Increasing energy yield in challenging terrain and high wind scenarios

Single axis trackers enhance solar energy yield by following the sun, even in challenging environments. Progressive wind stow and terrain optimized backtracking strategies significantly reduce energy loss, improving performance in high winds and uneven terrains.

With the proliferation of solar power plants worldwide, single axis trackers are proving an invaluable resource. Rotating solar panels throughout the day to follow the sun increases energy yield, providing more consistent energy output. These solar trackers are increasingly installed in challenging environmental and topographical areas. Projects are now being installed in hurricane prone areas with high windspeeds and sites with steep, quickly changing slopes, like mountainsides.

The need for structural solutions to these complicating factors is currently being addressed through increased damping for wind, improved hail mitigation, and flexible table designs for terrain, among others. However, the impact on power production over a project's lifetime is less accurately estimated and understood. Developing and accurately modeling tracking algorithms for challenging terrain and wind stow strategies is critical to the continued adoption of single axis trackers.

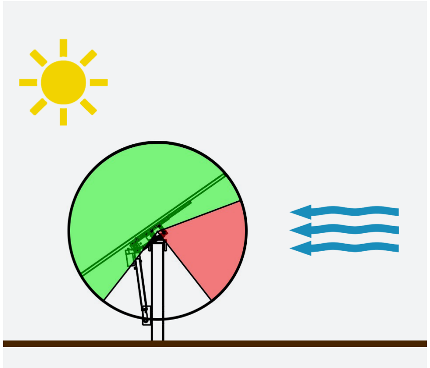
What is a progressive wind stow strategy?

During wind events like thunderstorms or hurricanes, single axis trackers will turn to a specific safe angle where they are strongest to withstand the increased loading. Most common across single axis trackers are binary wind stow strategies, where the tracker tables turn to this defensive stow angle once windspeeds above a certain level are measured.

These strategies can help a tracker system protect the PV modules they support from wind damage, but result in energy generation losses when the tables turn away from the sun to their stow angle.

On the other hand, progressive wind stow strategies allow a tracker table to continue to follow the sun far longer than a binary strategy, resulting in decreased generation losses. Instead of having a single threshold at which tables turn to their stow angle, a series of thresholds are used, where each increasing threshold further restricts the allowable window of tracking angles for a table.

For wind speed events above the threshold, where a binary strategy would send tables to stow, a progressive strategy could keep tables tracking the sun or at as close an angle as possible that falls within the allowable window at that wind speed.



As wind speed increases, the tracking window (green) is decreased, but the table can still follow the sun

A progressive wind stow strategy is more complex, so thorough testing and modeling of a tracker system's performance under wind loading must be performed and used in the strategy's development. This testing must accurately show the windspeeds and angles at which the tracker system will go aeroelastically unstable: where wind vortices are amplified by the tables fluttering back and forth, causing system damage.

Aeroelastic tests are typically performed in a wind tunnel where scale models of the trackers are subjected to wind pressures at varying angles and directions. The wind tunnel testing is critical to accurately calibrating the windspeed thresholds and allowable tracking windows to ensure system safety.

Wind tunnel testing of scale tracker models to determine aeroelastic performance

Progressive wind stow strategies produce more energy

The reduction in power losses through the implementation of progressive stow strategies can be evaluated using wind and energy production data from real world sites. To verify the advantages over other binary strategies, the progressive stow strategy was compared against two baseline strategies commonly used in the industry.

Both baseline strategies turn the tracker tables to a stow angle at a trigger windspeed.

The first strategy sends the tables to 45 degrees, whereas the second sends the tables to zero degrees or flat.

For two sites with varying wind conditions, one in Southeast California and the other in Maryland, the modeled progressive stow strategy increased gains up to 3.15% compared to the baseline strategies. Full results are shown in the table below.

Location	Progressive vs 45 Degree Stow	Progressive vs Flat Stow
Site 1	3.00%	2.66%
Site 2	3.15%	0.73%

Yearly estimated energy gains for a progressive stow strategy

What is terrain optimized backtracking?

Backtracking allows tracker tables to avoid shading their neighboring tables to the east and west when the sun's angle is low, during mornings and evenings. This is achieved by rotating all tables on a site to shallower tilt angles at the beginning and end of days, thus decreasing the shadow each table casts behind it. Backtracking is especially critical when using silicon cell modules because any sliver of shadow obstructing just one cell will result in a dramatic loss of production for the full solar panel.

As solar tracker tables are increasingly installed on extreme slopes or rolling hills, avoiding shading becomes more complicated. If these tables are not all level with each other, tables higher than their neighbors will cast a larger shadow and vice versa.

To avoid energy loss due to shading, backtracking algorithms must account for height variations in tables across a site. With this optimized backtracking accounting for terrain, each table height is modeled to its surroundings and receives an individualized backtracking algorithm based on this.

Terrain optimized backtracking produces more energy

Optimized backtracking gains can also be verified through energy modeling and site inverter data. A base model with table shading due to height differences was generated for the same two sites used to analyze wind stow strategy gains. The energy generation from this model was compared to that of one with no table shading. This comparison highlights the potential minimized energy losses from an optimized backtracking algorithm.

For Site 1, these modeled gains were verified by comparing real world inverter data across two time periods: one with optimized backtracking enabled and one with it disabled.

Modeled and real world gains are shown in the table below.

Location	Yearly Modeled Backtracking	Real-World Backtracking
Site 1	2.34%	7.10%
Site 2	5.49%	-

Yearly modeled gains and real world gains over two months for an optimized backtracking strategy

Note that the real world energy gains are higher than the modeled gains due to the differing periods of study and the limitations of the modeling software used to incorporate individual table tracking strategies.

Impacts on future projects

Both progressive wind stow strategies and terrain optimized backtracking are powerful tools for increasing power generation while working in challenging environments.

These factors and analyses further highlight the need to keep energy generation in mind as solar trackers move into increasingly challenging environments. We must develop and accurately model tools like progressive wind stow strategies and terrain optimized backtracking to ensure the continued performance of solar trackers in the future.

www.gamechangesolar.com

About Nat Healy

Nat Healy is the Product Manager for GameChange Solar, a global leader in single axis trackers and fixed tilt structures for utility scale solar farms. Starting as a Structural Engineer, he oversaw the design, installation, and commissioning of over 4 GW of solar racking and trackers across six continents.

In his role as Product Manager, he works directly with the Business Development, Research & Development, and Engineering staff to facilitate collaboration and promote continued learning on products and industry trends.

Nat is passionate about education, leading internal and external workshops to both train and learn directly from clients, field installers, and internal teams around the world.

He received his B.A. in Engineering Sciences and B.Eng. in Mechanical Engineering from Dartmouth College's Thayer School of Engineering.