Make Sun Shine on Your Solar Array - Be Safe, Sure, Satisfied

Lower solar Feed in Tariffs has required developers to look at cost effective solutions to meet project IRR requirements. Trackers are increasingly being preferred by many IPPs, as good trackers are the only Bankable way to meet the IRR target. Decision to be made is which Tracker technology is suitable in terms of cost but at same time, will last for 25 years. Simply compromising on the structure integrity to arrive at lower cost is not prudent.

Scorpius Trackers Private Limited (SCORPIUS), based Pune India, is a pioneer provider of robust, intelligent, and trustworthy solar tracking array designs, systems and equipment's. With ground breaking relentless tracking innovation, design research and stringent testing, we at SCORPIUS bring you the quality excellence in solar array tracking equipment and design, which you and your investor can trust.

Design Philosophy: Play with Wind

At Scorpius Trackers, we evolved the array design incorporating length and breadth of behavior of wind, its turbulent nature, effect on solar arrays and aftereffects on subsequent array rows.

The dynamic nature of trackers necessitates the study to inculcate the actual effect of such ground based moving PV panels mounted on module mounting systems (MMS). The wind for bigger structures varies in nature as against the multiple multiline arrays of solar plants. Various national and international codes and standards refer to canopies which are much stiffer and heavier as compared to solar panels in the field. Varying sources clearly point out the necessity to investigate the nature of such off-normal non-standard structures to be specifically studied for their behavior under wind effects.

SCORPIUS, knowing the importance of this, took help from a well-established Wind Tunnel Test facility in the US, for its expertise in area of boundary layer wind tunnel testing. The boundary layer wind tunnel also has a large length where obstructions of appropriate roughness are added to create the turbulence expected for a particular exposure category to reach the test area. This differs from aerospace wind tunnels where the speed of the air flow is more or less uniform across the cross section of the wind tunnel. Boundary Layer facilities and testing is very time consuming and costly, and is not commercially available in many countries.

Wind Tunnel: Don't be Blown

SCORPIUS design incorporates the static and dynamic nature of wind on its solar arrays. From wind tunnel studies, the effect of wind turbulence was quantified in the real sense. This differs from many existing national and international codes. It is evident from wind tunnel study by SCORPIUS, that in a typical tracker block, the extreme edges facing wind or where there are sufficient gaps available in arrays and adjoining blocks, the wind is far more aggressive and uproots the peripheral areas.

Whereas it was also evident from the study, that for internal rows of arrays at specific distances from the periphery of wind exposures, the panels and MMS experience much lower wind effects than those estimated from existing code or standard provisions. It would be in interest of everyone to note that various national and international standards have clearly noted requirements and importance of such wind tunnel studies for special structures.

Figure 1: SCORPIUS Scaled model of typical solar arrays in boundary layer wind tunnel (©SCORPIUS)

Interesting Facts Uncovered by Wind Tunnel Studies

Twisting: Over the length of single row array it was noted that wind does not impart a uniform flow pattern and consequently uniform loading on single row is a very common misunderstanding. Referring any national or international code provisions, it would be un-realistic to model the forces on MMS as same uniform line loads and corresponding turning-twisting effects. The wind effect on MMS is similar to sketch in Figure 2.

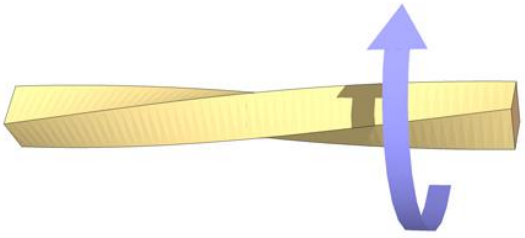

Figure 2: General Uniform Twisting

At SCORPIUS we incorporate these non-uniform twisting moments on structure at places designated by wind tunnel study. This gives the model more stability against ferocious wind torque. These correlated torques caused by wind are accumulated at center of the row of MMS at the drive line.

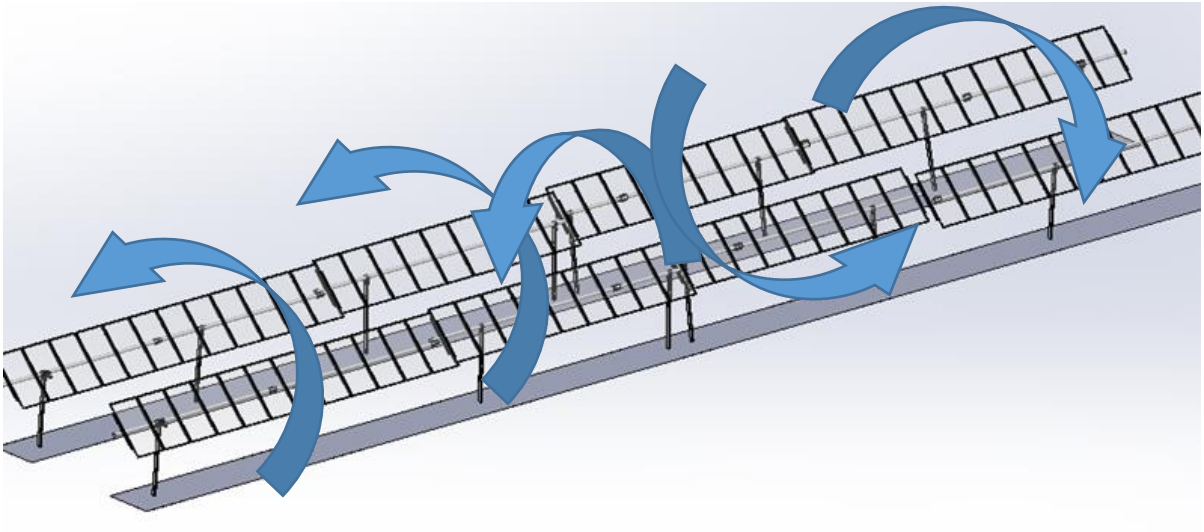

Figure 3: Schematic Representation of Uneven Twisting Torque on Line of Arrays

What renowned pioneers in national and international standard establisher's say:

"The response of a building to high wind pressures depends not only upon the geographical location and proximity of other obstructions to airflow but also upon the characteristics of the structure itself. The dynamic characteristics of a flexible structure defined by its time period of vibration and damping would affect its response to the gustiness or turbulence in wind, which itself gets modified due to presence of other structures/ obstructions, particularly those in the close vicinity of the structure. The effect of the latter is difficult to evaluate."

The above statement is a perfect example giving necessity of wind tunnel tests for solar array plants. SCORPIUS took the adept step to incorporate wind tunnel test into its design, which results in safe, sound and realistic design withstanding wind's ferocity.

Flexing / Heaving: The fundamental weakness of solar arrays against winds with higher velocity is flexing of structure due to its nature, geometrical arrangement, weight, etc., resulting in horizontal, vertical and heaving deformation. Some tracker companies assume that the wind load on the structure decreases the further you go into the array. This is not necessarily true as the turbulent nature of the wind during periods of high wind speeds causes higher loads on some parts of the tracker in the interior which are dependent on their vibration modes and damping ratio.

Aerodynamic flutter: Though with static designs complying the codes and standards are theoretically and functionally sound, there is much more the solar array has to undergo. One of the most critical code requirements is that "cumulative effect of undamped rhythmic forces" produce "intense resonant oscillation." In other words, the structures' lightness, combined with an accumulation of wind pressure, causes huge stress mechanisms, to which static design fails.

Although the static air loads on the array are always less than its structural strength, once the array begins to twist and bend in a periodic manner, under certain conditions the dynamic air loads may begin feeding the elastic motion of structure, causing its amplitude to grow, which in turn causes increased air loads that eventually exceed the structural strength. Such a catastrophic dynamic coupling between the elastic motion and the unsteady aerodynamic loading is called "flutter".

Calculating wind deflection on solar trackers is one of the most challenging computations and falls under Fluid Structure Interaction in computational fluid dynamics. Needless to say that the person using this approach has to know what he is doing! But having done all this, it is still necessary to cross check results in a boundary layer wind tunnel.

If this analysis is not performed and if the tracker does not have a torsion mitigation system, you will observe wild oscillations, resulting into quick failure of the central torque tube during high wind events that often accompany thunderstorms.

This is the area where most of the designs being quoted in the market are lacking.

Scorpius Trackers Strong Fundamentals

Another area of importance are foundations. No matter how strong the structure is, should those loads not get transferred to earth, the huge investment is at stake. SCORPIUS's design methodology ensure that due care is taken to place the proper foundations of requisite strength at all vulnerable areas of wind aggressiveness and danger to arrays getting blown off or damaged is negligible. This gives us edge over other solution providers. As known to all, and through many failure cases, foundations if improperly designed and placed, do not suffice the structural strength of superstructure causing irreversible damage to structure resulting in overturned arrays. Driving some tent pegs-alike into the ground to hold down the mounting structure with/without a bucket of concrete will not last for five minutes in strong wind.

SCORPIUS has devised and tested (on and off site) ways to dampen the aerodynamic flutter resulting in rugged installations. Our dampers play a major role in avoiding the structure's entry into uncontrolled oscillatory mode. Placements of well thought and engineered dampers play important role in saving structure and owners' investment against treacherous nature and effect of wind gusts.

Torsional stiffness and torsional damping with proper stow angle are the only defenses against aerodynamic flutter. SCORPIUS has taken a lot of efforts to improve the damping characteristics of the structure to ensure that structures stay safe in the field.

SCORPIUS has taken due care in its robust design to guard against catastrophic damage to structure of arrays in adverse wind conditions. Though this may result in slightly heavier structures, it is better to be safe than sorry!

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Passionate about structural engineering, Aniruddha leads the design department at Scorpius Trackers. He has a decade of structural engineering professional experience in varying areas of structures like airport cargo, ancillary buildings and structures, telecommunication towers, cold formed steel and many more. He has a drive towards quality, *poka-yoke* and is a certified lead auditor IS 9001:2015 and a Six Sigma Black Belt. With masters in Structural engineering and verification and validation experience in structural deliverables, he has exposure to Indian, American and British standards and codes.

Aniruddha has previously worked spent more than 10 plus years at L&T and Black &Veatch. Aniruddha has also taught civil engineering students at Cusrow Wadia Institute of Technology and has a zeal to keep up sound engineering ethics and promoting good quality habits.