3D Backtracking®
Proprietary algorithm to boost production avoiding shades

suntrack

The global solar PV market keeps its rapid growth and single-axis trackers are no exception

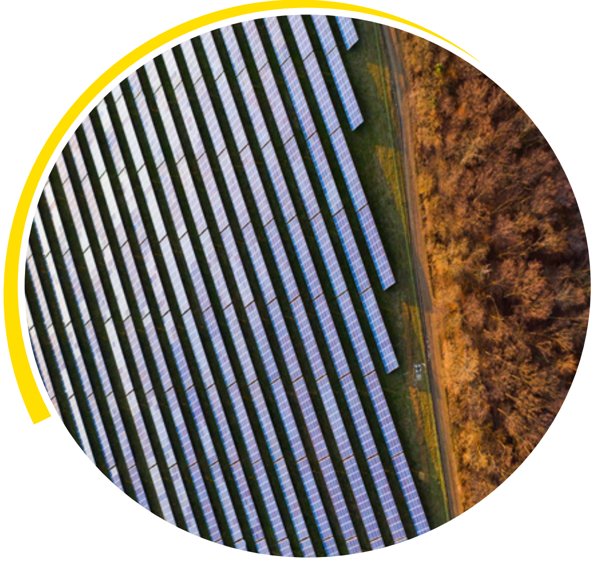
However, massive growth in tracker adoption brings new challenges to the table, like performance in irregular terrains, intelligent weather defense mechanisms and remote monitoring.

The primitive tracking systems have been gradually replaced by more intelligent and sophisticated technologies, always targeting the same goal: decreasing the LCOE of PV plants.

Suntrack's mission has been aligned with that purpose since day one. We were pioneers in the early days, when 2-axis trackers and AC motors were the norm industry-wide, and we are leaders now, when technologies like Big Data and AI are reimagining what is possible in the industry.

As always, our objective remains intact: helping our customers deliver the best tracker possible.

The problem: PV Panel Shading



Even though single-axis trackers are the best option for **maximizing power generation of large solar projects**, serious challenges arise, panel shading being one of them.

The most common method to combat inter-row shading is using backtracking algorithms. These types of algorithms calculate the optimal angle of each tracker to avoid shading, taking into account variables like the position of the sun, date, pitch, tracker height and terrain slope.

For many years, conventional backtracking has been enough to satisfy the demands of the market. Topographies were mostly even and regular, with no steep hills or depressions. Thus, conventional backtracking models and manual 'fine tuning' was the most effective way of avoiding shading.

As flat project sites began to run out, some changes were needed to keep shading at a minimum. Introducing constant slopes for tracker groups was the common approach of the industry, while manually adjusting parameters to get that extra production. Nevertheless, another step forward needs to be taken, to maximize production even in the most challenging terrains.

Suntrack by P4Q, as the largest independent vendor of tracker control systems, has developed a revolutionary backtracking algorithm that boosts production even in the most irregular topographies, **3D Backtracking®**.

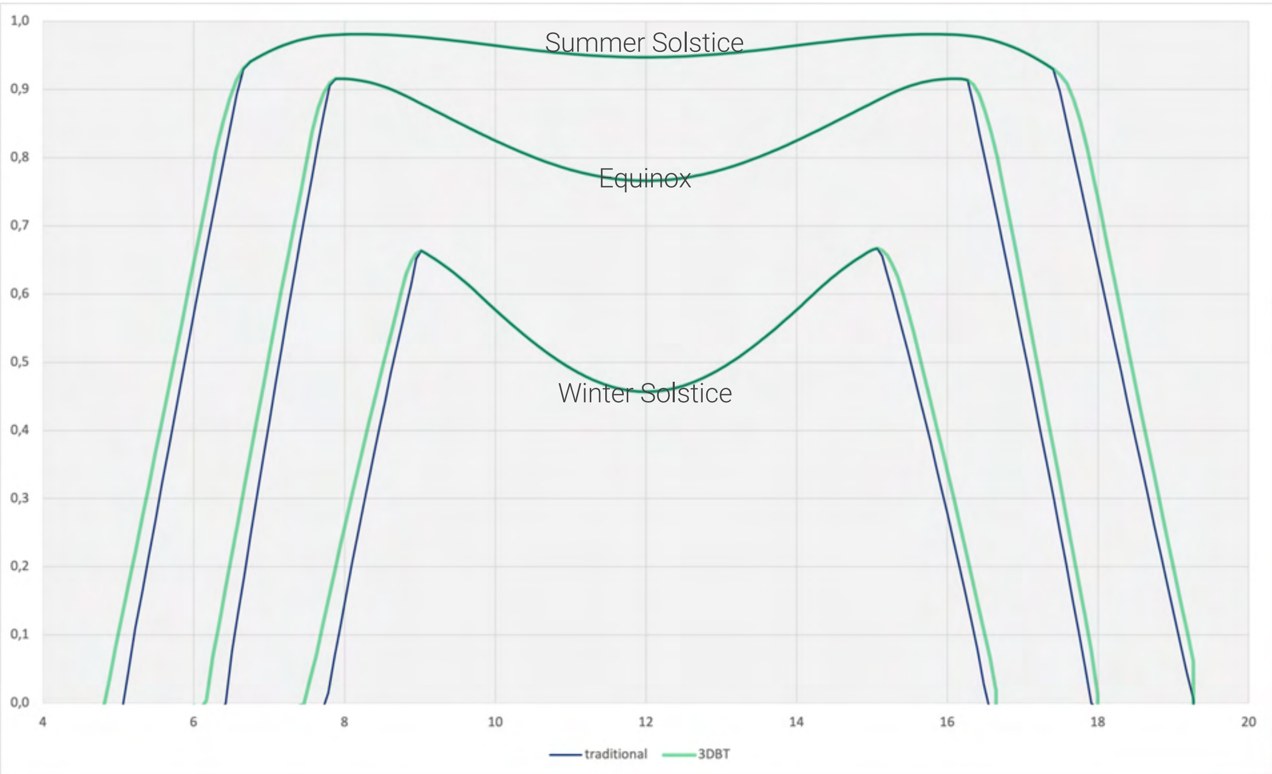
3D Backtracking® increases capture surface up to 5.93%

While other approaches in new solar tracking algorithms use machine learning models for topography characterisation, or rely on continuous target position updates sent by a centralised controller, at Suntrack we believe that the most efficient solution to avoid shading is solving a geometrical problem. That is why our **3D Backtracking®** is based on advanced polygonal analysis.

Based on the topographic analysis of the site, an optimization is performed that requires significant computational capacity, resulting in the generation of angle transformation tables. In consequence, the TCU can calculate locally the optimal target through simple operations.

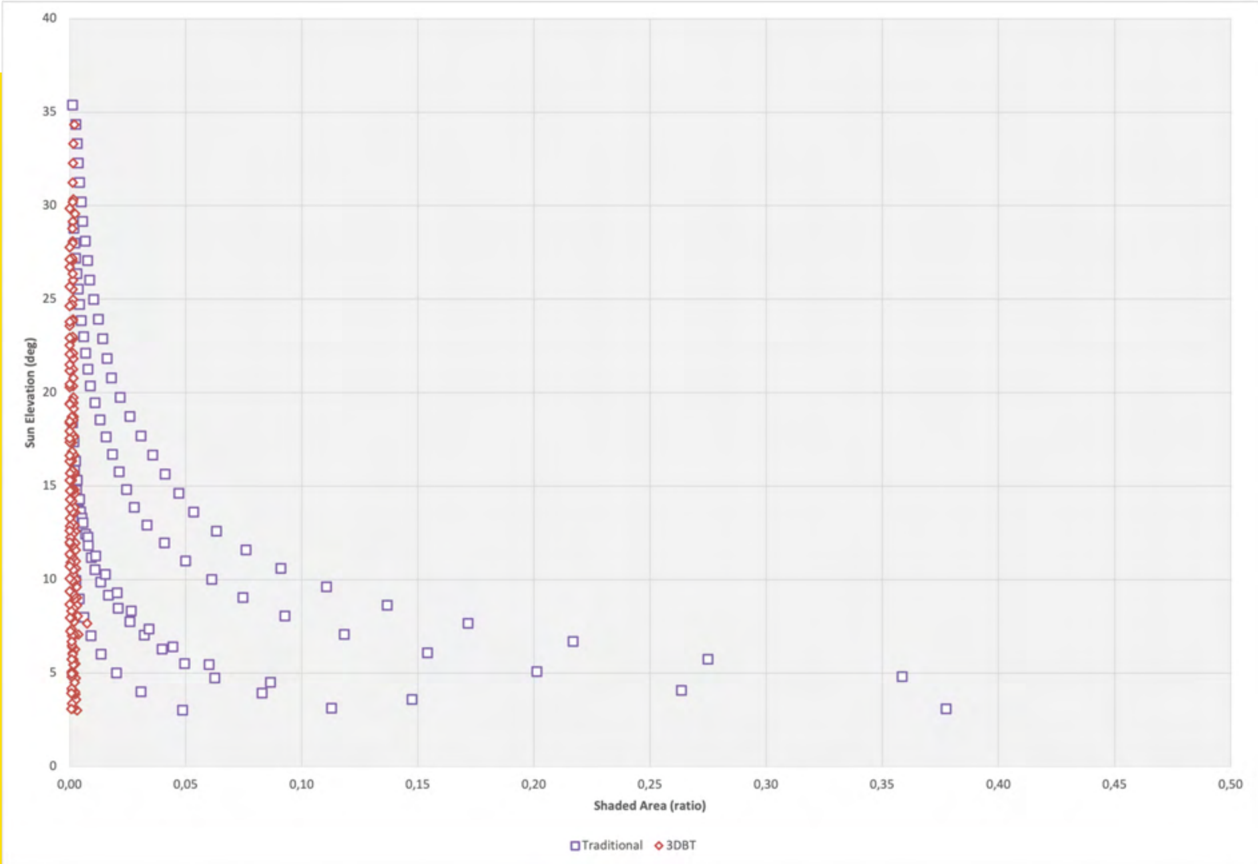
Thanks to this approach, we can ensure that the theoretical production gains will be really similar to actual gains, since there won´t be any altering factor such as communication losses, for example.

Since the development of the 3D Backtracking® algorithm, the goal at Suntrack has been to verify the gains in surface capture area in real projects. The chart below shows a 3.4% capture area gain for a project in Spain with slopes lower than 3%.



3D Backtracking® increases capture surface up to 5.93%

The project, whose name can´t be disclosed due to confidentiality reasons, suffers from abundant shading caused by irregular slopes throughout the site. Apart from capture surface gain, this algorithm can mathematically prove the scale at which shading is avoided, as shown in the scatter plot below:



The red points represent the ratio of shaded area against the sun´s elevation using a traditional backtracking algorithm. The more red points along the x axis, the more panels that are shaded.

However, observing green points, which account for the 3D Backtracking® algorithm, all of them are concentrated at the 0.00% shaded area. This means that even with low sun elevations, the algorithm is capable of reducing the shading of the panels to practically zero.

3D Backtracking® Performance Benefit. Terrain Variation (East-West)

LOW UNDULATION (3% SLOPE)	MODERATE UNDULATION (4.5% SLOPE)	HIGH UNDULATION (6% SLOPE)
2.76%	3.70%	5.93%

3D Backtracking® ensures a robust and flexible implementation

At Suntrack by P4Q we have been working with the main players in the global tracker market since the beginning and we acknowledge the different tracker solutions that each client has. From single-row trackers to dual row and multi-segment trackers, the 3D Backtracking algorithm is designed to work with any tracker configuration.

Furthermore, the system is designed to work with outputs that are often used when developing solar projects. These are the inputs needed to apply the algorithm:

- X, Y and Z coordinates of the edges of each segment
- Table width
- Axis offset
- Rotation axis

Once the inputs are given, the optimization process is carried out, which basically consist of reaching the maximum effective capture area.

This process is not based on ray tracing, but by means of polygonal analysis from the direction of incidence of solar radiation, giving rise to areas of capture and obstruction.

“The method is highly efficient and does not require a high calculation capacity for its execution”

To take into account the effect of the electric shading, a degradation factor is applied to the obstruction areas, and the result is subtracted from the capture areas, resulting in an effective capture area for the whole solar site.

The algorithm also incorporates a safety margin, which allows for uncertainties in the measurements, dead bands of movement, twisting of the trackers, etc.

The main objective of the optimization is to maximize the effective capture area, and secondarily, to minimize the dispersion of angles between the trackers. This is done to achieve a more balanced production between the trackers, and to avoid anomalous situations with very disparate pointing.

Embedded in each TCU

One of the key aspects of the 3D Backtracking®, apart from boosting production gain in irregular terrains, is that it runs locally, embedded in each TCU.

Other approaches to avoid shading are based on external systems which broadcast the optimal position for each tracker every few minutes. This approach faces several risks of implementation:

- Communication losses
- Additional hardware / software
- Safety and data integrity

Suntrack´s algorithm only requires data processing before the project is delivered. Once the processing is completed, each TCU will function independently, with no need to be commanded by an external entity.

The TCUs will function with only a few dozen registers, so memory requirements are kept to a minimum. Those registers are used by the TCU to continuously calculate the optimum angle thanks to a transfer function designed to execute fast and efficiently.

Compatible with Suntrack´s portfolio

The 3D Backtracking® algorithm is compatible with TCU 2020 version developed by Suntrack. No matter the TCU 2020 version, whether it is self-powered, AC-powered or string-powered, the algorithm will boost production for your solar project.

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