are bent, with modules at 90 degrees to the horizon. Some rows have completely collapsed, with steel puncturing modules, and the whole structure resembling little more than a tangled wreckage. And, perhaps most tellingly, badly damaged rows are twisted in a kind of demented helix." According to in-field data from the adjacent solar farm, wind gusts during the storm topped out at 74 kilometers per hour (46 miles per hour), well below the project's design wind speed.

**TWISTING IN THE WIND** Exploring what broke at a 55 MW solar farm in Queensland in an article<sup>3</sup> for *pv magazine Australia*, Jonathan Gifford describes "tracker rows twisted like denatured strands of DNA." This type of twisting failure mode is often associated with torsional galloping, a dynamic wind effect that can occur at relatively modest wind speeds when a flexible structure resonates at its natural frequency.

Courtesy pv magazine Australia



**Wind Risk Mitigation** Wind-related single-axis solar tracker failures in Australia and elsewhere around the world are vexing for project stakeholders. On the one hand, these tracker-mounted solar projects are generally designed and installed to comply with applicable code-mandated structural design requirements. On the other hand, insurers are seeing a rise in wind-related claims associated with damages that have occurred well below the project's basic design wind speed. These types of premature failures occur when product and project designers fail to adequately address dynamic wind effects.

In order to mitigate the risk of wind-related perils, project stakeholders must evaluate wind load analysis methodology. It is also essential to qualify tracker characteristics and capabilities, while considering module-specific risk factors. Lastly, it is important to address manufacturer-specific risks by working with financially stable companies that demonstrate a commitment to quality and reliability.

### WIND LOAD ANALYSIS METHODOLOGY

Nextracker has long recognized that applying minimum wind-design code standards to solar trackers is inadequate to accurately and reliably characterize these structures. Other industry subject matter experts have come to the same conclusion. According to a paper presented in 2015 at a conference for the Structural Engineers Association of

California<sup>4</sup>, "Structural failures of utility-scale PV plants are rare events, but some failures have been observed in code-compliant structures."

This result is in part due to the fact that it is effectively impossible for codes and standards to move at the speed of technological innovation and market expansion in high-growth sectors such as the solar industry. It is also due to the unique characteristics of a solar tracker structure, which are poorly understood by some designers. "There are no reference structures in the wind codes that look anything like row-upon-row of single-axis trackers in large-scale solar farms," notes David Banks, president at CPP, a leading wind engineering consulting company.

Based on extensive research, engineering, and field experience, Nextracker has developed and implemented best practices for wind testing and analysis. As detailed in a previous Nextracker white paper<sup>5</sup>, our recommended wind load analysis methodology includes: static wind tunnel testing; wake buffeting-based dynamic analysis; single- or multi-row computational fluid dynamics (CFD) analysis; and a full three-dimensional multi-row aeroelastic study. By qualifying tracker structures based on adherence to these best practices—which account for dynamic wind effects, exceed minimum standards, and incorporate peer review—IEs, owners, and financiers can protect investments and mitigate against wind-related losses.

**SUPER-SIZED PV** Technological innovations have enabled module companies—including Longi, JA Solar, Jinko, Trina, and others—to introduce large-format, ultra-high-power modules with capacity ratings in the 500 W to 800 W range. While large-format modules promise some efficiencies of scale, larger chord and row lengths also increase wind loads.



Courtesy Blattner

**Dynamic Wind Effects** If engineers design a single-axis tracker solution based only on static loads, the analysis is not going to account for aeroelastic wind effects that occur in the field due to dynamic wind effects. Most trackers are not breaking down in the field due to static load. Rather, these structures are failing due to the effects of dynamic loads. These dynamic-wind effects include resonant vibration due to buffeting and vortex shedding, as well as torsional galloping or flutter.

Standards published by the American Society of Civil Engineers (ASCE)—or similar organizations elsewhere around the world—characterize a building or structure as *rigid*, as opposed to flexible, if its “fundamental natural frequency is greater than or equal to 1 Hz [Hertz].”<sup>6</sup> In practice, however, tracker structures are not rigid, by and large, but rather are relatively flexible. Trackers move by design, as does the direction and speed of the wind. This means that wind loads and the natural frequencies of the structure are dynamic. Moreover, what happens in one row impacts and potentially amplifies what happens in adjacent rows. As a result, trackers are susceptible to resonant effects and instability.

Low wind speed dynamic effects explain how a tracker designed per code to a static load of 160 kilometers per hour (100 miles per hour) can experience a catastrophic in-field failure at a wind speed of 80 kilometers per hour (50 miles per hour) or even 65 kilometers per hour (40 miles per hour). These premature failures are even more shocking when you consider that wind loads do not scale linearly. Since wind loads scale according to the square of the wind speed, the wind-applied force at 80 kilometers per

“Do owners and insurers really want to invest in a \$1B asset that is engineered only to meet minimum design standards?”

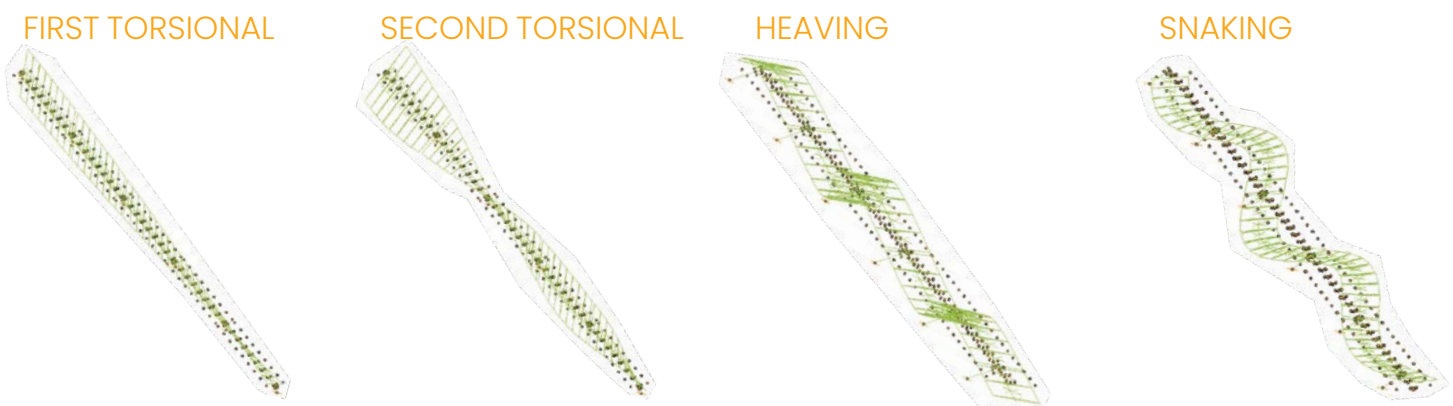
—Jake Morin, owner, Structurology

hour is not one-half that at 160 kilometers per hour but is instead one-quarter of the wind load.

**Beyond-Minimum Standards** When a wind-affected system or structure is resonating according to its natural frequency, the dynamic amplification factor increases in magnitude. A structure resonating due to these dynamic wind effects might be exposed to six times more energy at the same wind speed as compared to a non-resonating structure. Meeting only minimum requirements for static loads will not mitigate against these perils.

“The industry really needs to move away from doing the bare minimum required by code just to get a permit,” says Jake Morin, owner of Structurology, a consulting firm that provides structural engineering peer review services. “Building codes are *minimum* design standards. Do owners and insurers really want to invest in a \$1B asset with a 25- or 30-year service life that is engineered only to meet minimum design standards?”

“Some wind studies, including those for solar trackers, require methods that go beyond conventional, well-documented techniques,” says Banks. “Investigations based on classic bridge instability equations may predict stability while section model tests conducted



**MULTIPLE DYNAMIC EFFECTS** Most in-field tracker failures are the result of shortcomings in wind engineering analyses. Dynamic effects such as torsional resonance, heaving, and snaking can all lead to catastrophic failures if wind loading and dynamic modes are misunderstood.

in a wind tunnel or via computational fluid dynamics reveal torsional galloping or vortex lock-in. In these cases, multi-row aeroelastic studies are necessary to fully characterize the stability boundary.”

Tracker bankability guidelines<sup>7</sup> published by DNV, which has conducted independent engineering (IE) assessments for solar trackers for more than 20 years, note that, “Wind loads on PV tracking systems are not well-addressed by industry standards, nor are they addressed in existing building codes and standards that are generally relied upon by designers. In addition, project-level structural calculations provided by the designer generally address only the interface between the foundation piles and rely solely on the manufacturer’s ratings for all other mounting system components.”

**Peer Review** The industry’s reliance on manufacturer-reported ratings can increase a project’s risk profile. “Manufacturers have to do their own wind load testing and determine coefficients that apply exactly to their structures and use cases,” explains David Banks, president of the wind engineering consulting company CPP. “Companies that build projects and move on benefit from trading an increase in risk for an increase in volume. Owner and insurers, meanwhile, benefit from an accurate risk assessment.”

Properly conducted and validated wind tunnel testing is only the starting point for wind load analysis. To further reduce risk exposure and improve confidence, it is critical that wind load analyses are subject to peer review. Some companies may simply lack the resources to properly evaluate and validate the structural capacity of all major components and assemblies. Other companies may provide results that underestimate wind loads.

It is especially important to demand peer review when qualifying new market entrants and second-tier manufacturers that may lack a complex understanding of wind-related forces and risk profiles. “The fact of the matter is that wind tunnel tests are very difficult to execute properly,” notes Morin. “Once you have the data, it is even more difficult to interpret these results correctly.”

“It is a bit of a red flag if your numbers are lower than everybody else’s,” says Banks. “Unless there is good

*“One of the reasons I like working with Nextracker on wind-load analyses is because it wants the right answers.”*

—David Banks, president, CPP

reason—such as a unique geometry or stow position—there could have been a mistake. The goal of peer review is to catch these mistakes before systems make it into the field. Since it benefits everyone, we welcome peer review of our work.”

The results of peer review speak for themselves. Nextracker clients have installed our NX Horizon Gen 2 single-axis trackers in locations all around the world that are subject to extreme or frequent winds. Many of these systems have experienced high-wind events, including thunderstorms, hurricanes, cyclones, and typhoons. None of the systems have experienced significant failures or damages, even when storm paths crossed directly over Nextracker sites.

## TRACKER DESIGN QUALIFICATION

Divergent field experience illustrates that solar trackers are not interchangeable commodities. In order to mitigate tracker-specific project risks, project stakeholders should analyze and qualify different solutions based on command and control capabilities, tracker architecture, stow angle, and fastener type.

**Command and Control** To prevent damages associated with infrequent high wind speed events, asset managers and plant operators can use NX Navigator, our proprietary solar power plant monitoring and control software platform, to remotely trigger a defensive hurricane or typhoon stow mode. To prevent damages associated with the more frequent dynamic wind effects, NX Navigator uses on-site weather station sensor data to automatically trigger and clear a defensive wind stow mode.

Once a stow mode is initiated, the self-powered, independent-row tracker tables will immediately begin to rotate to the appropriate defensive position. An entire large utility-scale PV power plant can achieve the commanded stow position within one or two minutes. Because the trackers are self-powered using DC power, moving all of the tables in unison does not result in any AC power surges or peak demand charges. (See Part 1<sup>2</sup> for more information on



**STABLE AT FLAT STOW** Nextracker’s 2P NX Gemini tracker—shown here at the National Renewable Energy Laboratory’s (NREL) Flat Irons Campus for wind testing in Boulder, Colorado, U.S.A.—incorporates self-locking linear actuators at each foundation to ensure stability against dynamic wind effects.

Courtesy NREL

NX Navigator and its extreme weather stow and load shed modes.)

**Tracker Architecture** While dynamic wind analyses are complex, some of the physics associated with different tracker design architectures are quite simple. From a wind-loading perspective, for example, trackers with a 1P architecture have an inherent advantage over trackers with a 2P architecture insofar as chord length (see p. 4) has a squared effect on torque. In other words, since 2P designs have twice the chord length of a 1P tracker, the wind loads are 400% larger. These wind-loading effects are amplified under dynamic loading.

As the leading Tier 1 manufacturer of both 1P and 2P single-axis trackers, Nextracker is uniquely qualified to understand and address the wind design challenges associated with 2P tracker architectures. At the most basic level, a stable tracker is a healthy and long-lasting tracker. In order to withstand the additional wind-applied forces, 2P tracker designs require considerably more steel, stronger dampers or actuators, and deeper piles as compared to a 1P design.

**Stow Geometry** Horizontally stowed modules are especially susceptible to dynamic wind loads. During high wind events, vortex shedding can lead to instability, torsional galloping, and torsional divergence. The risks associated with dynamic loading vis-a-vis tracker architecture wind stow geometry are well-illustrated by the divergent field performance, previously described, of two neighboring solar farms in Queensland, Australia.

“In an extreme weather event, you generally do not want to be flat,” explains Banks. “When a tracker is stowed flat, the threshold between stable and unstable is sudden and potentially destructive. The question is not if the flat-stow system will become unstable but rather at what speed it will become unstable. Generally speaking, the instability threshold occurs at relatively moderate wind speeds.”

To ensure tracker stability across many dynamic modes, manufacturers of trackers that stow at 0° need to account for the fact that a flat stow angle increases instability and dynamic factors. As an example, Nextracker’s 2P NX Gemini, which integrates up to four 1,500 VDC strings, uses a flat-stow position for wind defense. To ensure flat-stow stability, NX Gemini uses sturdy structural steel profiles and integrates a self-locking linear actuator at each foundation post.

**Fastener Type** Fasteners are an essential and often overlooked aspect of tracker system reliability and structural integrity. Failure to account for high-cycle fatigue and cyclic loading can have catastrophic consequences. The authors of DNV’s

*“Loosening of connections due to cyclic loading is of special concern, since it leads to greater structural flexibility, enhancing both flutter and divergence problems.”*

—DNV Tracker Bankability Reviews: Guidelines for Stakeholders

bankability guidelines<sup>7</sup> warn that fastener instability can exacerbate tracker instability: “Loosening of connections due to cyclic loading is of special concern, since it leads to greater structural flexibility, enhancing both flutter and divergence problems.”

In order to minimize both preventative and corrective maintenance activities over the life of the system, Nextracker uses highly durable, permanent fasteners that do not loosen over time for module-to-mounting rail and mounting rail-to-torque tube connections. These so-called *swaged* fasteners or lockbolts rely on tension between the components rather than friction. Unlike standard threaded connections, which loosen and must be retorqued over time, machine-set tension fasteners are structurally held in compression and will not vibrate loose. Laboratory testing indicates that the swaged lockbolts are stronger, longer-lasting, and more reliable than a comparable nut-and-bolt type of fastening system.<sup>8</sup>

“These seemingly small mechanical details can have a big impact in the field,” notes Brian Tyluki, senior vice president and senior underwriter at GCube, a renewable energy insurance specialist. “GCube had two projects right next to each other in Puerto Rico that both experienced the same catastrophic hurricane event. One project experienced minimal damage, involving only a few modules. The project next door experienced 100% loss. The major difference between the sites and the racking was the type of module mounting hardware.”

*“One of the things that sets Nextracker apart is that it goes to great lengths to understand the large losses and issues facing insurers.”*

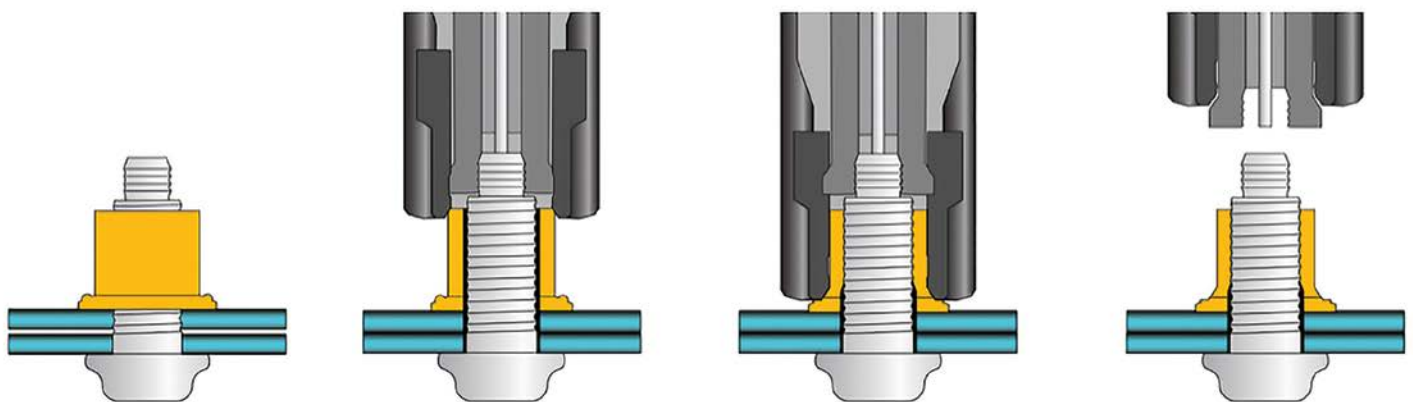
—Brian Tyluki, SVP & senior underwriter, GCube

### MODULE-SPECIFIC RISKS

While solar trackers play a vital role in solar project reliability and financial performance, project stakeholders must also recognize the extent to which PV module qualification and specification will drive investment and insurance risk profiles. Tyluki observes, “The largest losses we’re seeing are related to modules, which may be challenging for racking manufacturers to address.”

PV modules are constantly changing and evolving. Some of these changes are incremental advances, whereas others—such as bifacial or large-format module designs—are potentially disruptive step changes. Only time will tell whether technology changes that look like an improvement today, based on cost or performance, ultimately prove successful and reliable over the long term. When assessing leading-edge PV module technologies and architectures, we recommend that industry stakeholders pay special attention to the risks associated with large-format modules and cell microcracking.

### TYPICAL LOCKBOLT TENSIONING STEPS



**LOCKBOLTS** To prevent fastener loosening and high-cycle fatigue, Nextracker uses lockbolts rather than conventional nuts and bolts. After initially assembling the lockbolt, installers use a powered installation tool that stretches the bolt and crimps the collar over the threads. The resulting connection is permanent and provides a consistent preload and clamp load.



**Large-Format Modules** One of the major trends in today's utility-scale solar projects is a move toward large-format modules.<sup>9</sup> Large-format modules drive down first costs by reducing the number of modules and person-hours on a per-megawatt basis. At the same time, large-format modules increase wind risk. In some applications, this may be an acceptable tradeoff; in others, it may be less palatable to investors.

As module areas and tracker row lengths increase, the wind speeds at which tracker-mounted systems become unstable decrease. Moreover, this trend toward larger windswept areas and longer rows increases the risks associated with dynamic modes. Generally speaking, owners and IEs focus only on mitigating the first dynamic mode, torsional twisting. As module area and tracker row lengths increase, higher-order dynamic modes also come into play.

Though not widely analyzed to date, there is increasing evidence that heaving and snaking failure modes are beginning to occur in some tracker portfolios. These failure modes indicate that some manufacturers do not understand the complex dynamic wind effects associated with flexible structures. Wind speeds around 160 kilometers per hour (100 miles per hour) or lower will excite these second- and third-order harmonic modes in systems fielded with large-format modules. An increase in these types of failures—and a corresponding market correction—may be an inevitable consequence of the widespread adoption of large-format modules.

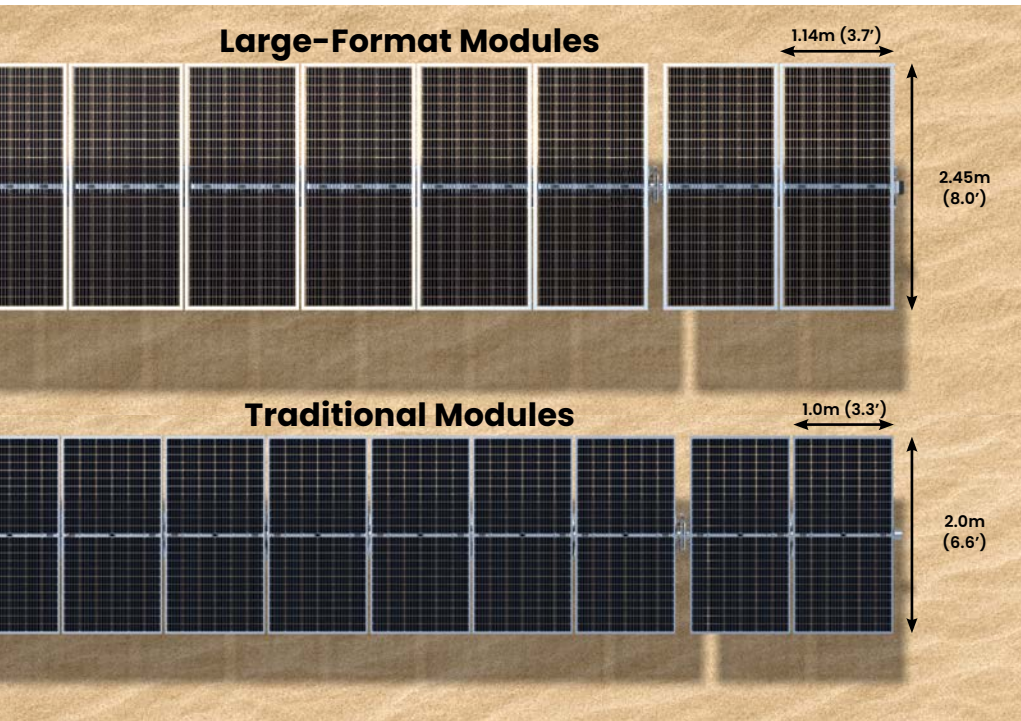
**Microcracking** The trend toward larger module aperture areas is not only coupled with a heightened exposure to dynamic wind effects, but also generally coincides with a trend toward thinner PV glass and thinner module frames. As compared to smaller area counterparts with thicker glass and frames, larger and thinner modules will experience greater wind deflection and cell curvature at the same wind speed. Over time, these coincident trends could lead to a surge in the number of PV modules and systems exhibiting signs of premature power degradation due to cell microcracking.

IEC standards and technical specifications pertaining to flat-plate PV modules—such as IEC 61215 and IEC TS 62782—define static and dynamic load test methods intended to evaluate the effects on non-uniform wind loads. These minimum test requirements are based on a generic set of assumptions that do not necessarily reflect the wind-applied forces in tracker-mounted applications. A sandbag test, for example, bears little resemblance to short and powerful wind gusts. Push-pull tests conducted using computer-controlled actuators with vacuum cups better simulate strong wind effects, but do not account for mounting system-specific dynamic effects, such as flutter, heaving, or snaking.

A larger windswept area is more susceptible to wind-induced forces and dynamic loads; enhanced wind exposure increases deflection in flat-plate modules; excessive deflection leads to cell microcracking; with exposure to environmental heat and humidity

**WIND DEFLECTION** The static and dynamic load tests defined in product qualification and certification standards and technical specifications are not intended to characterize mounting system-specific dynamic effects, such as flutter, heaving, or snaking.





*“Quality does not sell your first system, it determines whether or not you have sold your last one.”*

—Kent Whitfield,  
VP in charge of quality,  
Nextracker

**SHAPE OF THINGS TO COME** While module companies have not settled on standard specifications for large-format modules, Nextracker’s innovative and data-driven single-axis trackers are uniquely positioned to ensure installation quality and reliability regardless of module size and weight.

cycling, widespread cell microcracking can lead to severe performance degradation. This type of technology risk can be difficult for industry stakeholders to assess absent long-term, in-field reliability data. Nextracker’s commitment to long-term reliability is exactly why it is the industry leader in terms of wind engineering investments.

### MANUFACTURER-SPECIFIC RISKS

Part of what makes technology risk so insidious is that it walks hand in hand with company risk. To avoid manufacturer-specific risk, project stakeholders should evaluate original equipment manufacturers (OEMs) based their commitment to quality and business-risk profile.

**Quality-Management Program** Risk mitigation requires robust quality-management programs that not only ensure product quality and manufacturing consistency, but also evaluate the supply chains holistically. In order to effectively manage and mitigate risks, companies must continually identify and prioritize risks, evaluate risk profiles, execute mitigation strategies, and quantify residual risk.

At Nextracker, for example, we have rigorously engineered solar tracking technology, featuring

intelligent software and controls, that is deployed across the largest global tracker fleet. We also have highly qualified vendors, ongoing production monitoring, statistical process control, best-in-class reliability testing, and a corporate commitment to continuous process improvement. Each of these elements is essential to the delivery of a high-performance solution that satisfies customers, complies with stakeholder requirements, and performs reliably over the life of the system.

“One of the reasons I like working with Nextracker on wind-load analyses is because it wants the *right* answers,” says Banks at CPP. “That is not true of every company building solar projects. A lot of companies want to get the lowest possible wind load numbers from a reputable lab in order to win a lot of jobs.”

“Companies that want to stick around need to do their homework,” notes Kent Whitfield, Nextracker’s vice president in charge of quality, who has more than 30 years of experience relating to product manufacturing, certification, and reliability testing. “Companies that are not doing their due diligence to identify wearout mechanisms and quantify risks associated with wind and extreme weather cannot properly account for warranty reserves. These

companies will not be around in the long term. Quality does not sell your first system, it determines whether or not you have sold your last one.”

**Business Risk** When evaluating long-term stability and viability, project stakeholders need to take a step back and think through the profile of a responsible tracker manufacturer. In addition to assessing company size and in-field experience, it is also important to differentiate products based on hardware characteristics, software capabilities, and safety features.

“Too often,” Whitfield warns, “customers come in with one priority, which is the lowest CapEx. Then reality happens and questionable quality results in early field failures, premature wearout, or avoidable weather damage. The reason Nextracker goes the extra mile to ensure product quality and understand business risk exposure is because we recognize the value and importance of making strategic investments to business longevity.”

“On the business side of things,” says GCube’s Tyluki, “solar is a largely an unconsolidated market—in manufacturing, operations, and development—which is challenging in terms of risk assessment. Products are rapidly evolving. Companies come and go. One of the things that sets Nextracker apart is that it goes to great lengths to understand the large losses and issues facing insurers. We value the fact that the company is willing to identify best practices and share that information and subject matter expertise.”

*“Why is every tracker system getting the same insurance rate? You would not give an adult with a safe driving record the same rate as a 17-year-old with a sports car.”*

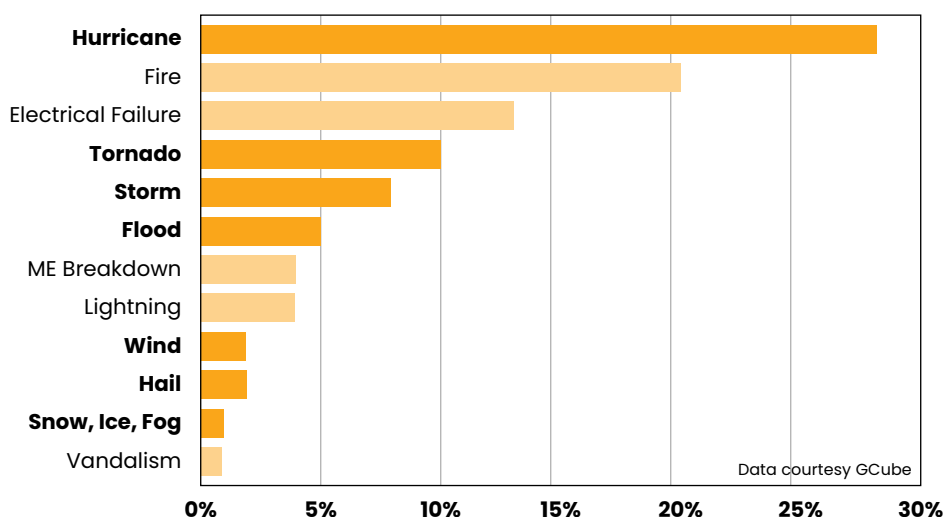
—Dan Shugar, CEO, Nextracker

### INSURING INVESTMENT RETURNS

According to GCube’s insurance market update from June 2020<sup>10</sup>, increasing extreme weather-related losses are threatening the viability of insurers’ books and investment portfolios. While power generation is among the top 10 worst-performing insurance business lines, it is worth noting that catastrophic risk profiles within this sector are not created equally. On the one hand, conventional power plants intensify climate change and contribute to the increasing prevalence of extreme weather events. On the other hand, solar power and other renewable energy assets decarbonize the power system and deescalate climate risks. Moreover, solar projects that appear similar on paper may perform very differently in the field.

“Why is every tracker system getting the same insurance rate?” asks Dan Shugar, CEO of Nextracker. “You would not give an adult with a safe driving record the same rate as a 17-year-old with a sports car. Nextracker has done its due diligence to understand project risk profiles and identify the meaningful and substantive things that we can do to lower that risk. Insurance rates should reflect this reduction in risk exposure.”

### NORTH AMERICAN SOLAR CLAIMS (2012–2017)



**WIND-RELATED CLAIMS** GCube shared North American solar claims data covering a 5-year period as part of NREL’s annual PV Reliability Workshop series.<sup>11</sup> Project stakeholders can mitigate wind-related perils—such as hurricanes, tornadoes, thunderstorms, and windstorms—by strategically specifying trackers with differentiated design features and control capabilities. As detailed in Part 1 of this white paper<sup>2</sup>, these same features and capabilities mitigate project risks associated with hail, flood, and snow.

“Insurers and financiers are a few steps removed from in-field design considerations, such as wind loads and pier depths,” says Banks. “Historically, these industry stakeholders have been happy with a black-and-white compliance-type model. If an IE signs off on a product, that box is checked and it is time to move on. In practice, risk is a continuum. Moving from a pass/fail model to a tiered good/better/best model would be an improvement relative to current practice. An even better approach might be to ask for inputs and uncertainties to a risk model.”

A lot of tracker companies now adhere to Nextracker’s guidance and engage independent third parties to peer review static load analyses. As more of these companies follow our lead by conducting third party peer review of aeroelastic studies, project stakeholders can expect to see a decrease in the number and magnitude of insurance claims.

**Eyes on the Prize** While Nextracker has seen signs of incremental improvement, some improperly designed PV power systems continue to win high-profile projects. The inevitable failures illustrate that there remains a need for education and higher standards within the industry. By aiming for the least expensive system based solely on first costs, many IEs and owners are missing the mark and inadvertently driving up operating costs. Moreover, simply meeting minimum design codes may leave solar projects susceptible to dynamic wind effects.

The least expensive systems over the long term tend to be those designed and deployed properly the first time. “Ultimately, you tend to get what you pay for,” says Tyluki. “I know it is easier said than done, but one way to reduce project risk is to make the CapEx investment required to do it right, first and foremost. That way you are not having to do the work all over again later. Also, whether you are dealing with EPCs or OEMs, work with companies that stand behind their product.”

At the end of the day, a race to the bottom on price may be incompatible with the goal of improving reliability. Prices keep going down, both at the module level and the system level. At the same time, systems are getting larger as are the PV modules themselves. This can create conflicting priorities. Stakeholders want more stable tracker products. They also want to pay lower and lower prices. These twin goals are not always compatible.

“In a very competitive industry,” observes Banks, “a 10% difference in loading can make the difference between who wins and who loses the job—based on the cost of steel or the number of foundation piles. If you are overbuilding projects, you have not been successful. If you are underbuilding, you are increasing risk, catastrophic losses, and driving up insurance premiums. At a minimum, owners, financiers, and insurers need to ask for a simple explanation as to how companies are achieving lower cost without increasing risk.”



## NX NAVIGATOR GRAPHICAL USER INTERFACE (DETAIL)

The screenshot displays two main panels from the NX Navigator interface:

- Tracker State & Controls:** Features a circular wind stow indicator with a green line and a sun icon. It includes a toggle for 'Autotracking' (checked) and 'Manual'. Below are sections for 'Maintenance Controls' (with a snow shed icon and 'Start Now'/'Schedule' buttons), and 'Safety Stows' (with 'Hail Stow' and 'Hurricane/Typhoon Stow' both set to 'Off'). A note at the bottom states: 'Wind Stow enabled at 2:31 PST. Will clear'.
- Equipment Status:** Shows a '99.8%' completion rate for '2,768 Total Trackers' with 'Trackers On Target'. It lists four categories:
 

Available Trackers	2,691	<a href="#">View Map</a>	<a href="#">View List</a>
Faults	74	<a href="#">View Map</a>	<a href="#">View List</a>
Low Battery	3	<a href="#">View Map</a>	<a href="#">View List</a>
Alerts	28	<a href="#">View Map</a>	<a href="#">View List</a>

**RISK CONTROL** In the event of a wind- or weather-related hazard, Nextracker’s intelligent software control system, NX Navigator, will rotate all of the independently driven tracker rows to an appropriate defensive stow position within one or two minutes.

## About the Authors



**Alex Roedel** is the Senior Director of Design and Engineering at NexTracker. With more than 15 years in the solar industry leading design and engineering for Fortune 1000 companies such as SunPower and SPG Solar, Alex is responsible for the design and engineering of more than 40 GWs of installed projects. He leads a global team of design engineers and is the company's customer-facing technical lead with developers and EPCs worldwide. Alex earned his B.S. in mechanical engineering from the University of California, Santa Barbara.



**James Butcher** joined NexTracker's Australian team as a Senior Engineer in 2017. With a background in Geotechnical Engineering, James has extensive experience with geotechnical investigations and foundation design for wind-sensitive structures in utility-scale solar applications. This experience dates from 2010 and includes working on some of the first utility-scale solar farms and solar tracker projects in Australia. James earned his Bachelor's in civil engineering from the University of Sydney and a Master's in engineering management from the University of Technology, Sydney.

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