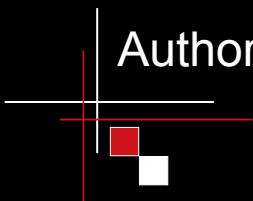




# Market Survey

## Solar Trackers 2021

Authors: Dr. Olga Papathanasiou, Michael Schmela







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TaiyangNews Market Survey Solar Trackers 2021

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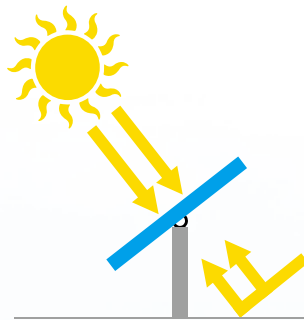
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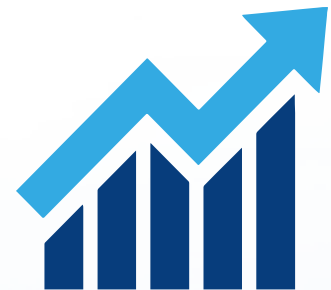
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# Executive Summary

TaiyangNews 1st Solar Market Survey on Solar Trackers includes 36 tracker products from 19 companies, including all market leaders from three continents - Asia, Europe and America.

Our survey looks into the tracker topic at a time, the technology has reached a share of over 30% of the utility market, from basically nil only a handful of years ago, and is forecasted to further increase its stake over the coming years.

The attractiveness of trackers comes from its ability to increase a solar power plant's yield while reducing cost, primarily in sunny regions and locations with little space constraint. The winning streak of bifacial solar modules with its advantage to generate power on both sides provides another argument for solar trackers.

In Chapter 2, we explain the basics of trackers in detail. A typical tracking system includes the mount structure, drives, block- mechanisms, tracking algorithm, alarms and optionally high-level supervisory control and data acquisition (SCADA) system. Today's PV power plants opting for trackers mostly implement horizontal single-axis tracking (HSAT) systems. These consist of a module mount structure that drives the solar modules on a trajectory relative to the sun's path position using a single pivot point for the rotation process. Solar modules can be either assembled in portrait (P) or landscape (H) configuration and in different numbers of rows. There are also dual-axis trackers (DAT), that have both a horizontal and vertical axis, enabling higher yield but at higher cost, resulting in a miniscule market share. Only two companies in our survey offer DAT products.

With the advent and rapid expansion of bifacial solar modules, tracker suppliers have redesigned their latest systems to increase the gain from the rear side of the bifacial modules. In response to bifacial solar, most tracker manufacturers now offer taller tracking

structures in 2P configurations with a big gap over torque tube and clamp mounting to avoid shading of the back side of the modules.

As wind induced dynamic failures have become prevalent and highly visible in recent years, tracker manufacturers have been developing strategies and add-on products such as smart alarms, intelligent wind stowing control algorithms and proprietary locking mechanisms to mitigate weather risks.

The mount structures of HSAT trackers have similar estimated lifetimes as PV modules. Most relevant standards for solar trackers IEC 62817, UL 3703 and UL 2703 include several test procedures regarding tracker design and safety. All trackers in our survey are certified according to at least one of these three standards, most comply with two, and 15 products are even certified for all three.

As none of these international standards includes dynamic aeroelastic tests that could give confidence for real-life conditions under extreme winds in the field, the leading tracker manufacturers have been investing heavily in wind-tunnel dynamic load experiments and studies on the performance of their products. Such testing has been also necessary to adapt their products to the latest bifacial and large-form-factor module designs.

In Chapter 3, we provide brief summaries of the different products in our survey that are also listed with their most relevant data in the product specification tables on p. 46.

This market survey also includes on p. 42 an interview with Kevin Shu from TrinaTracker, a division of TrinaSolar, one of the world's largest solar module manufacturers and the only one operating its own solar tracker manufacturing unit.

## Enjoy reading our Market Survey on Solar Trackers 2021



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# 1. Introduction

Boosting the energy yield of a PV power plant is the key factor to reduce the levelized cost of energy (LCOE) and further increase solar's attractiveness to investors. A 'handy' tool to enable cost reduction for utility-scale solar power generation in many locations are solar trackers, which follow the sun path to increase the intercepted irradiation and maximize solar generated energy production. Such systems can be designed in two different main configurations based on the tracker's degrees of freedom, one-axis and two-axis systems. Single-axis trackers have one degree of freedom, while dual-axis trackers (DAT) have two degrees of freedom, as the names indicate. Today's utility-scale PV plants implement almost exclusively single-axis devices. Although there are different types of tracking systems, horizontal-single axis-trackers (HSAT) are the state of the art solution.

According to an Expert Market Research (EMR) report from March 2021, the global solar PV tracker market was estimated at 27 GW in 2020 and is expected to grow at a CAGR of 30% in the period of 2020 to 2026. Another report from Global Market Insights released in the same month estimates the revenue pool for Solar Trackers to increase from \$3 billion in 2020 to \$4.5 billion in 2027.

VDMA's 11<sup>th</sup> International Technology Roadmap for Photovoltaic (ITRPV) sees the market share for

tracking systems in utility-scale PV plants at 30% in 2019 and expects a 10%-point increase to the 40% mark in 2030 with HSAT to remain the dominant technology. The market share of DATs is expected to remain static at a minor level of 1%.

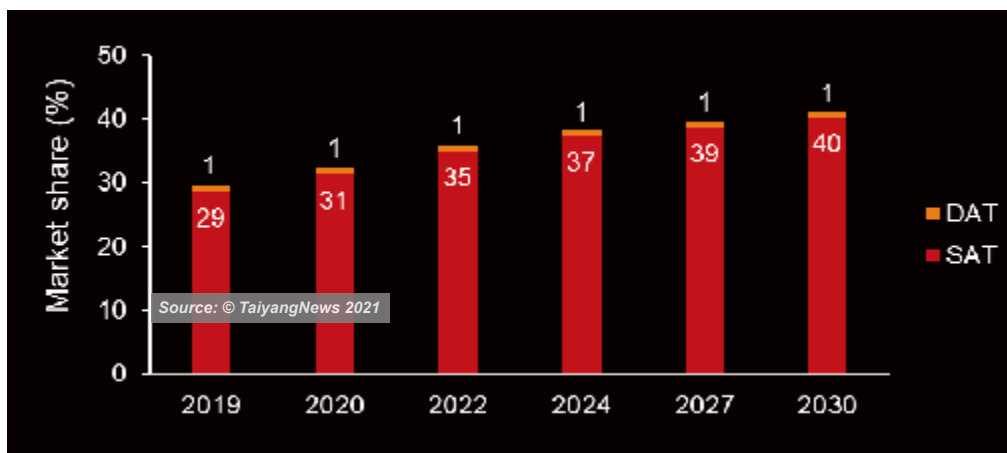
While the number of tracking systems and the technology's market share has been quickly increasing over the last few years, and are supposed to continue its growth path, cost pressure and the dramatic changes in module design have been posing challenges to both tracker manufacturers as well as its customers.

Our first TaiyangNews market survey on solar trackers strives to provide an introduction into tracker technology in general, an overview on the different tracker solutions and insights into the different models and components of tracking systems offered by leading suppliers across the globe including technical specs for the latest products.

## 1.1 Survey participants

The survey features 36 solar tracker products from 19 companies, including all market leaders from three continents - Asia, Europe and America (see table, [p. 9](#)).

### Global Market Share of Single- & Dual-Axis Trackers - ITRPV



**Singles preferred:** As the global share of solar tracker technology in utility-scale is expected to increase by 11% points between 2019 and 2030, this segment will continue to be completely dominated by single axis trackers, according to the International Roadmap for Photovoltaic (ITRPV) 2020.




# Solar Trackers

How to Follow The Sun Optimally to Maximize Yield of Utility-Scale PV Systems

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13:00 – 13:05 |

**WELCOME**

Michael Schmela  
Managing Director,  
TaiyangNews



13:05 – 13:30 | **Solar Trackers – TaiyangNews Report Launch**

Dr. Olga Papathanasiou  
PV Technology Expert,  
TaiyangNews

## 13:30 – 17:00 Presentations



13:30 – 14:00 | **Tracker Bankability Review – How to mitigate investment risk in tracker technology**  
César Hidalgo López  
Principal Engineer,  
DNV



14:00 – 14:30 | **Experience with trackers from a globally active solar developer**  
Christoph Reiners  
Product Manager,  
BayWa r.e.



14:30 – 15:00 | **Evaluation of tracker technology in the Northern Hemisphere**  
Jan Vedde  
Senior Project Manager,  
European Energy A/S



15:00 – 15:30 | **From solar modules to trackers and power plants – a comprehensive utility-scale system solution for low-cost operation**  
Kevin Shu  
Vice Director,  
Trina Solar



15:30 – 16:00 | **Transitioning from Flexible to Rigid Trackers to enable Large Size**  
Pedro Magalhães  
Director, Global  
Engineering and R&D,  
Artech Solar



16:00 – 16:30 | **2021 Trackers redesign challenge: How to improve adaptability and production with the new extra large modules trend**  
Eduardo Chillarón  
Design & Eng. Manager,  
PVH

## 16:30 – 17:00 Executive Fire Chat

**Conclusions & Outlook – What's Next for Solar Trackers and Utility Scale Solar**



Philip Shen  
Managing Director,  
Senior Research Analyst – Cleantech,  
ROTH Capital Partners



Arturo Herrero  
Chief Business Development Officer,  
GameChange Solar

## 17:00 CONFERENCE CLOSING | MICHAEL SCHMELA, TAIYANGNEWS



The TaiyangNews Solar Tracker Market Survey 2021 was launched at TaiyangNews Solar Tracker Virtual Conference on 13 April, 2021. Please check TaiyangNews YouTube Channel to watch the presentation recordings at:

<https://www.youtube.com/c/TaiyangNewsAllAboutSolar>

All major suppliers, among them Arctech, Array Technologies, GameChange Solar, Ideematec, Nextracker, PV Hardware (PVH), STI Norland and Soltec offer HSAT systems. Only leaders from two of the 19 participants, Mechatron and Big Sun Energy offer DAT systems.

**Arctech** is a Chinese-based publicly listed company – and among the top five world's largest solar tracker manufacturers. It has over a decade experience in tracker manufacturing. Founded in 2009, it entered the international markets in 2014, operating subsidiaries and sales centers in Asia, Europe, Americas and Australia.

**Array** is headquartered in New Mexico, USA and is the world's second largest tracker company with over 30 years manufacturing experience in that field. The company, which closed its IPO in Oct. 2020, shipped trackers worth around 22 GW so far, and secured several very large supply contracts last year, among others in Nov. 2020, a 1.4 GW order from Lightsource BP and a 1 GW order from RP Construction Services.

**Axial** is a Spanish company and part of the Alonso Group that encompasses around a hundred companies operating in logistics, energy and construction, among others. The company was founded in 2008 and said it executed around 270 PV projects in more than 26 countries. By mid-2020, it had installed a total of 2.75 GW.

**Big Sun Energy** from Taiwan started its solar business in 2006 first as a manufacturer of solar cells and later module. It has been manufacturing DAT systems since 2012.

**Clenergy** is a Sino-Australian joint venture headquartered in Xiamen, China. The JV was founded in 2007 and has branch offices in Australia, China, Germany, Thailand, Japan and Philippines. Next to solar mounting systems – fixed and tracking solutions, it offers power electronic products among them combiner boxes and inverters.

**FTC** was founded in 2017 in Texas, USA. In 2020, it booked \$187 million in sales. End of March, the tracker supplier filed for an IPO on US Nasdaq, hoping to raise up to \$100 million.

**GameChange** is headquartered in New-York, USA. It offers both, fixed-mounting structures and solar trackers. For the international market, the US company opened a factory in China with 12 GW annual capacity at the end of 2019, where they manufacture most parts needed for their solar trackers. So far, the company has shipped trackers equal to capacities of over 12 GW.

**Grace Solar** was founded in 2009 in Xiamen, China. The company offers both trackers and fixed-mounting systems. Grace Solar said it installed its products in over 100 countries and regions.



Intelligence  
beyond steel

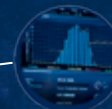
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- Self-powered
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- Adapted to any module



Wide range of trackers and structures



Smart controllers with LoRa technology



Advanced SCADA and monitoring system



Waterless PV cleaners for 1P and 2P





## Manufacturers of Solar Trackers in TaiyangNews Survey 2021

Manufacturer	HSAT	DAT
<b>Arctech</b> Solar Holding Co., Ltd, China	×	
<b>Array Technologies</b> Inc., USA	×	
<b>Axial</b> Structural Solutions, Spain	×	
<b>Big Sun Energy</b> Technology Inc., Taiwan		×
<b>Clenergy</b> (Xiamen) Technology Co., Ltd, China	×	
<b>FTC</b> Solar Inc., USA	×	
<b>GameChange</b> Solar LP, USA	×	
<b>Ideematec</b> Deutschland GmbH, Germany	×	
<b>Mechatron</b> Solar Inc., USA		×
<b>Mounting Systems</b> GmbH, Germany	×	
<b>Nexans</b> Solar Technologies, France	×	
<b>Nextracker</b> Inc., USA	×	
<b>PVH</b> PV Hardware Solutions S.L., Spain	×	
<b>Schletter</b> Solar GmbH, Germany	×	
<b>Soltec</b> Energías Renovables S.L., Spain	×	
<b>Soltigua</b> S.r.l, Spain	×	
<b>STI</b> Norland S.L., Spain	×	
<b>TrinaTracker</b> , China	×	
Xiamen <b>Grace Solar</b> Technology Co., Ltd.	×	
* bold font indicates company name in survey		
Source: © TaiyangNews 2021		

**Mostly following the sun in one direction: Of the 19 manufacturers listed in our survey, including all market leaders, only two smaller companies offer 2-axis trackers.**

**Ideematec** is a 2003 founded Germany-based manufacturer of tracking systems with a track record of more than 2 GW from over 52,000 systems. It has been offering trackers for over 12 years and owns a production capacity of over 160 MW/month.

**Mounting Systems** was founded in 1993 near Berlin, Germany. The company has been offering fixed mounting systems for small and large systems from the start and introduced its first solar trackers in 2016.

**Mechatron** is based in California, USA and is focusing on DAT solar tracking products since 2008. In the past, Mechatron's portfolio also included HSAT systems. Over 3,700 of Mechatron's trackers have been installed and 890 active solar plants are using its products.

**Nexans** is a French company headquartered in Paris that is mostly known for PV cables. Last year, it entered the solar tracker segment and signed its first contract for supply of 800 of its tracker products for a 26 MW solar park in the southwestern part of France.

**Nextracker** is headquartered in San Francisco. Founded in 2013, the start-up was taken over in 2015 by multinational manufacturing giant Flextronics (Flex) and has been the market leader in the solar tracking for years. It has shipped more than 50 GW of solar trackers to projects on all continents.

**PVH** is a Spanish company, founded in 2011 in Alcobenda and has supplied trackers and fixed-structures to more than 11 GW of utility-scale PV with 70 projects being above 50 MW around the world. According to GTM's Global PV Tracker Market Analysis 2019, PVH was the third largest tracker supplier in 2019 with a market share of 9%.

**Schletter**, a Germany-based company has been offering solar mounting systems since 2001. The company has entered the tracker market in 2015.

**Soltec**, one of the top 5 solar tracker companies, is headquartered in Murcia, Spain and has been manufacturing solar trackers since 2004. The company is present in 16 countries and has supplied trackers for a total of 8.4 GW of installed capacity by end 2020. In Oct. 2020, Soltec went public at the Spanish stock market and recently signed significant

contracts, such as a tracker supply deal in Brazil for a 852 MW project, the largest bifacial tracker project in Latin America.

**Soltigua** is an Italian solar tracker manufacturer. The company entered the solar market in 2006 with the manufacturing of parabolic troughs and linear Fresnel collectors and expanded its solar activities also into PV trackers.

**STI** is a company that was founded 1996 in Pamplona, Spain. It claims designing the world's first solar tracker PV plant in 2002. Since then, it has been offering both fixed mounting and tracking solutions. In 2020, it nearly doubled its turnover to close to 200 million Euros.

**TrinaTracker** is a division of world leading PV module manufacturer Trina Solar. After acquiring a 51% stake of Spanish tracker manufacturer Nclave in 2017 and taking full control of in 2020, Trina Solar changed the brand to TrinaTracker, a full solar tracker solution provider with over 5 GW of its products developed worldwide in more than 300 projects.

# Very High-Power Solar Modules

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## 2. Overview

Solar trackers orient the PV panels towards the sun. Depending on PV plant location, weather conditions, topography, PV plant layout and soil conditions tracker manufacturers optimize their systems for a specific project. That's why trackers come with several options, and almost all manufacturers are quite flexible with tracker design. A typical tracking system includes the mount structure, drives, block-mechanisms, tracking algorithm, alarms and optionally high-level supervisory control and data acquisition (SCADA) system.

In the following part the main features for non-concentrating PV solar tracking systems will be discussed.

### 2.1 Basics of trackers

Depending on the driving mechanism solar trackers can be classified as follows:

**Passive tracking systems** are quite simple as they do not have any mechanical drives. Their driving mechanism is based on gravitational systems. They use the effect of thermal expansion in materials due to temperature increase. A simple passive solar tracker system consists of a pivotal frame and two equal cylindrical tubes filled with liquid gas. Thermo mechanical actuators are practical, as they work without electricity. As passive trackers are not very accurate and vulnerable to wind gusts they are not used in utility-scale PV power plants.

**Manual tracking** means that someone changes the sun angle from season to season or even during the day using a gear. If changed daily, the panels are usually reoriented three times (morning-noon-afternoon). A manual solar tracker includes a mechanical device that snaps or is easily guided and latched into a position.



Source: Trina

**Solar powered:** Leading tracker manufacturers, such as TrinaTracker, equip their systems with extra PV modules that power independently the DC motor of the trackers, although they usually also offer the option for grid-connection.

Furthermore, there is a mechanical setting that is changed on a monthly basis to follow the sun's changing maximum elevation angle.

**Active tracking** uses motors, drives, sensors and controllers to allow finding the optimal position of the

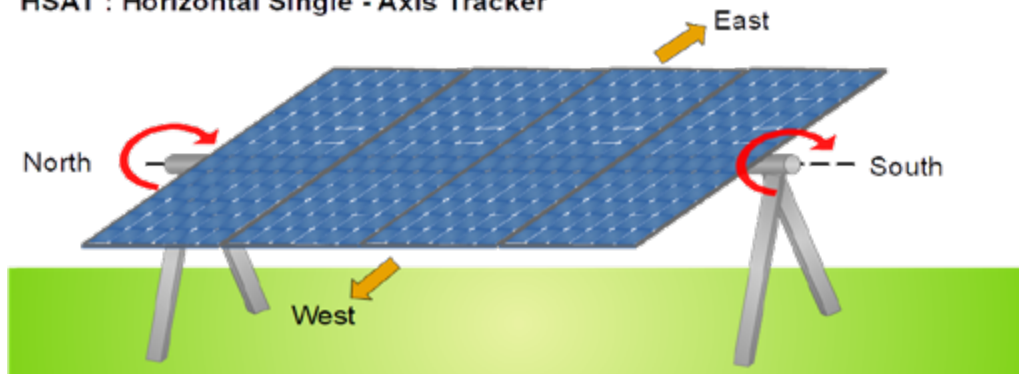
solar modules towards the sun. Active tracker will be discussed in detail in this report.

## 2.2 Utility-scale PV Trackers Review

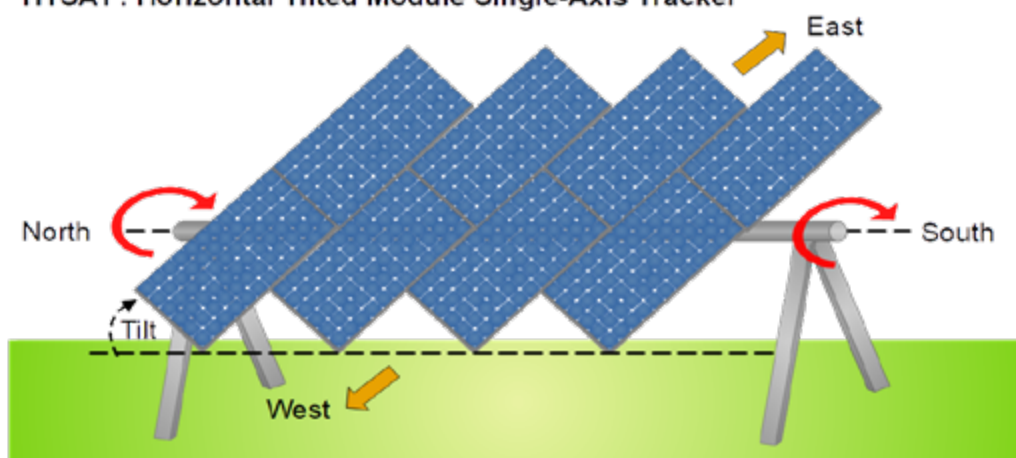
Active solar tracking systems are mostly deployed in utility-scale PV power plants.

### Different Single Axis Tracker Configurations

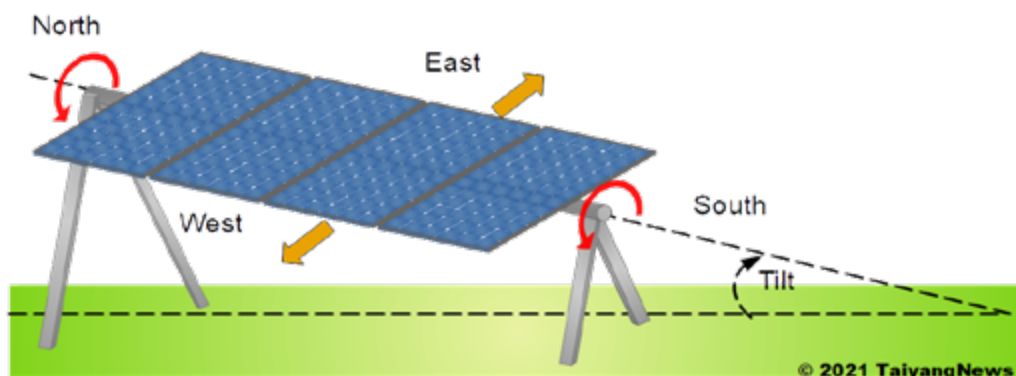
**HSAT : Horizontal Single - Axis Tracker**



**HTSAT : Horizontal Tilted Module Single-Axis Tracker**



**TSAT : Tilted Single-Axis Tracker**



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**More than one single-axis tracker configuration: While horizontal single axis tracking (HSAT) technology is the workhorse among SAT, alternative configurations HTSAT and TSAT are suited for PV plants located in higher latitudes.**



**Single-axis** trackers, also called 1-axis solar tracker systems, consist of a module mount structure that drives the solar modules on a trajectory relative to the sun's path position using a single pivot point to rotate. There are three categories of single axis trackers: **horizontal single-axis tracker (HSAT)**, **vertical single-axis tracker (VSAT)** and **tilted single-axis tracker (TSAT)**. The axis of rotation is horizontal with respect to the ground and the solar module is oriented parallel to the axis of rotation in HSAT systems. In VSAT systems, the axis of rotation is vertical with respect to the ground. As VSAT systems follow the sun around a vertical axis, they need larger space compared to HSAT to avoid negative shading impacts on yield. There are also tilted HSAT (HTSAT) systems in the market where the solar panels are mounted with an optimum tilt at the horizontal axis.

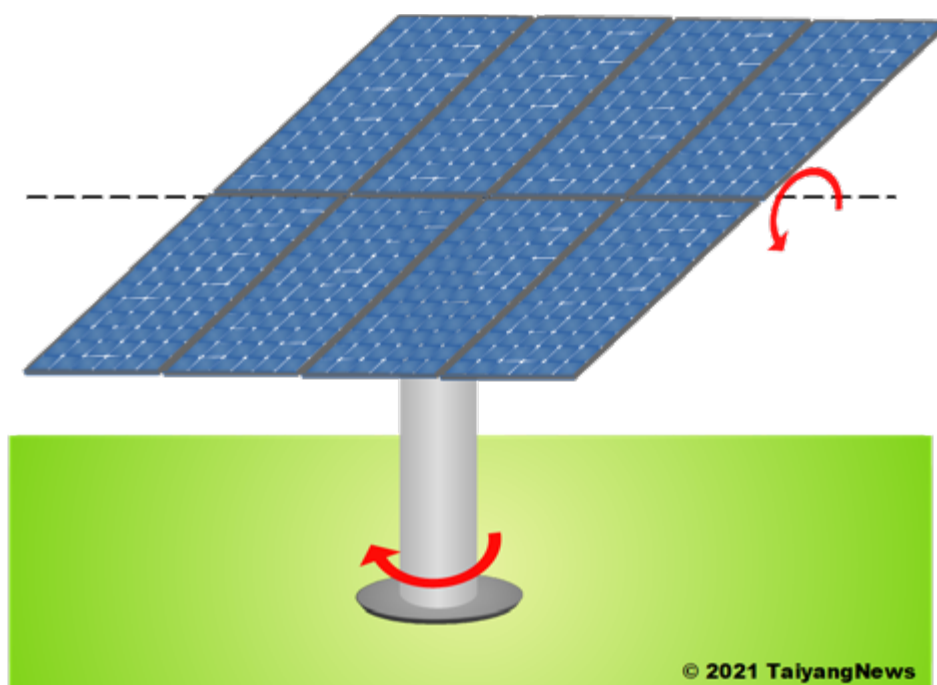
According to technical specification IEC / TS 62727, all trackers with the axis of rotation between the horizontal and vertical are considered as tilted

single-axis trackers (TSAT), but these products are very rare. TSAT have a rotation axis placed between the horizontal and vertical axis.

The axis of HSAT systems can be oriented either in East-West (E-W) or North-South (N-S) configurations. In N-S axis configuration the modules follow the sun in E-W tracking direction. In case of the E-W horizontal oriented axis the solar panels can only rotate to follow the sun in its elevation angle. E-W axis configuration is not commonly used because the collected energy yield is quite lower than in N-S axis configurations. HSAT systems are the most widely used in practice, as they come with simple and robust mechanics, which often trade off the smaller collection of radiation with respect to the dual-axis trackers.

Jacobson & Jadhav<sup>1</sup> from Stanford University showed that single-axis horizontal tracking provides much higher output than single-axis vertical tracking below 65° N and S, whereas output is similar elsewhere.

### **DAT: Dual-Axis Tracker**



**True sun followers: Dual-axis trackers (DAT) promise the highest yields among all tracking technologies, as they follow the sun's trajectory in both elevation and azimuth. But their market share is negligible due to higher cost.**

<sup>1</sup> M. Z. Jacobson, V. Jadhav "World estimates of PV optimal tilt angles and ratios of sunlight incident upon tilted and tracked PV panels relative to horizontal panels ", Department of Civil and Environmental Engineering, Stanford University, Stanford, CA 94305-4020, USA, Solar Energy 169 (2018) 55–66

# EzTracker Horizontal Single-axis Tracker

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- ◆ Easy maintenance
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IEC 62817



Wind Tunnel Test



## D2P - 2 Portrait Optimum Solution for Bifacial Modules

- ◆ Low construction costs
- ◆ Easy maintenance
- ◆ High stability and reliability



However, solar trackers offer only little benefit over optimal tilting for higher latitudes above 75° N and 60° S. When considering optimal output and LCOE reduction but not CAPEX reduction, single-axis horizontal tracking (HSAT) is recommended for utility-scale PV parks.

**Dual-axis trackers**, also known as 2-axis solar tracking systems, have both a horizontal and vertical axis and can move in a circular path (north-south and east-west) and follow the sun in any direction. Thus, solar modules mounted on such trackers achieve the highest energy yield with modules facing perpendicular to the sun irradiation all day. The two-axis of the tracker are positioned perpendicular to one another. The fixed axis with respect to the ground is the primary axis and the other is the secondary axis. As two actuators are needed for dual-axis trackers, costs are much higher, which explains the very small market share of this tracking solution.

Interestingly, Jacobson & Jadhav found out that the energy yield of single-axis horizontal tracking differs from dual-axis tracking only by 1–3% at all latitudes.

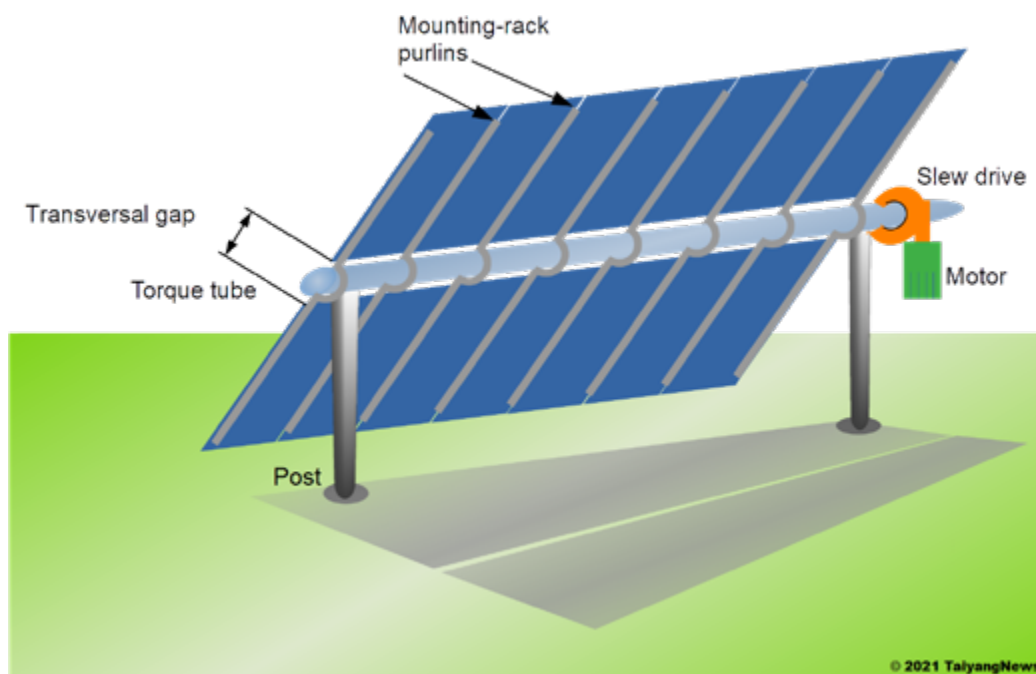
## 2.3 Main Components of HSAT

Horizontal single-axis trackers employ various mechanical and electrical components. The electrical components consist mainly of motors, sensors, controllers, and actuators, while the axis or torque tube, the tracker mount, fasteners and clamps belong to the mechanical components.

The **torque tube** or **axis** is an important component of a HSAT system. All PV modules are connected to the torque tube which take care for the tracking of the sun's path of all modules simultaneously. The torque tube can be either round or quadratic. The axis has to support heavy and dynamic loads; thus, the choice of material is crucial, typically galvanized steel is used. The axis is driven by one or several motors using different approaches, such as slew drives. The reflectivity of the torque tube is important if bifacial modules are employed.

The **tracker mount** is the skeletal metal construction on which the solar modules are placed. In case of bifacial modules, it is favorable if the tracker mount has no crossbeams to avoid shadowing.

### Main components of HSAT systems



**A HSAT system consists of mechanical and electrical components: The solar modules are attached to mounting-rack purlins, which are fixed to a torque tube that is moved using a slew drive, motor and controllers.**

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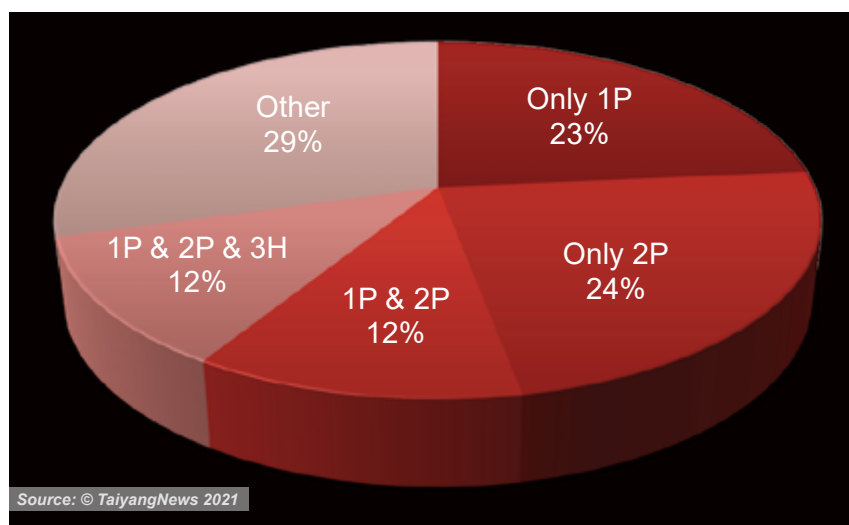
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Tracker manufacturers offer different mounting options for the modules: one-in-portrait (1P) or two-in-portrait (2P) or two to four in landscape (horizontal) orientation (2H or 4H) on the tracker rack. Of the 17 HSAT suppliers listed in our survey, four companies offer only 1P and another four only 2P trackers, while two companies offer 1P, 2P and 3H systems and only 1 company offers 3P and 6H systems. For bifacial systems the torque tube is mostly placed with a bigger gap between the modules in a 2P configuration. Some companies offer 1P tracker architecture also for bifacial modules and modify the torque tube geometry and reflectivity.

The core of a solar tracker is its **driving mechanism** and its ability to function up to the maximum operational wind speed and prevent damages under all operating conditions. The driving mechanism typically consists of a **motor**, a **gearbox** to transform motor speed in torque and a **drive**, which provides rotary or linear motion to turn the tracker axis. Either alternate-current (AC), or direct-current (DC) electric motors are employed. AC inductions motors can draw power directly from grid. **Stepper motors** are offered at low prices, but the motor speed is limited at around 600 rpm and the devices are sensitive to high temperature differences between different parts of the motor. These motors are disadvantageous in

harsh storms when trackers have to quickly reach the stowing position. **Brushed DC** motors use a configuration of wound wire coils (armature), which act as a two-pole electromagnet. The directionality of the current is reversed by a mechanical rotary switch (commutator). Brushed DC motors are offered at low cost with simple and inexpensive controllers and are ideal for extreme operating environments. A draw back are the wear-prone brushes and the need of replacement to extend service life. In contrast, brushless (BL) motors are equipped with permanent magnets at the external rotor. Furthermore, **brushless DC motors (BLDC)** utilize three phases of driving coils and sensors track the rotor position. They need less overall maintenance due to lack of brushes. BLDC motors are offered in reduced size with much better thermal characteristics, lower electric noise generation and higher speed range, which is beneficial in stowing conditions. The high-end solution motors for trackers are intelligent BLDC motors with embedded control electronic units. Arctech, Array and Nextracker have sent data about HSAT products equipped with BLDC motors for our survey. Sometimes hydraulic motor types are employed, where a fluid is used to move the actuator, such as a hydraulic cylinder. Hydraulic systems are useful when load requirements change rapidly.

### HSAT Configurations - 17 Companies



**Different tracker system architectures: 17 of 19 companies in our market survey offer HSAT systems in various configurations - 1P, 2P, 2H, 3H or 3P / 6H. Most manufacturers have opted either for 2P or 1P technology.**



The DC motors can be powered independently with extra PV modules and battery storage as backup. Such self-powered systems are offered by the majority of companies listed in our survey – Arctech, Axial, Clenergy FTC, GameChange, Nexans, Nextracker, PVH, Schletter, Soltec, Soltigua, STI and TrinaTrackers.

**Slew drives**, a gearbox stage that is specifically designed to handle radial or axial loads while providing rotational output torque, can also withstand overhung or moment loads. Slew drives for azimuthal tracking consist of a metal-ball bearing, worm-gear mechanism, rubber seals and a sturdy housing to protect the drive from the environment. Worm-gear slew drives for solar trackers come often with a reverse self-locking mechanism, which locks a module row automatically when it does not move and thus makes it suitable for installations in locations with high wind speeds.

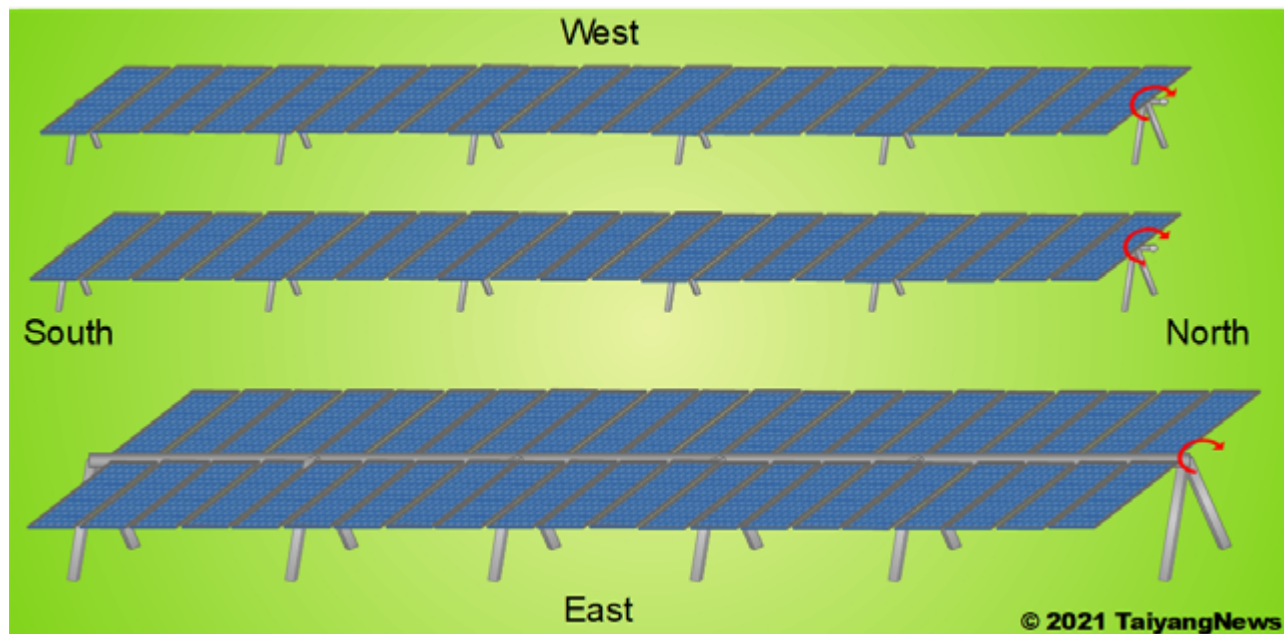
Slew drives are used in many applications across the industry, when strength and precession are required, as they enlarge the power of the motor into a controlled, high torqued output. Linear actuators

are used for the vertical elevation adjustment of solar trackers.

In case of **independent-row** architecture, each tracker is independently actuated and controlled, while in **dual-** or **multi-row** HSAT systems two or more trackers are simultaneously driven with a single actuation system. The majority of companies participating in our survey offer independent-row HSATs (Arctech, Array, Ideematec, FTC, GameChange, Grace Solar, Mounting Systems, Nexans, Nextracker, Schletter, Soltec); while a few manufacturers sell both single-row and dual-row systems models (like TrinaTracker, PVH, Axial).

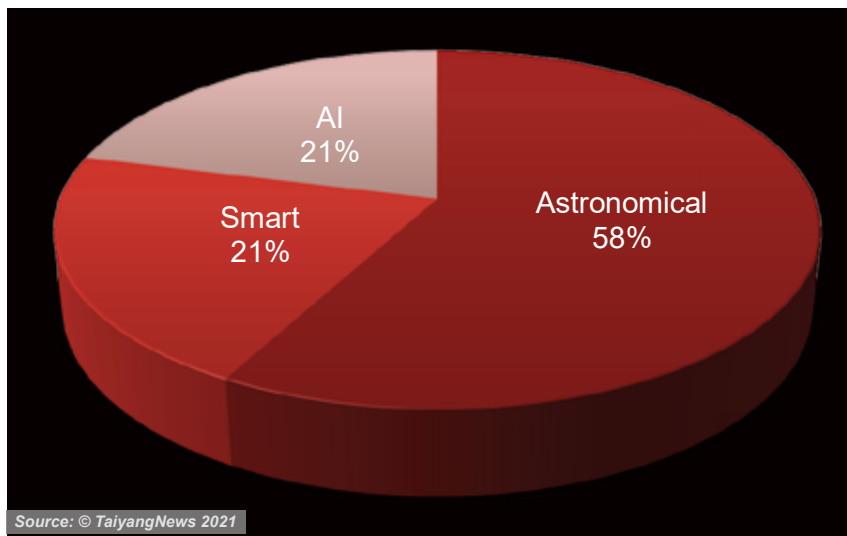
All drive system components are activated by a control and communication system. Solar trackers are mostly equipped with a programmable logic controller (PLC), which is driving the motors of the solar tracker to an optimal position depending on the actual irradiation and weather conditions. The PLC can use inputs from several sensors such as GPS receiver, an inclinometer, a GMT clock, irradiation and wind sensors, PV inverters to determine the optimal position in closed-loop or open-loop control algorithm.

### **HSAT with one or two PV modules in potrait orientation - 1P/2P**



**Modules in potrait:** Of the 17 HSAT suppliers listed in our survey, four companies offer only 1P products and another four only 2P trackers.

## Tracking Algorithms – 19 Companies



**Solar trackers get smarter and smarter: Four of 19 companies listed in our survey offer tracker systems equipped with AI-based controllers.**

**Closed-loop controls**, also called feedback controllers, use solar sensors or the inverter output to determine the sun's position. The input data from the sensors come into the controller unit, which drives the motors and actuators to position the tracker. The majority of the participants in our market survey offer closed-loop control systems. Four companies offer artificial intelligence (AI) based controllers to allow for self-learning control routines. In this case, trackers can calculate the optimal tilt angle for various weather conditions and terrains, which results in increase of a system's bifacial gain by differentiating between overcast skies and few scattered clouds. Four of 19 companies in our survey, Arctech, GameChange, PVH and TrinaTracker have equipped their solar trackers with AI-based controllers.

**Open-loop control systems** use a microcontroller and do not need any sensors to detect the sun's position. The sun's path is predicted by astronomic relationships programmed in a microprocessor which calculates the sun's position at any time. Some devices use for accurate tracking a solar map, which depending on the location gives information on where the sun is at different times of day throughout the year. This is solution used by

Ideematec, Mechatron, Big Sun Energy, Nexans and STI. Furthermore, some tracker suppliers, such as Schletter, use GPS signals to determine the tracker's latitude and longitude, as well as the date and time. With this information, the tracker will know the position of the sun for any given time and orient itself to face the sun. The tracker will be facing the sun even during cloudy periods; and when the clouds part the tracker will already be positioned to maximize power production without any delays to reposition itself.

Some trackers use both, sensors and a solar map; when the weather is sunny, the sensors are used to track the sun and during cloudy days, the information from the solar map is used. In order to maximize the energy yield, shading should be obviously avoided. However, sometimes a shadow-free module position might not be optimal in terms of module sun alignment. Some solar tracker manufacturers use smart control algorithms to detect when tracker self-shading between the module rows occur and update the current rotation angle for eliminate shading by module alignment for maximized solar generated electricity yield. This is the so-called backtracking, which is implemented by almost all participants in our survey.

Solar trackers integrate either active or passive mechanisms to reduce the impact of high wind and snow loads as well as hailstorms. In such extreme weather conditions, the trackers move from the operational to a more favorable stow position. Ideally, the stow position is not the same for all extreme weather conditions. As an example, 0° stow position, which is advantageous for reducing the sailing effect at high-wind speeds might lead to module damages in case of hailstorms. Just a few tracker suppliers offer different stowing strategies for different potential weather risks.

HSAT 2P trackers, manufactured by some established top 10 suppliers, showed malfunctions due to storms in Australia and Brazil in 2018. The modules were twisted off vertically and the piles onto which the trackers were mounted were bent. Some rows completely collapsed, with steel puncturing modules. Renewable developer RES' global solar procurement leader, Tomaso Charlemont, points out, that these examples unveil risks of 2P design which can be related to an underestimated sail effect, insufficient engineering or other reasons. Charlemont is nevertheless confident that manufacturers are addressing and sorting out these conceptual defects

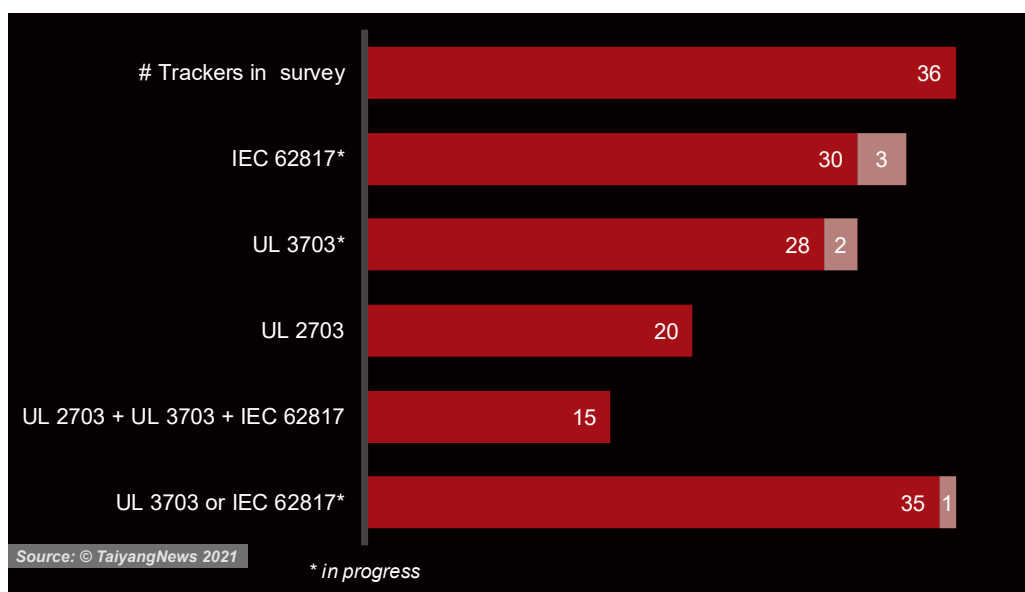
and that 2P trackers will become as reliable as 1P.

## 2.4 Certification Standards and Requirements for Solar Trackers

Solar PV trackers must withstand harsh weather conditions and at least the mount structure should have an estimated useful lifetime similar to that of the PV modules. The most relevant standards for solar trackers are IEC 62817, UL 3703 and UL 2703.

The **IEC 62817** international standard defines accelerated wear test procedures for the solar tracker's key components such as for electronic control units and drive train, and tests for the complete solar tracker. The tests on the complete solar tracker include daily energy and peak power consumption, tracker accuracy characterization, deflection under static load and moment testing under extreme wind loading, stow time, stow energy, and accelerated mechanical cycling procedures. The drive system has to withstand wind and snow events not only without any damage, but also in a way that the impact of such harsh environmental conditions will not significantly affect the PV plant's annual energy production.

### Solar Tracker Certifications



**Taking certification seriously: All trackers in the survey are certified either according to IEC 62817 or UL 3703, or the certification process is in progress. 15 products comply with all 3 standards.**



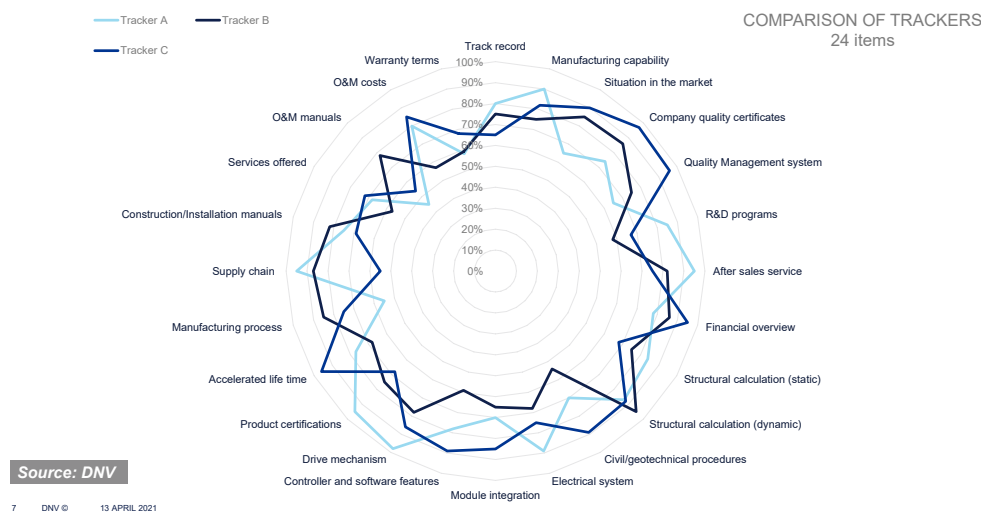
Therefore, drive tests are extensive including torsional stiffness, mechanical drift, drive torque and backlash tests. Additionally, temperature cycles, humidity-freeze cycling and freeze-spray water tests in a climatic chamber as wells as temperature cycle tests with dust in a special chamber have to be performed. The main tests for the electronic control unit include IP, IK class, functioning test, UV, damp-heat, thermal cycles, humidity-freeze and robust terminal test. Visual inspection and functional tests are performed initially and are repeated after the performance of climatic and mechanical tests.

The standards UL 3703 and UL 2703 are applicable for solar PV tracker installations in the US. **UL 2703** refers to safety of mounting systems including mounting, clamping, retentions devices and ground lugs for use with solar panels. (**UL 3703** includes safety evaluation for all mechanical and electrical aspects including tracker controllers and associated components to mitigate risks of harsh weather conditions, mechanical failure, and electrical shock. Of the 36 products listed in our survey, 30 comply with IEC 62817 and 28 with UL 3703. All systems are certified either according to IEC 62817 or UL 3703, or are in the process of certification, while 15 tracker models comply with all 3 certifications (see graphic, p. 17).

When it comes to trackers in utility-scale PV plants, IEC and UL certificates build the bottom line from what EPCs, independent engineers and lender's technical advisors would like to see. Especially for large investments in case of hundreds of megawatts, wind load testing for the envisaged trackers and project specific modules are mostly required. In such cases, the wind loads have to be applied perpendicular to the solar panels with load distribution being triangular in shape and wind coefficients (pressure and suction) being derived for several inclinations in open und fully blocked tracker positions.

Project financing does obviously not rely only on certificates, but on a detailed technical due diligence. Technical advisory company DNV evaluates tracker suppliers based on 24 different aspects, such as product certifications, manufacturing process, track record, R&D programs, after sale services and controller and software features. The info graph below shows an analysis based on three different tracker systems. While the two certified systems perform better overall, they are not topping for each criterion. Product quality differs and some aspects are also project specific. Intensive O&M might not be a problem for a project in China or India, but it is crucial in the USA or Europe, where labor cost is much higher.

## Zooming into aspects



**Tracker bankability:**  
At the TaiyangNews Solar Tracker Conference, consultancy and independent engineer DNV showed how it evaluates tracker suppliers to solar projects based on 24 different topics.

## 3. Product Descriptions

For our first market survey on solar trackers 19 manufacturers have provided data for a total of 36 products in two categories: HSAT and DAT systems. This chapter includes detailed descriptions of the different trackers listed in the survey in alphabetical order.

### 3.1 HSAT systems

**Arctech's** SkySmart II is configured in 2P architecture for increased bifacial gain, as there is no torque-tube shadowing effect on the rear side of bifacial modules. Arctech's tracker adapts up to 20% N-S slope. Additionally, the Chinese company offers a patented 4 point / 6 point mounting method for reducing the back-shading for bifacial panels. The independent-row tracker can accommodate all solar module dimensions and string sizes due to its possibility for modular fix-fix and fix-free spans configuration. It supports up to 4 strings with 1,500 V DC voltage each. The brushless DC motor is powered by a string of modules. In case of emergency, a Li-ion battery offers back-up to bring the tracker in safety position. The driving-mechanism for SkySmart II has been upgraded from a single-point drive to a synchronous multi-point slew drive with direct gear boxes. Despite having multi-mechanisms there is only one motor and controller, which enables SkySmart II to be synchronously connected and driven by a transmission rod. To mitigate the risks under strong winds, all slew drives are fixed points providing more stiffness and enlarging the natural frequency

at system level. Arctech collaborates with CPP Wind Engineering Consultants for multi-row aeroelastic wind tunnel testing to ensure the effectiveness of its 0° stow angle to lower the pressure on the tracker surface and minimize loads on panels and tracker components without any galloping effects. Arctech's SkySmart II passed successfully IEC 62817 certification by TÜV Rheinland early this year.

Arctech has developed an artificial intelligent (AI) solar tracking system to realize self-learning control routines, which allow the system to calculate the optimal tilt angle for various weather conditions, terrains and increase bifacial gain. SkySmart's II tracking cloud strategy is based on real data to differentiate between cloudy days and single clouds. The tracking position for modules is based on sharing parameters with the inverters and takes under consideration the albedo values and if the modules are bifacial or not. The communication signal can be kept stable by the use of low-energy consumption and large coverage-range LoRaWAN technology.

**Array's** DuraTrack HZ v3 1P has been introduced into the market in 2016. The 1P configuration tracker system links rows together and uses less than 1 motor per MW solar generated DC power. Array has developed a single-bolt per module clamp, which enables fast installation. Articulating drivelines allow for rows to follow site contours.



Source: Arctech

**Very stiff:** Arctech has optimized its SkySmart II trackers to have many fixed points and be very rigid, so it can stow in 0° position even with the new very large solar panels, it highlighted at TaiyangNews' Solar Tracker Conference.

DuraTrack is equipped with a patented, mechanically passive wind load mitigation system which adjusts to full-tilt angle and activates automatically, if the wind load exceeds the safety threshold established by Array. The US company applies dynamic aeroelastic tests to ensure its solar trackers reliability.

DuraTrack's weather risk mitigation system does not require any complex communications systems, batteries or power, hence it reduces danger to both workers and equipment, especially during the PV plant construction period.

Field data from CFV labs in the USA together with 3D ray-tracing irradiance model for energy yield simulations performed by PVLighthouse quantify the torque-tube shading in 1P DuraTrack system to have no significant impact on power generation for bifacial modules. The results take under consideration the geometric (size, shape, spacing to the modules) and material parameters (reflectivity) of the torque tube, as well as the height-to-width row ratio.

Array's solar trackers hold IEC 62817 and UL 3703 & 2703 certificates and come with market standard warranties of 10 years for the structure and 5 years for electromechanical components.

**Axial** provided data for 6 HSAT systems: Axial Tracker 3H, 1V, 1V Twin, 2V, 2V Bi and AgriTracker. All of Axial's designs are adapted to project characteristics and panel type, and the company does not have restrictions in terms of module configurations. AxialTracker 2V Bi is optimized for bifacial modules by adding a central gap to avoid torque-tube shading on the module's rear side. All of Axial's trackers can do without any special machinery for installation; all components are said to cope with ground unevenness and elements are assembled by means of bolted connections, avoiding the need of on-site welding or mechanization.

There are three variants available regarding power supply: a self-powered variant by a dedicated PV panel and battery storage to operate the system.



**Several options:** Axial offers its trackers in three different configurations, 1-in-portrait (1V), 2-in-portrait (2VBi), or 3-in-landscape (3H). Its 2VBi model is optimized for bifacial modules. Axial's HSAT systems are certified according to all relevant tracker standards.



The battery charging takes place when solar energy is available without affecting the string production. The grid-powered tracker version (AC 100-240 V, 50-60 Hz) is recommended for cold climates when battery usage is not convenient. The string-powered version uses the energy produced directly by the strings and is supported by a battery storage system.

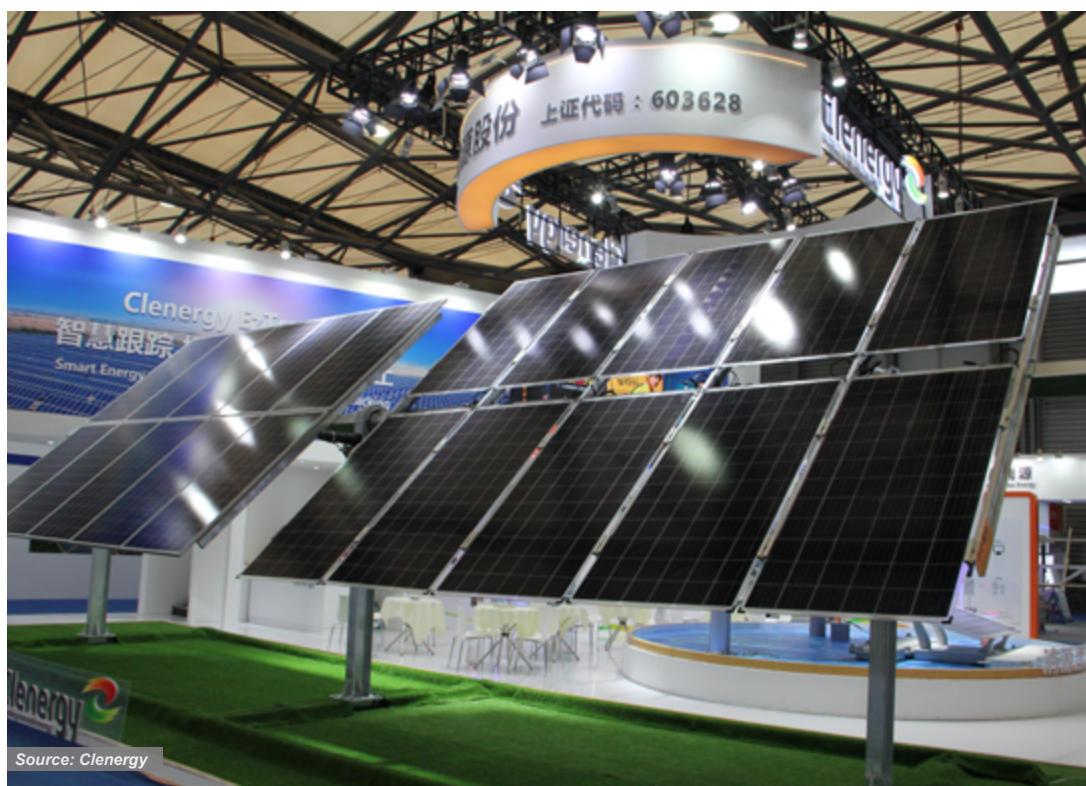
Axial's stow strategy and components are variable depending on the tracker model to optimize the design according to its geometry and project requirements. Typically, AxialTracker 3H and 2V models include the Axial blocking system, while AxialTracker 1V, 1V Twin and AgriTracker models may include dampers. During the day, the Axial blocking system works 98% of the time and converts the solar tracker into a fixed-ground mounting system with optimized tilt angle. Thus, the solar tracker structure is fixed at each end to stabilize the system by reducing oscillations. For the remaining 2% of the time the blocking system works as a shock absorber with a high damping coefficient to balance the tracker in movement towards its optimum position for solar generated electricity.

Axial systems use Zigbee wireless communication between trackers and control units, which can control 150 to 200 trackers. The control units require AC

power supply of 100 to 240 V and 50 to 60 Hz, as well as internet connection via RSJ45 and ethernet. Axial's monitoring solution allows for remote control of the tracker position. The Spanish company uses its own SCADA solution to optimize these features.

Axial provides an extraordinary long-warranty time of 25 years for the mechanical structure and market standard warranties of 5 years for both, motor and electronics.

**Clenergy** offers its EzTracker D tracker series, which achieved IEC 62817 certification by TÜV Süd early this year. Clenergy's trackers are available in 1P and 2P configurations. The latest update is a design with a wide gap above the torque tube to avoid back shading of the bifacial modules. Each row of Ez Tracker D series is independently controlled by its own DC brushless motor. Clenergy applies an astronomical algorithm and closed loop tracking method, which uses the concept of an open-loop system as its forward path but has one or more feedback loop or path between its out- und input. Thus, the tracking system automatically realizes the sun position and improves the solar generated power. The EzTracker D series is equipped with slew drive and self-calibrated system and can be easily commissioned by mobile phone App.



**Optimized for bifacial modules: Clenergy has upgraded its EzTracker D with a wide gap above the torque tube to avoid rear shading of bifacial modules.**

**FTC** sent information for its Voyager 2P solar tracker, which uses its patented “slide and glide” module assembly method for lean construction. The independent row design supports 4 strings per row with up to 30 modules per string with up to 1,500 V. The DC self-powered drive system uses two 60 W solar modules for power supply with a 3-day Li-ion battery backup.

Voyager tracker systems apply NREL’s Solar Position Algorithm (SPA) with backtracking and provide additional energy yield gain with SunPath algorithm for diffuse light capture. FTC offers different stow conditions for various harsh weather conditions: 0° stow for wind and flood, 40° for snow and 60° for hailstorm.

A wireless Zigbee mesh network connects to SCADA/DAS through modbus TCP communications.

**GameChange** provided the specs for its Genius independent-row tracker system. It is offered in both, 1P and 2P configurations and incorporates stronger

and lighter S550 (80 ksi) steel versus S275-S355 (30-50 ksi) used by most of its competitors.

Genius trackers come with proprietary integrated hardware for faster structure assembly and pre-assembled components, such as drive arms and SpeedClamps (1P), and oversized serrated flange nyloc nut and star bolt with integrated star washer to eliminate the need for washers and star washers and reduce the installation time. GameChange claims zero maintenance for its drive system.

The 2P Genius tracker version is designed with a gap between the module row and the tube to avoid back-shading and support bifacial modules. In order to further boost the bifacial gain, GameChange Solar has design its BifacialReflector with an albedo value of 0.95. GameChange Solar claims that its self-cleaned reflector can boost the energy-yield gain by up to 15-20%. This is an extra 5-8% bifacial gain, as with the HSAT tracker but without its white reflector. GameChange’s trackers use intelligent algorithms Weathersmart and SmartStow.



Source: FTC

**Fully self-powered: FTC equips its Voyager 2P solar trackers with two 60 W modules and a 3-day Li-ion battery backup to power it completely off-grid.**



The first one is a proprietary algorithm for tilt-angle optimization, which interacts dynamically with the environment and is able to differentiate between random cloud-shading and overall cloudy days for determine best tilt position for energy-yield optimization. Due to SmartStow the tracker is able to identify, if there are sporadic and passing gusts of wind, or really continues strong wind. In this case, the tracker will be positioned of 35 to 45° stow angle. Thus, the US-based company avoids the 0° stow flatterring.

GameChange offers market typical warranties of 10 years for the structure and 5 years for electromechanical components with possible warranties extension upon negotiation.

**Grace Solar's** G-Light tracker is an HSAT system that is available in 1P and 2P architecture and uses a self-developed linear actuator multi-point drive. The tracker systems support large-form-factor modules. The 2P architecture with a higher gap over the torque tube makes Grace Solar's

trackers compatible with bifacial modules. GS-Light trackers are able to adopt 15% slope in N-S, while the slope in E-W direction is unlimited. GS-Light uses three material combinations of hot-dip galvanized steel, aluminum-magnesium-zinc plating and pre-galvanized steel, for the different positions and stress levels of the tracker. The trackers can be configured with differentiated column design and different pile foundations for different topographies and soil conditions.

Grace Solar offers smart tracking by combining astronomical tracking algorithm and closed-loop control with integrated artificial intelligence (AI). The smart control strategy combines real-time meteorological data with astronomical algorithms, terrain data and power generation data from the system's inverter. The AI control system learns and obtains the maximum power generation angle and control strategy through data analysis. Grace Solar has verified an additional energy power generation by its smart tracking of 6%, when compared with conventional tracking.



**Intelligence in focus: GameChange's Genius trackers comes with AI based controllers for tilt optimization under different weather conditions and proprietary reflectors for maximizing bifacial gain.**



For this purpose, the Xiamen company selected data from May 2019 to June 2020 in the company's test station with 3 sets of 1 x 84 tracking test brackets on a 10° slope.

GS-Light trackers hold IEC 62817 and UL 3703 & 2703 certificates. Grace Solar offers the market's standard 10 years warranty for structure and 5 years for motor, but only 3 years for electronics.

**Ideematec** has provided data for two independent-row tracker systems for this market survey, H4Plus and L:Tec with completely different drive systems. The L-Tec works with sprocket wheels and the H4/H4plus works with steel ropes. Both systems come with the decoupled drive technology meaning that the drive tube is mounted more than 1 m below

the module surface. In case of H4plus each row of modules is driven by universal shaft with fixed drive via posts and steel cables. L:Tec trackers comes with a device on the drive tube which drives a sprocket wheel, initiates the table's rotation and is able to mechanically lock the module table at every post. Once the system is locked no loading acts on the driving tube anymore. While L-Tec systems come with a full-locking mechanism in every inclination, H4/H4plus trackers work with a high eigenfrequency and high damping ratio. This patented tracking system using steel ropes eliminates the need for shock absorbers, which are sensitive to dust and sand. While both tracker models are compatible for bifacial modules, the modules are only complete free from the backside when installed on L:Tec trackers.



Source: Ideematec



Source: Ideematec

**Independent: Ideematec offers two different independent-row tracker models. H4plus (top) works with steel ropes and L.Tec (bottom left) uses a sprocket wheel and a full-locking mechanism in every inclination.**

In case of installations with H4Plus, there are rear profiles that slightly reduce the bifacial additional yield, which is still high due to the wide gap between module backside and substructure.

Another difference between H4Plus and L:Tec is the number of tracker parts. L:Tec needs about 35% fewer parts than with the H4Plus and therefore installation with L:Tec trackers is significantly faster. Both, H4plus and L:Tec have started the process to obtain the tracker certification according to IEC 632817. Ideematec offers market standard 10 year warranty for structure and 5 years for motor, but only 2 years for electronics.

**Nexans** introduced its Keylios tracker last year. The independent-row solar tracker is a modular product with a new design based on a lattice structure. Keylios 2V comes with a design that allows to carry up to 40 modules per foundation. It is self-powered and comes with Zigbee wireless communication and proprietary SCADA for an optimized predictive maintenance.

The tracker is adaptable to difficult terrains that are not suitable for typical configurations. The company says it is capable for terrains with steep slopes and it's compatible with all kind of drilled or superficial foundations.



**Totally different: Nexans' product Keylios uses a lattice structure to allow tracking of difficult terrains.**



Keylios requires less piles than other technologies. As an example, Nexans' solar tracker requires only 112 piles and 56 concrete beams per MW per, when using standard c-Si solar modules rated at 450 W. These are less than half of the foundations needed with typical HSAT systems and that can support about 15 modules with 450 W per foundation.

Nexans offers pre-assembled tracker components and workshop for its customers to enable faster and easier assembly. Nexans' trackers are certified according to IEC 62817 and come with market standard 10 years warranty for structure and 5 years for motor and electronics.

**Nextracker** provided specs for two tracker models. NX Horizon independent-row tracker uses self-powered motor and control system, with self-aligning module rails and vibration-proof fasteners. NX Horizon's bifacial enhancing features in 2P architecture include high-rise rails, gaps above piers and bearings and the drive system. The vertical separation from torque tube to solar cells is 90 mm and the round torque tube diameter is 124mm.

Its NX Gemini features a patent-pending distributed drive system for maximum stability in extreme weather, which eliminates the need for dampers and produces virtually zero energy losses associated with stowing.



Source: Nextracker



Source: Nextracker



Source: Nextracker

**Market leader: Nextracker's NX Horizon and NX Gemini have the biggest track record. The US company has shipped products for about 50 GW of solar projects.**



Its NX Gemini features a patent-pending distributed drive system for maximum stability in extreme weather, which eliminates the need for dampers and produces virtually zero energy losses associated with stowing.

Nextracker's assembly process uses electric tool-actuated swaged fasteners and bolted connections, with no field cutting, drilling or welding required. Anyway, the electric tools for the swaged fasteners have to be purchased separately.

NX Horizon and NX Gemini hold IEC 62817 and UL 3703 & 2703 certificates. Nextracker offers market standard 10 years warranty for structure and 5 years for motor and electronics.

**Mounting Systems'** independent-row Sigma Tracker uses a knee-level (scissor jack) mechanism for self-locking by severe weather conditions. In such case, every rafter is supported and held in place by the adjustment devices. Sigma Tracker's compatibility with bifacial PV modules is achieved by avoiding any shading behind the active module areas.



Source: Mounting Systems

**Scissor jack: Mounting Systems' independent-row Sigma Tracker uses a knee-level mechanism for self-locking.**



Source: Mounting Systems

In addition, pre-assembled components and standard fasteners significantly improve the system's assembly time with minimal tooling required.

Sigma Control unit allows for control of each individual tracker. While Sigma View control system is based on robust industrial automation components that are also available from stock at any time. A central data acquisition system provides a real-time overview of the PV plant with additional user functions such as fault logging, data recording and logging of O&M activities. A data interface, integration with a wide variety of SCADA systems is also possible.

Sigma trackers are certified according to IEC 62817 and come with market standard 10 years warranty for structure and 5 years for motor and electronics.

**PVH** offers various HSAT systems configurations and connections with easy-to-install screw terminals, which eliminate the need for on-site welding or time-consuming labor for installation. It provided data for six models Monoline 1V, Monoline 2V, Monoline 3H, AxoneDuo and its latest systems Monoline+1V and Monoline+ 2V.

The Spanish tracker manufacturer uses high resistant Magnelis material from ArcelorMittal and self-lubricating and UV protected polymeric bearings for its trackers to withstand corrosion and sand abrasion in desert regions with harsh environmental conditions. To overcome the challenges of dessert installations, PVH's trackers are also equipped with alarms against sandstorms. PVH has designed a water-free cleaning robot suitable for all types of solar modules, with 4 hours of autonomy and interchangeable batteries and the ability to bridge the gap, where the actuator is located, and to jump between rows with a distance up to 60 cm.

The principal difference between Monoline 1V, Monoline 2V and Monoline 3H is the configuration. The nomenclature is referring to the module position. 1V stands for one module in-vertical (1P), 2V stands for two modules in-vertical (2P) and 3H for three modules in-landscape. The 3H is designed only for monofacial modules, while the other can handle both mono- and bifacial modules. Monoline+ is specifically redesigned for large-form-factor modules in two configurations, 1P and 2P, both optimized for bifacial modules.



Source: PVH



Source: PVH



Source: PVH

**Different Solutions:** PVH offers different solutions for different climates and applications. Magnelis protection against sand abrasion, sandstorm alarms, water-free cleaning robots and intelligent stow strategies are key features for desert installations. Pictured are its Monoline 2V product with the vertically mounted modules in different angles (top) and its 3H product with 3 rows of horizontally mounted panels (left). The Spanish company recently introduced its Monoline+ product, which was optimized to handle the new very large module formats.



The Monoline trackers use a motor-per-row architecture and are especially suited for hilly terrain and irregular shaped plots. Monoline+ trackers come with an extraordinary high slope tolerance of 23.5° for N-S slope approximately each 20 meters. PVH tracker systems are self-powered and equipped with back-up systems to ensure stow capability in the event of power failure. All PVH trackers are tested by CPP. Based on the test results, the company does not consider 0° as the optimal stow angle. For the external rows, the optimum stow angle is 30° and for the internal rows it is 15° or 5° depending on the structure.

The AxoneDuo tracker uses a central driveline architecture in dual-row and is controlled by an astronomical algorithm with GPS input.

Smart controllers, powered by DeepTrack IIoT technology, can easily be connected to the Tracker SCADA developed by PVH, according to the company. This should provide easy integration with the plant SCADA through open communication protocol and allow for maximum performance control of the trackers thanks to a dedicated user interface.



Source: PVH

**PVH's AxoneDuo tracker uses a central driveline architecture in dual-row and is controlled by an astronomical algorithm with GPS input. The company's smart controllers are powered by DeepTrack to allow for easy and wireless communication with SCADA.**



Source: PVH



The Spanish tracker supplier has also designed a smart alarm system, which features a short-term wind prediction algorithm based on AI. PVH uses LoRaWAN to ensure long-range communication throughout the PV plant without any interferences or blind spots.

PVH offers standard warranty conditions of 10 years for structure and 5 years for all electrotechnical components for its IEC 62817 and UL 3703 certified trackers.

The **Schletter** Tracking System belongs to the group of few HSAT systems that do not require a central torque tube. Each row is working self-powered. A dedicated PV panel with a battery back-up system provides the power to the controller and the motor.

For bifacial gain optimization, Schletter adjusted the reverse side of the system's tables. The German company reduced the size of the steel sections and elevated the modules by approximately 100 mm from these sections to avoid dark shades on the backside and optimize it for bifacial use.

The Schletter Tracking System uses a patented self-locking mechanism. Each post is equipped with a mechanical locking element, which locks immediately, when the row has stopped moving. This eliminates all wind-induced vibrations for the entire row and in the resting position, the system has the characteristics and resilience of a fixed installation.

Schletter Tracker's upper assembly group with the drive unit is delivered pre-assembled leading to faster installation times.

The German company uses GPS coordinates and the time to implement the tracking system position and terrain information for its 3D tracking adjustments and the distances between the rows. The Tracking System uses these values and the tracking takes place with an astronomical algorithm. Schletter Trackers hold IEC 62817 and UL 3703 & 2703 certificates and come with market standard 10 years warranty for structure and 5 years for electromechanical components.



Source: Schletter

**Reducing installation time: Schletter Tracker's upper assembly group with the drive unit comes pre-assembled to enable faster installation.**

**Soltec** offers the SF7 and SF8 independent-row trackers. SF7 has been in the market since 2017, SF8 is available since last year. While SF7 comes with slew-drive DC motors, SF8 is equipped with multi-drive DC motor system. Both systems offer up to 17° N-S slope.

Soltec applies dynamic wind analysis in its tracker array design, which is beyond building code requirements. The Spanish company follows a high tilt stow angle policy to mitigate the instability risk under extreme wind weather conditions.

SF7 and SF8 trackers use TeamTrack 3D algorithm with NREL sun-position data and programmed constants of local irregularities to execute energy optimized backtracking position control and avoid inter-row shading in the early and late-day hours due to uneven terrain influences. TeamTrack also provides secure remote data communication.

Soltec offers standard warranty conditions of 10 years for structure and 5 years for all electrotechnical components for its IEC 62817 and UL 3703 certified SF7/SF8 trackers.

**Soltigua** provides different solar tracker technologies - PV trackers, parabolic troughs and linear Fresnel collectors. For PV applications, the company has in its portfolio 3 models – iTracker WL, iTracker Duetto and BiTracker. All these models are designed in 1P architecture. The standard iTracker WL gap between the torque tube and the rear side of the frame of the PV modules is 50 mm, while for the BiTracker this gap rises up to 60 mm to avoid shading of the modules backside and increase bifacial gain.

The Italian company applies an astronomical algorithm with individually customized 3D backtracking.



Source: Soltigua

**One-in-portrait: Soltigua's models, iTracker WL, iTracker Duetto and BiTracker are designed in 1P architecture.**



Additionally, Soltigua has designed a Sub-GHz wireless architecture radio network using one antenna for each tracker and central receivers that allows for operation over longer distances and connection of more nodes per control unit as Zigbee does. Soltigua's wireless system is supported by Soltigua's mobile app for both commissioning and field supervision.

Soltigua's PV trackers are certified according to IEC 62817 and come with typical 10 years warranty for structure and 5 years for motor, but only 3 years for electronics.

**STI Norland** from Spain offers solar trackers since 2002 and is one of the pioneers in this field. Its STH-250 has been introduced to the market in 2017 and is touted as the world's first dual-row HSAT system, which consists of two-linked torsion beams moved by one motor with slew drive.

The STH-250 model is equipped with an in-house tracker control system, which is programmed with an astronomical algorithm to determine the sun's path.

It includes a backtracking mode to avoid shadowing between rows as well as a stow positioning to protect the tracker in extreme wind conditions. Thanks to Modbus TCP/IP standard, STI's control system can be easily integrated into the plant's communications system and SCADA.

STI's STH-250 holds IEC 62817 and UL 3703 & 2703 certificates and comes with market standard 10 years warranty for structure and 5 years for electromechanical components.

**TrinaTracker** has taken major efforts in wind-tunneling testing and design method regarding 3D-flutter stability analysis and shock response for its tracker systems. Its Agile and Vanguard models have undergone static and dynamic load tests by RWDI wind engineering experts.

Agile uses cardan-joined slew drives, while Vanguard is equipped with multiple linear actuators. TrinaTrackers introduced this year a smart algorithm and SCADA system for cloud-based tracker control monitoring providing real-time system management.



Source: STI Norland

**'Robust' slew drive: STI Norland underscores its STI-H250 model uses robust slew drives to enlarge the power of the motor into a controlled, high torqued output.**





**Pioneer: STI-H250 was the world's first dual-row solar tracker on the market in 2017, according to STI. The tracker control system is programmed with an astronomical calculation algorithm and includes backtracking mode.**



SuperTrack combines astronomical algorithms with real-time meteorological data for tracking control. It can distinguish between light clouds and overcast skies and light and strong winds or gusts. The control system integrates multiple extreme weather risk mitigation strategies, including strong wind, heavy snow and hailstorm.

The Chinese manufacturer has also designed a smart alarm system, which includes three pre-configured stow levels based on wind velocity, according to which TrinaTrackers go to 0° stow position only for high-speed winds above 60 km/h.

Additionally, a slope model and neural network algorithms optimizes the tracking angle for complex terrains through three-dimensional modeling. The communication signal can be kept stable by LoRaWAN technology. According to Trina, its SuperTrack leads to a 3-8% energy gain which is verified by Solar Energy Division of China's General Certification Center (CGC).

TrinaTracker's Vanguard is certified according to IEC 62817, even for large form factor solar modules based on 210 mm wafers, a product strongly

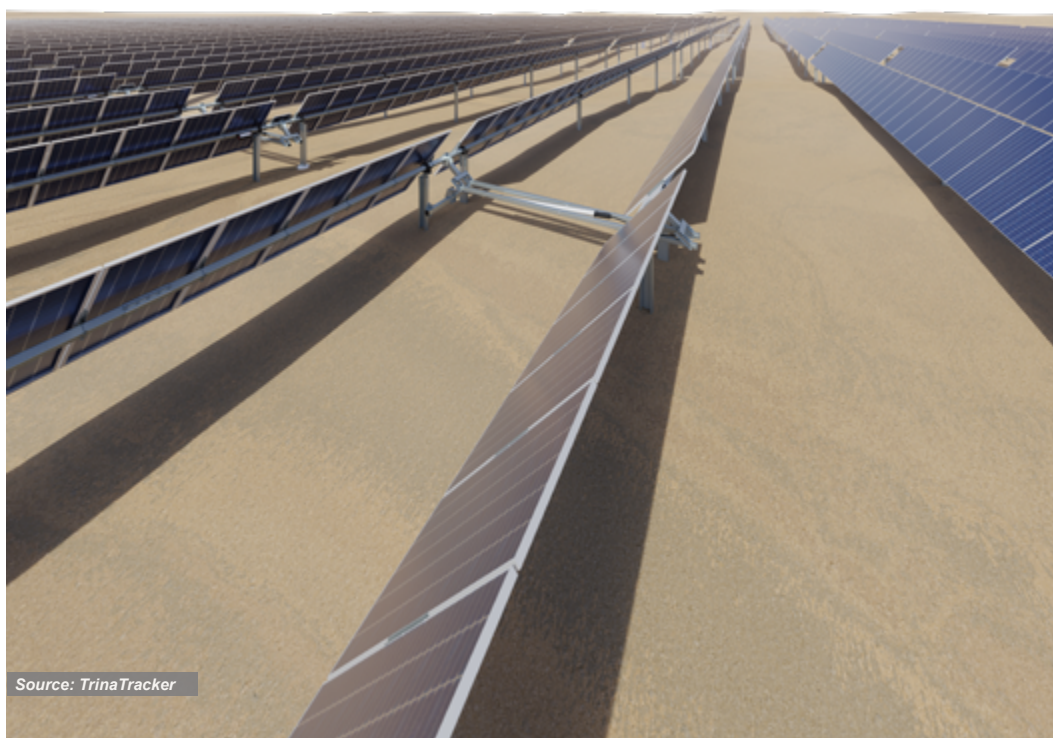
supported by Trina Solar. For its Agile tracker, the IEC 62817 certification process is still ongoing, which is also the case for UL 3703, but here both systems still have to finalize the certification process.

Trina offers typical a 10-year warranty for structure and 5 years for both motor and electronics.

### 3.2 DAT systems

**Big Sun Energy** offers iPV tracker, a cable-driven DAT system able to swivel in 360° to maximize solar generated electricity. The iPV system has been introduced into the market in 2014. Since then, Big Sun Energy's tracker system has undergone several improvements, such as the addition of a horizontal automatic adjustment function, stainless steel as cable material, and a lowering of the gravity center of the cross-joint point.

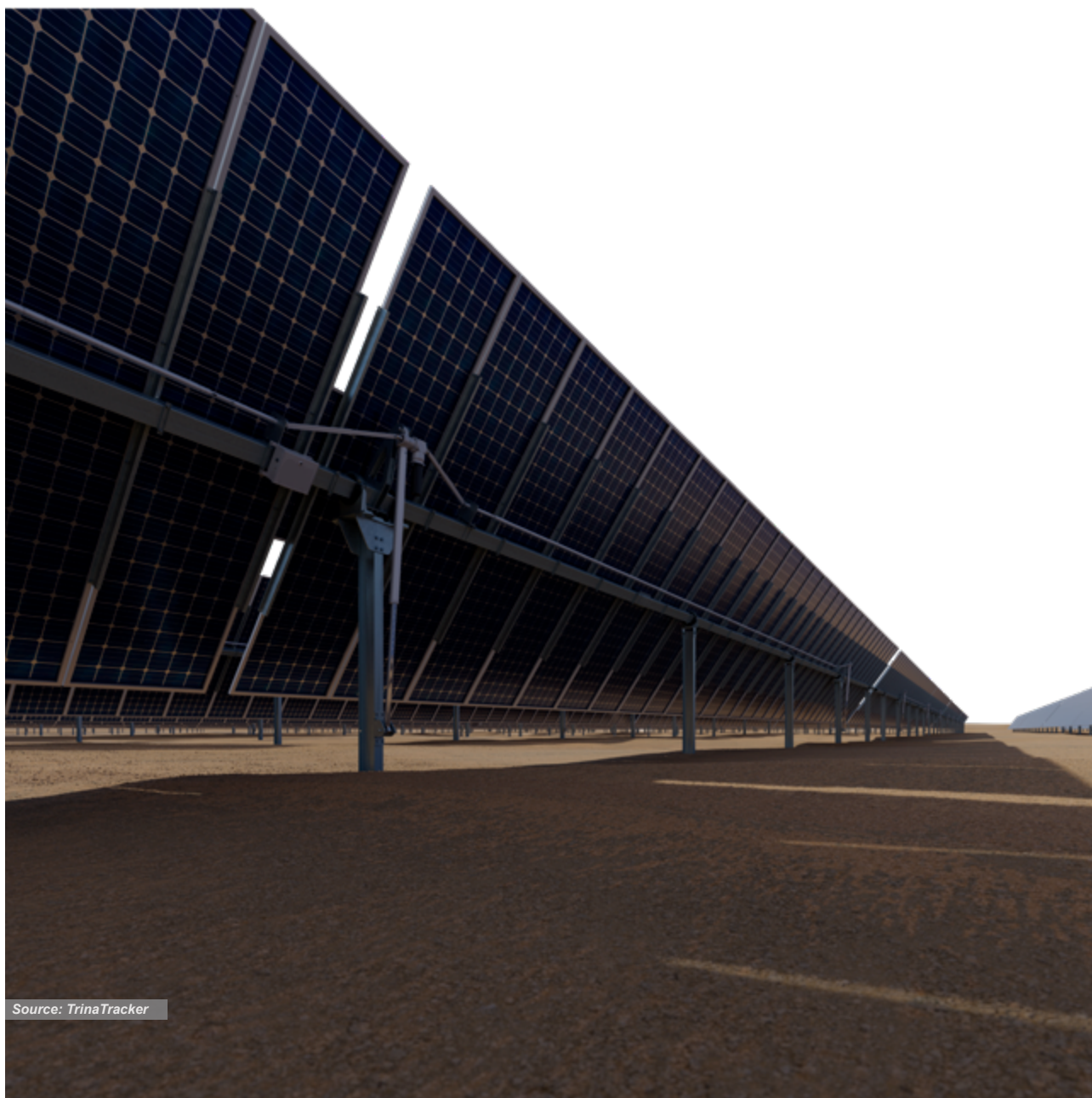
The solar tracker allows tilting at any azimuth due to its steel-wire drawn drive mechanism. Its iPVita cloud-based PV monitoring and control portal provides real-time system management. The DAT tracker can be remotely controlled and automated via software interface.



Source: TrinaTracker

**Cardan-joined & intelligent: TrinaTracker's Agile model uses cardan-joined slew drives and is controlled by its AI-based SuperTrack software.**





Source: TrinaTracker

**Large-scale form-factor: TrinaTracker's Vanguard uses multiple linear actuators and is able to support modules with output power exceeding 600 W. Trina is the only world leading module manufacturer that has in its portfolio an in-house made tracker product line.**

It is designed for commercial and rooftop applications including rooftop and mounting. Big Sun Energy offers a warranty of only 5 years for structure and 1 year for motor and electronics.

**Mechatron** has sent data for its full-tilt M18KD and limited tilt M18KD-20 trackers. The latter is equipped

with a shorter elevation cylinder and is limited up to 20° on the zenith axis. M18KD-20 is designed for parking lots and has a limited platform distance from the parking pavement to avoid car crashes. Mechatron's DAT systems are based on gearless slew drives with hydraulic motors and can spin all around the azimuth range from -180° to +180°.



A hydraulic system is used for the azimuth motion and the motion of the elevation axis utilizes an additional piston and oil as dampener. In case of sudden wind load with force exceeding the brake pressure, the drive slips and protects the mechanism from damage. The braking position of the brake band is achieved at low oil pressure in the cylinder, meaning that in case of brake failure, the tracker remains stationary. In case of a leak at the main brake cylinder, the system generates an error

message, freezes operation, stows its platform and remains stationary until the cylinder gets repaired. There is no backlash as there are no free moving parts anywhere in the mechanism.

Mechatron offers a guaranteed uptime of 99.6% and an extraordinary 20-years long warranty for all tracker components including mechanical components, electronics, hydraulics and pneumatics.



**360° swivel: Mechatron's gearless DAT product can spin all around the azimuth from  $-180^{\circ}$  to  $+180^{\circ}$  and comes with an extraordinary 20-years long warranty for all tracker components.**

## 4. Conclusions

Everyone in solar knows beautiful photos of gigantic power plants using trackers, with the modules directly facing the sun at dawn, high-noon or sunset, thus enabling higher power yields over the course of the day compared to fixed mounted solutions. But unlike for cells, modules or other components of a solar system, there is hardly any comprehensive and free technical information available for such solar trackers. That's why we decided to publish a first TaiyangNews Market Survey on Solar Trackers, providing background on this promising technology, the main players and their products.

In fact, we've seen PV tracking systems already nearly 2 decades ago, when very generous feed in tariffs in Spain paved the road for the pioneers in the field to design the first commercial volumes of tracking systems for traditional solar modules. But with the sudden end of the first Spanish solar boom, the first large tracker wave ended as well. Quickly decreasing module prices versus high tracker cost, teething troubles with the products, missing standards – all that had developers rather rely on one of solar's main advantages in the power game: Generating electricity without need for any moving parts, thus reducing maintenance requirements to comparatively very low levels. In other words, mostly stick to fixed tilt racking.

Fast forward to 2015, tracker technology has further improved and entered the 10% utility-scale solar market penetration level, with 2-year-old NEXTracker from the US changing this solar technology segment,

when it was taken over by multinational Flex for around \$330 million. In the coming 5 years, trackers expanded their market share to over 30%, and two leaders in that field were able to raise capital on public markets in 2020, with Soltec's IPO marking the first at the Spanish Mercado Continuo after 2 years without any debuts.

Today, the tracker market is very diversified. While only a handful companies dominate the solar tracker segment, a total of 19 companies, including all market leaders, have sent us technical specifications for 36 products; and there's more out there.

Over the next 7 years, the International Roadmap for Photovoltaic (ITRPV) forecasts the solar tracker share to grow to 40% in the utility scale solar segment. This growth rate is doable, but it might go faster. At our Solar Tracker Conference on April 13, BayWa r.e., a leading European renewables developer, showed financial modelling data for trackers versus fixed tilt mounted solar modules – and the LCOE advantage for the moving product was high, and even higher with bifacial modules.

While trackers have been traditionally installed as part of solar systems located in very sunny regions, their much higher yield make them increasingly attractive also in less sunny places. European Energy, another developer speaking at our event, already has tracking PV systems installed in its home country Denmark – and plans to add more. A pro-tracker decision, however, is only taken if a site

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has no area constraints or high land cost, which both penalizes tracker solutions. On the other hand, the growing share of solar and grid constraints plays in the hand of trackers as the technology enables flattening the generation curve.

One reason for the tracker success story is also its manufacturer's ability to implement changes quickly, in particular following the rapid technological evolution of solar modules in recent years. All leading solar tracker suppliers have re-engineered their systems to support bifacial modules, which are a perfect match to HSAT systems. Tier 1 tracker producers have been also optimizing designs and stability of their devices to support the new very large form factor modules – and without compromising on safety under harsh weather conditions. Just this April, TrinaTracker and PVH, for example, have come out with new products that are designed for handling also 600 W+ modules.

After severe damages with solar trackers were seen in a number of utility-scale PV power plants in 2018, investors requested compliance not only to relevant standards but also performance of dynamic aeroelastic tests. While all tracker manufacturers in our survey do have certified their products according to at least one of the three international standards for solar trackers (IEC 62817, UL 3703 and UL 2703), DNV, a leading independent engineer, pointed out at our conference, that the PV tracker

industry is lacking appropriate standardization. To be on the safe side, established tracker producers are working with specialized firms to conduct aeroelastic testing procedures in wind tunnels that are not part of the official test standards. However, what's ultimately needed are simply updated standards with comprehensive testing procedures.

With cost pressure on solar technology continuing, tracker manufacturers have been further optimizing their products. The latest developments to squeeze the most out of solar panels are based on Artificial Intelligence optimized tracking control and weather alarm strategies with LoRaWAN for communication between tracker drives, sensors and SCADA systems. AI tracking allows for learning control routines for optimal tilts under various weather conditions; it can differentiate between overcast sky and partly cloudy conditions and optimize the tilt for high bifacial gain, for example. The optimized tilt even considers inverter power output and albedo values.

So, when looking next time at a beautiful photo with a tracker based solar power plant in a sunset scenario, you might want to keep in mind that these trackers have become a fairly important part to reduce solar cost and its intelligence helps enabling flexible solar technology to master its growing role as the key technology in the energy transition.



## 5. Interview – TrinaTracker

### From Solar Module to Trackers & Power Plants

With ‘bifacial’ becoming an important technology part of a PV system, trackers have truly started to enjoy the limelight. These sun tracking devices, when combined with bifacial modules have proved to result in synergistic gain in energy generation yield. Given this increasing market demand, Trina Solar – a world leading PV solution provider has embarked on the tracker business since 2018. TaiyangNews talked to Kevin Shu, Vice Director TrinaTracker Product Management, about Trina Solar’s background for entering into the trackers stream and various techno commercial aspects of trackers.



**KEVIN SHU, Vice Director TrinaTracker Product Management**

Kevin Shu has worked at Trina Solar for over 12 years with main focus on PV module and tracker product development. With 7 years in R&D and 5 years in leading the product management, he has a wide understanding of the trends in PV module, tracker, and PV system development. He holds a MSc. degree in mechanical engineering.

**TaiyangNews:** Despite the pandemic situation, the solar market has fared well in terms of installations and shipments in 2020. As a leading vertically integrated PV manufacturer, how do you feel about the business in the first quarter of the year 2021 and what is your estimate for year-on-year global growth and installations this year?

**Kevin Shu:** When looking back into early 2020, due to COVID 19, the industry faced big pressure with the supply of modules faced. But most Chinese module manufacturers have overcome the difficulties and reduced the supply impact as much as possible. With the support of positive policies globally, total newly installed PV capacity in 2020 grew to around 135 GW.

Regarding the 2021 outlook, I believe the key topics are module and system prices. If we can continue with the general price downward trend, global shipment is expected to reach 160 GW in 2021.

**TaiyangNews:** With utility-scale solar being the core of PV applications, what are the most important technology developments in this segment?

**Kevin Shu:** As it is widely known in the industry, from the module side, employing larger wafers, like the 210 mm format, is one of the key technology advancements in 2020. Trina Solar has been on

the forefront in making this wafer size a standard - and many companies have been following suit. Strictly speaking of module technology, MBB and half-cell are pretty common these days. Reducing the cell gap has caught some interest, especially with modules becoming larger and more powerful. Meanwhile, “bifacial” is increasingly gaining market shares, especially in combination with trackers, it has proven to have increase the energy yield and reducing LCOE, ultimately making solar power more affordable.

**TaiyangNews:** Speaking of trackers, what really attracted a world leading module maker to venture into trackers by taking over Spanish tracker manufacturer Nclave?

**Kevin Shu:** First, from a technical point of view, I believe bifacial module plus trackers is a very effective way to reduce the LOCE of the PV industry. Second, from the perspective of PV system cost structure, the module share is around 50%, the tracker share is between 15% and 20%, and then come inverters with 10%. As modules and trackers account for the largest share of costs, we concluded that we can be more cost competitive, when we manufacture both modules and trackers.

**TaiyangNews:** With bifacial being a key enabler for trackers, what is Trina’s opinion on bifacial technology?

**Kevin Shu:** *Bifacial is a strong and an important technology trend in the industry. The technology offers an effective way to boost system yield. I. At Trina, over 70% in the utility segment of our module products will be bifacial in 2021. In fact, last year, the strong demand of bifacial is one of the main reasons why the glass industry was in short supply, since bifacial modules need one extra piece of glass compared to the mono-facial variant.*

**TaiyangNews:** *Trina is now the only leading module manufacturer that also produces solar trackers. Do you see any advantages in further development of tracker design with your experience in module manufacturing? What is this exactly?*

**Kevin Shu:** *Since the module is still the heart of a PV system, tracker design needs to take solar module trends into consideration. We can clearly see Trina's rich module R&D and manufacturing experience is a huge advantage, not only for our tracker arm, but also for the tracker industry as a whole. The biggest challenge for solar tracker manufacturers is the solar module integration. Everything from wafers to cells to modules is changing rapidly. Last year, the solar module output power increased by over 100 W within only one year. Solar tracker manufacturers need an "all-seeing eye" to understand the whole PV related industry. As an experienced module manufacturer, we do have a head start in terms of what kind of modules are coming next into the market and thus can adapt the tracker development accordingly. For example, we do evaluate the reliability of "module + tracker" as package product together, not only as separate product. And we also explore opportunities to ease the module connections with trackers to speed up the installation and grounding work. Without going into details, you can imagine the cost savings potential.*

**TaiyangNews:** *You provided product specs to our market survey for a 1P and a 2P tracker design. What's the difference, where are these products applied, and what is the most successful of these two?*

**Kevin Shu:** *We have been developing different tracker product lines for different environments and applications, like the Vanguard is our 2P product fit for challenging terrain conditions, where piles and ramming costs are high, while Agile 1P is our universal solution.*

**TaiyangNews:** *Are you selling your trackers only as part of total solutions or can they be bought also separately? If the second, how frequently is this happening?*

**Kevin Shu:** *Currently our tracker business model is flexible. We want to meet customers' needs by offering the most advanced trackers in the 600W+ era. Thus, we prefer to pack Trina modules and trackers together, which allows us to offer standardized, reliable, and easy-to-assemble solutions – as we can act as a one stop solution for both trackers and modules, taking care of different matters such as sales, shipment, warranty and customer support. In addition to selling standardized package solutions we are also selling trackers and modules separately, cooperating with those tracker customers that prefer other modules brands. In fact, so far the share between combined Trina modules/trackers and individual tracker sales holds the balance at 50%.*

**TaiyangNews:** *Nearly 3 years after the tracker business incorporation, are you happy with that decision to further integrate into a full utility-scale solutions provider? If yes, why?*

**Kevin Shu:** *Absolutely, we are more than happy for this decision. But when I look 3 years back, I see the difficulties we have overcome and the big progress we have made. We integrated the European tracker technology quality and design concept, which is globally advanced, and we added from China the cost control and the supply chain to support tracker manufacturing. Now our Chinese R&D department is working very closely with our EU team to support the global business; at the same time, we are still keeping our European channels open. Based on our good understanding of module technology trends, we develop new trackers accordingly, ensuring all products are impeccably compatible with the latest modules. And we have upgraded our overall quality and service system and apply stricter quality standards. In addition, Trina Solar has good bankability and well-established marketing channels globally, and the same can also be used for trackers, which is yet another advantage we have over "trackers-only" producers.*

**TaiyangNews:** *What are your plans regarding tracker manufacturing this year?*

**Kevin Shu:** *TrinaTracker's manufacturing capacity reached 8 GW this year, around 70% of which is based in China and the other 30% in Europe, Latin*

America and Brazil. As PV projects become bigger, 10 MW in the past versus over 500 MW nowadays, labour costs are more important. Thus, it is important to manufacture in China for the Chinese market and also have production lines in Europe, Latin America and Brazil.

**TaiyangNews:** Where do you see the most attractive markets for solar trackers this year and mid-term?

**Kevin Shu:** Currently, market penetration for trackers varies from country to country. In the mid-term, TrinaTracker will continue its strength in traditional markets meanwhile growing in emerging markets. TrinaTracker will identify and decide which emerging markets are worth developing.

**TaiyangNews:** And how do you see the general market development for utility-scale PV with trackers in the coming years?

**Kevin Shu:** In general, we expect a market increase potential of tracker applications in the utility sector. The market share for utility scale solar is 70%, and 50% of installations in mature markets like USA are equipped with trackers. This share depends strongly on location: in the US, investors ask themselves what kind of trackers they should use, while in China and emerging markets people still think about employing trackers or not. In the next 4 years, the average global market share for trackers will be around 50%. Anyway, we believe there is a saturation point even in the US of 70% to 80% regarding too high latitude, extreme weather conditions and undulated terrain, which means fixed tilt mounting systems will still take some shares in the future.

**TaiyangNews:** Trina is a leading force in pushing 210mm wafer-based modules. How do they fit with your and other tracker products?

**Kevin Shu:** Already 8 Top tracker suppliers have announced that they have made their trackers compatible with 210mm wafer-based modules: TrinaTrackers, Arcotech, Array Technologies, GameChange Solar, Nextracker, Ideematec, Soltec and PV Hardware.

**TaiyangNews:** What kind of tests are you performing to see if the large module types work sustainably and reliable in the long run with the tracker?

**Kevin Shu:** We perform statical, dynamic and

aeroelastic wind tunnel testing to ensure the reliability of our solar trackers. We do not rely only on tests according to IEC 62817 and UL 3703, we go beyond the standards. Passing the standards does not warrant reliability. Because, as with modules, technology development is taking place at a much higher pace than adaptation of standards is able to catch-up. Today, we have separate testing standards for modules and trackers, but what would be more interesting is to test modules and trackers together; that would provide much more realistic data. In the end, testing the whole system with modules, trackers, inverter and SCADA system would be even more beneficial.

**TaiyangNews:** Talking about tracking algorithms and control systems – what does TrinaTrackers implement?

**Kevin Shu:** We apply SuperTrack, an intelligent tracking technology - a smart algorithm which can boost extra power generation by 3-8%, and a SCADA system for tracker control monitoring and alarm. We keep the signal stable by LoRaWAN communication technology. Moreover, TrinaTrackers are available in various configurations and customers can select based on their needs and preferences.

**TaiyangNews:** What are your strategies for reducing installation time and costs?

**Kevin Shu:** There are two important avenues for further cost reduction. There is a potential to reduce the material costs by 10% to 15%. Further research in new materials and pre-assembled design can also reduce costs 5 to 10%. However, too many pre-assembled configurations may pose problems in transportation and strength. Reducing the installation time per watt can also contribute to a little savings, which we are addressing by using fast installation clamps and click fasten.

**TaiyangNews:** What's the next big thing for trackers in general? And what's the key development tasks on Trina's To-Do list?

**Kevin Shu:** In terms of technology, currently the industry focuses more on wind tunnel tests for hardware structural stability, but software, such as smart algorithms, monitor platform are important to be taken into consideration for the long-term. In terms of integration, product development of trackers needs to consider the whole industry chain, including modules, inverters, cleaning robots, etc. But for me the most important topic is standards.



*Currently, there are no unified mature standards in the tracker industry, which leads to transaction costs increase. Standards needs to be established and improved in the long-run.*

*In summary, with the technology development, well-established standards and integration of the whole industry chain, the value of trackers will be greatly improved, which will further increase the global market share of trackers.*

**TaiyangNews:** Thank you for the interview.

## 6. Product Specifications Table

TaiyangNews Market Survey on Solar Trackers 2021		
Company	Arctech	Array Technologies
Product name	SkySmart II	DuraTrack HZ v3
Available since	2019	2016
Tracking type	HSAT independent row	HSAT, centralized
Bifacial enabled	Yes	Yes
Dimensions		
Typical row size	Max. 4 strings 120 modules	104
Total system size (length × width × height)	70 x 5 x 2.5 m	118 x 2.3 x 1.4 m
Total system weight	NA*1	-
General		
Modules supported	All types	All framed & various frameless
String voltage	1,500V	1,500 V
Module configuration	2P (4 x 1500V)	1P
Module attachment	Self ground. (fix-fix & fix-free spans)	Single-bolt, integr. grounding, top-down clamp
Array height	~ 2.3 m	≥ 1.2 m*1
Bifacial features	2P big. gap tor. tube	Optim. mounting height above tube, 1P*2
Ground coverage ratio GCR	≥ 35%*1	28 - 45 %*3
Material	HDG , pre-galvanized steel	Galv. steel, aluminum
Tracking range of motions	± 60°	52°
Operating temperature range	-40 ~ 80 °C	-40C ~ 60 °C
Mechanical		
Allowable wind speed & wind gust duration	169 km/h, na*1,*2	225 km/h, 3s gust
Wind protection	0° stow pos.	Passive wind mitigation, fully mechanical system
Corrosion protection standard	NA*1	C2, C3, C4 applications offered
Coatings	ISO 1461. ASTM A653	ASTM A653 G90, POSMAC M140, ASTM A123 G45, EN10346 ZM310
Foundations	W8, ram., pre-dril., concrete piles	W6, W8, IPE
Electrical		
Power supply	String-powered	Aux. AC powered
Drive type	Multi-point slew	Motorized helical-worm gearbox
Drive type accuracy	± 2°	± 2°
Motor type	DC brushless, 28V	AC brushless, 400 V - 480 V
Electronics and controls		
Solar tracking method	AI astron. alg. & tilt sens. close loop	Algorithm with GPS input, SmarTrack
Backtracking	Yes	Yes
Sensors	Wind, snow, inclination	No requir., tilt angle measured at motor encoder
Communication system	LoRaWAN	Wired to MCU, MODBUS over ethernet to site SCADA
Safety position	0°	52° wind / hail
Nighttime stow	Yes	Yes
Installation, operation and service		
PE stamped structural calculations and drawings	Included	Included
Online training and system commissioning	Included	Included
Installation requirements	No	All bolted connections, no field welding or riveting
Monitoring	SCADA	No
Module cleaning compatibility	Yes	Robotic, tractor or manual
Certificates		
IEC 62817	Yes	Yes
UL 3703	Yes	Yes
UL 2703	Yes	Yes
Warranty, time of delivery, distribution area		
Warranty - structure	10 years	10 years*3
Warranty - motor	5 years	5 years*3
Warranty - electronics	3 years	5 years*3
Time of delivery	NA	3.5 - 4 months
Distribution area	Global	EU, USA, LATAM, AUS, MENA
The most important benefits	<ul style="list-style-type: none"> <li>Fully certified</li> <li>Slew drive</li> <li>multiple-point</li> </ul>	<ul style="list-style-type: none"> <li>Wind-tun. aeroelastic tests</li> <li>AI tracker controlling</li> <li>20% N-S slope</li> </ul>
Notes		
	*1 Berings or bushings; *2 Dep. on project	*1 Share logics & motorization betw. ≥ 2 rows; *2 Berings or bushings

## TaiyangNews Market Survey on Solar Trackers 2021

Company	Axial	Axial
Product name	Axial Tracker 3H	Axial Tracker 1V / 1V Twin* <sup>1</sup>
Available since	2016	2019
Tracking type	HSAT independent row	HSAT
Bifacial enabled	Yes	Yes
Dimensions		
Typical row size	20 modules	56 modules
Total system size (length × width × height)	40 x 2.7 - 3.3 x 3 m	60 x 1.8-2.2 x 2.2 m
Total system weight	~ 1,200 kg	~1,200 kg
General		
Modules supported	All types	All
String voltage	1,000 / 1,500 V	1,000 / 1,500 V
Module configuration	3-in-landscape	1P
Module attachment	Bolted fix. / clamped for non-framed	Bolted fix. / clamped for non-framed
Array height	3 m at 55°	2.2 m at 55°
Bifacial features	-	-
Ground coverage ratio GCR	≥ 30%	≥ 28%
Material	HDG / contin. coating, plastic* <sup>1</sup>	HDG / contin. coating, plastic* <sup>2</sup>
Tracking range of motions	± 55°	± 55°
Operating temperature range	0 ~ 45°C self- / -40°C ~ 45°C grid-powered	0 ~ 45°C self- / -40°C ~ 45°C grid-powered
Mechanical		
Allowable wind speed & wind gust duration	50 km/h, 3s (10m)	50 km/h, 3s (10m)
Wind protection	Axial blocking system	Stow position / dampers
Corrosion protection standard	UNE-EN/ISO 14713 & DIN 50929 for buried profiles	UNE-EN/ISO 14713 & DIN 50929 for buried profiles
Coatings	HDG: UNE-EN 1179 & 1461 cont. coat. UNE-EN 10346	HDG: UNE-EN 1179 & 1461 cont. coat. UNE-EN 10346
Foundations	IPE / W, C profiles	IPE / W, C profiles
Electrical		
Power supply	Self- / grid- / string-powered	Self- / grid- / string-powered
Drive type	Slew	Slew
Drive type accuracy	≤ 0.2°	≤ 0.2°
Motor type	DC 24 V	DC 24 V
Electronics and controls		
Solar tracking method	NREL SPA & 3D backtracking	NREL SPA & 3D backtracking
Backtracking	Yes	Yes
Sensors	Wind, snow	Wind, snow
Communication system	Zigbee	Zigbee
Safety position	5°* <sup>2</sup>	45°
Nighttime stow	Yes	Yes
Installation, operation and service		
PE stamped structural calculations and drawings	Included	Included
Online training and system commissioning	Included	Included
Installation requirements	Bolted con. no on-side welding & mechanization	Bolted con. no on-side welding & mechanization
Monitoring	SCADA prop. software	SCADA prop. software
Module cleaning compatibility	Yes	Yes
Certificates		
IEC 62817	Yes	Yes
UL 3703	Yes	Yes
UL 2703	Yes	Yes
Warranty, time of delivery, distribution area		
Warranty - structure	25 years	25 years
Warranty - motor	5 years	5 years
Warranty - electronics	5 years	5 years
Time of delivery	1.5 months (ETD)	1.5 months (ETD)
Distribution area	EU, US, SA, AS, MENA, EMEA, CAR	EU, US, SA, AS, MENA, EMEA, CAR
The most important benefits	• Axial blocking system • Fully certified	• Fully certified
Notes		
	*1 Berings or bushings; *2 Dep. on project	*1 Share logics & motorization betw. ≥ 2 rows; *2 Berings or bushings



**TaiyangNews Market Survey on Solar Trackers 2021**

Company	Axial	Axial
Product name	Axial Tracker 2V / 2VBi	AgriTracker
Available since	2018	2020
Tracking type	HSAT independent row	HSAT*1
Bifacial enabled	Yes	Yes
Dimensions		
Typical row size	28 modules	32 modules
Total system size (length × width × height)	40 x 2.7-3.3 x 4-5 m	60 x 1.8-2.2 x 22 m
Total system weight	~1,200 kg	~1,200 kg
General		
Modules supported	All types	All
String voltage	1,000 / 1,500 V	1,000 / 1,500 V
Module configuration	2P	1P
Module attachment	Bolted fix. / clamped for non-framed	Bolted fix. / clamped for non-framed
Array height	3 m at 55°	2.2 m at 55°
Bifacial features	- / central gap for Axial 2VBi	-
Ground coverage ratio GCR	≥ 36%	≥ 28%
Material	HDG / contin. coating, plastic*1	HDG / contin. coating, plastic*2
Tracking range of motions	± 55°	± 85°
Operating temperature range	0 ~ 45°C self- / -40°C ~ 45°C grid-powered	0 ~ 45°C self- / -40°C ~ 45°C grid-powered
Mechanical		
Allowable wind speed & wind gust duration	50 km/h, 3s (10m)	50 km/h, 3s (10m)
Wind protection	Axial blocking system	Stow position / dampers
Corrosion protection standard	UNE-EN/ISO 14713 & DIN 50929 for buried profiles	UNE-EN/ISO 14713 & DIN 50929 for buried profiles
Coatings	HDG: UNE-EN 1179 & 1461 cont. coat. UNE-EN 10346	HDG: UNE-EN 1179 & 1461 cont. coat. UNE-EN 10346
Foundations	IPE / W, C profiles	IPE/W, C profiles
Electrical		
Power supply	Self- / grid- / string-powered	Self-/grid-/string-powered
Drive type	Slew	Slew trans. System
Drive type accuracy	≤ 0.2°	≤ 0.2°
Motor type	DC 24 V	DC 24 V
Electronics and controls		
Solar tracking method	NREL SPA & 3D backtracking	NREL SPA & 3D backtracking
Backtracking	Yes	Yes
Sensors	Wind, snow	Wind, snow
Communication system	Zigbee	Zigbee
Safety position	5°*2	45°
Nighttime stow	Yes	Yes
Installation, operation and service		
PE stamped structural calculations and drawings	Included	Included
Online training and system commissioning	Included	Included
Installation requirements	Bolted con. no on-side welding & mechanization	Bolted con. no on-side welding & mechanization
Monitoring	SCADA prop. software	SCADA prop. software
Module cleaning compatibility	Yes	Yes
Certificates		
IEC 62817	Yes	Yes
UL 3703	Yes	Yes
UL 2703	Yes	Yes
Warranty, time of delivery, distribution area		
Warranty - structure	25 years	25 years
Warranty - motor	5 years	5 years
Warranty - electronics	5 years	5 years
Time of delivery	1.5 months (ETD)	1.5 months (ETD)
Distribution area	EU, US, SA, AS, MENA, EMEA, CAR	EU, US, SA, AS, MENA, EMEA, CAR
The most important benefits	• Axial blocking system • Fully certified	• Fully certified
Notes		
	*1 Berings or bushings; *2 Dep. on project	*1 Share logics and motorization betw. ≥2 rows; *2 Berings or bushings

**TaiyangNews Market Survey on Solar Trackers 2021**

Company	Big Sun Energy	Clenergy
Product name	iPV Tracker	EzTracker D Series
Available since	2014	-
Tracking type	DAT	HSAT
Bifacial enabled	Yes	Yes
Dimensions		
Typical row size	24 modules	2 x 45 to 60 modules
Total system size (length × width × height)	6.6 x 6.8 x 3.3 m	Customized
Total system weight	730 kg	Customized
General		
Modules supported	All	All
String voltage	1,000 V	1,500 V
Module configuration	2P (2 x 1500V)	2P / 1P
Module attachment	Fastener	Self-grounding
Array height	3.3 m	Customized
Bifacial features	Yes	Torque tube, driverline gaps
Ground coverage ratio GCR	55%	28 ~ 50%
Material	HDG steel	HDG, Al-Mg-Zn coated steel
Tracking range of motions	±360°	± 60°
Operating temperature range	- 40 ~ 80 °C	-30 ~ 60 °C
Mechanical		
Allowable wind speed & wind gust duration	118km/h - 170 km/h, 20s	ASCE 7-05 180km/h
Wind protection	Stow position	Stow position
Corrosion protection standard	C3 (BS EN ISO 12944-2)	C4
Coatings	ISO 1461	DIN EN 10346
Foundations	H-pile, concrete, H-beam & ground screw	Steel pile, PHC pile, concrete
Electrical		
Power supply	AC motor (220 Vac circuit)	Self-/grid-powered
Drive type	Slew gear, motor	Slew drive
Drive type accuracy	± 0.5°	± 1°
Motor type	AC Motor (25 W)	DC brushless 24Volt
Electronics and controls		
Solar tracking method	Astronomical	Astronomical & closed-loop control
Backtracking	Yes 3D	Yes
Sensors	Wind, temperature	Wind, inclination, temperature
Communication system	RS-485 cable / LoRaWAN	RS-485 / zigbee
Safety position	Storm	15~20°
Nighttime stow	Yes	Yes
Installation, operation and service		
PE stamped structural calculations and drawings	Included	Included
Online training and system commissioning	Included	Included
Installation requirements	NA	-
Monitoring	iPVita	Clenergy software
Module cleaning compatibility	Yes	Yes
Certificates		
IEC 62817	No	Yes
UL 3703	Yes	No* <sup>1</sup>
UL 2703	Yes	No* <sup>1</sup>
Warranty, time of delivery, distribution area		
Warranty - structure	5 years* <sup>1</sup>	10 years
Warranty - motor	1 year	5 years
Warranty - electronics	1 year	5 years
Time of delivery	2 ~ 3 months* <sup>3</sup>	1 month
Distribution area	Global	CN, JP, AU, EU, AP
The most important benefits	• 360° swivel	• Tracking accuracy ± 1° • IEC 62817 certified
Notes		
	*1 Opt. up to 170 km/h; *2 Opt. extension; *3 After down payment	*1 In process

**TaiyangNews Market Survey on Solar Trackers 2021**

Company	FTC	GameChange
Product name	Voyager	Genius
Available since	2018	2015
Tracking type	HSAT independent row	HSAT independent row
Bifacial enabled	Yes	Yes
Dimensions		
Typical row size	Max. 4 strings: 120 c-Si, 96 FSLR6, 240 FLRSR4	1P: 90 / 2P: 120 modules
Total system size (length × width × height)	64 x 4.4 x 2.1 m	1P: 100 x 2.2 x 1.4m / 2P: 66 x 4.57 x 1.9 m
Total system weight	Customized	1P: 1,800 kg / 2P: 3,400 kg
General		
Modules supported	c-Si, thin-film, FS series, LFM	c-Si, FS series 4 & 6, frameless, thin film
String voltage	1,000 / 1,500 V	1,001 / 1,500 V
Module configuration	2P	1P, 2P, max. 4 in landscape
Module attachment	Self-grounding, bolted, power cinch clips	Bolts bottom mount, speedclamp™, clamps
Array height	2.1 m	1P: 1.42 m / 2P: 1.9 m
Bifacial features	Driveline gaps, wire harness solution	Gap between row tube, reflector 6-8% boost
Ground coverage ratio GCR	20 ~ 60%	25 ~ 65%
Material	HDG, pre-galv. G90, G185	Galv. steel
Tracking range of motions	± 60°	±45°, ±52°, ±55°, ±60°
Operating temperature range	-20 ~ 60 °C	-40 ~ 48 °C
Mechanical		
Allowable wind speed & wind gust duration	V105: 168km/h / V120: 192km/h	1P: 241 km/h/, 3s
Wind protection	Wind stow act. and pass. locking	Wind alarms, smartstow™
Corrosion protection standard	C3	C3
Coatings	UL 2703, UL 3703	ASTM A123
Foundations	W8, driven, screw, concrete	W6, W8
Electrical		
Power supply	24 V DC self-powered*1	Self-powered*1, battery, grid conn.
Drive type	Slew gear	Linear actuator stainl. steel & aluminum
Drive type accuracy	± 2°	± 5°
Motor type		24V DC UL Listed
Electronics and controls		
Solar tracking method	NREL SPA & backtracking*2	NREL SPA, weathersmart™
Backtracking	Yes	Yes
Sensors	Wind, flood, temperature	Wind, acccelometer, snow, flood
Communication system	Zigbee	Zigbee
Safety position	Wind 0°, snow 40°, flood 0°C, hail 60° stow	35°- 45°
Nighttime stow	Yes	Yes
Installation, operation and service		
PE stamped structural calculations and drawings	Included	Included
Online training and system commissioning	Included	Included
Installation requirements	No	No, pre-assembled comp.
Monitoring	SCADA / DAS Modbus TCP	WEBAPP, implem. SCADA PLANT
Module cleaning compatibility	Yes	Yes
Certificates		
IEC 62817	Yes	Yes
UL 3703	Yes	Yes
UL 2703	Yes	Yes
Warranty, time of delivery, distribution area		
Warranty - structure	10 years	10 years
Warranty - motor	5 years	5 years*2
Warranty - electronics	5 years	6 years*2
Time of delivery	3.5 months	2 - 2.5 months
Distribution area	EU, USA, MENA, AUS, ASIA PACIFIC	Global
The most important benefits	<ul style="list-style-type: none"> <li>Fully certified</li> <li>Var. stow pos.: wind 0°, snow 40°, flood 0°C, hail 60°</li> </ul>	<ul style="list-style-type: none"> <li>Fully certified</li> <li>Reflector for extra 6-8% bifacial boost</li> <li>AI tracker controlling</li> <li>Quick inst. pre-assembled comp. speedclamp™</li> </ul>
Notes		
	*1 3-day bat. backup; *2 Add. energy yield gain with Sunpath algorithm	*1 Through extr. PV panel; *2 Opt. 10 years



**TaiyangNews Market Survey on Solar Trackers 2021**

Company	Grace Solar	Ideematec
Product name	GS-Light	H4Plus
Available since	2017	2015
Tracking type	HSAT, independent row	HSAT, independent row
Bifacial enabled	Yes	Yes
Dimensions		
Typical row size	90 modules	360 modules
Total system size (length × width × height)	95 x 2.35 x 1.76 m	180 x 4.5 x 2.2 m
Total system weight	2,000 kg	7,500 kg
General		
Modules supported	All types	c-Si, thin-film, some FS series
String voltage	1,000 / 1,500 V	1,000 / 1,500 V
Module configuration	1P / 2P	2P / 4-in-landscape
Module attachment	Self-grounding, kind of fasteners	Clamps, bolts, rivets
Array height	1.8 m	2.2 m
Bifacial features	Higher gap betw. module and torq. tube	High dist. betw. module backside
Ground coverage ratio GCR	40%	30 - 50%
Material	HDG, pre-galv. steel	Galv. steel
Tracking range of motions	± 60°	± 55°
Operating temperature range	-30 ~ 60 °C	-20 ~ 50 °C
Mechanical		
Allowable wind speed & wind gust duration	169 km/h*1	160 km/h, 3 s
Wind protection	15° stow	0° wind stow
Corrosion protection standard	C1 - C5	C3, C4 / C5 opt.
Coatings	DIN EN 10346	DIN EN 10346
Foundations	Ramming, pre-drill., concrete piles	SIGMA foundation
Electrical		
Power supply	AC powered	AC powered
Drive type	Slew	Slew gear
Drive type accuracy	± 0.1°	± 0.2°
Motor type	24 V DC motor	TGB 380 V, 370 W
Electronics and controls		
Solar tracking method	Astron. algorithm & tilt-senser closed loop	Astronomical
Backtracking	Yes	Yes 3D
Sensors	Wind, inclination	Wind, inclination, temperature
Communication system	RS 485 / LoRaWAN	Wire / e.g. GSM
Safety position	15°	0°
Nighttime stow	Yes	Yes
Installation, operation and service		
PE stamped structural calculations and drawings	Included	Included
Online training and system commissioning	Included	Included
Installation requirements	Installation guide	Special tools for precise and fast installation
Monitoring	Yes, prop. software	Yes
Module cleaning compatibility	Yes	Yes*1
Certificates		
IEC 62817	Yes	No*2
UL 3703	Yes	Yes
UL 2703	Yes	Yes
Warranty, time of delivery, distribution area		
Warranty - structure	10 years	10 years
Warranty - motor	5 years	5 years
Warranty - electronics	3 years	2 years
Time of delivery	6 months	3 months
Distribution area	Global	EU, USA North and South, MENA, APAC
The most important benefits	• Fully certified • AI tracker controlling	• Patented drive technology • 35% fewer parts for faster installation
Notes		
	*1 opt. higher wind loads	*1 Three robots in evaluation; *2 In progress

**TaiyangNews Market Survey on Solar Trackers 2021**

Company	Ideematec	Mechatron
Product name	L:Tec	M18KD, M18KD-20* <sup>1</sup>
Available since	2020	1st version in 2008
Tracking type	HSAT, independent row	DAT* <sup>2</sup>
Bifacial enabled	Yes	Yes
Dimensions		
Typical row size	360 modules	90 modules
Total system size (length × width × height)	190 x 5.0 x 2.4 m	27 x 10 m on 4m tall concrete pier
Total system weight	7,000 kg	~ 2,087 kg
General		
Modules supported	c-Si, thin-film, some FS series	All types
String voltage	1,000 / 1,500 V	1,000 / 1,500 V
Module configuration	2P / 4-in-landscape	9 x 10 modules
Module attachment	Clamps, bolts, rivets	MechGrip clamp
Array height	2.4 m	4 m
Bifacial features	No parts on active area of modules' backside	Propr. design reflector attached to platform
Ground coverage ratio GCR	30 - 50%	45%
Material	Galv. steel	Galv. steel
Tracking range of motions	±60°	Zenith 0 - 80 °C, azim. -180 to 180 °C (360°)
Operating temperature range	-20 ~ 50 °C	-40~ 90 °C
Mechanical		
Allowable wind speed & wind gust duration	160 km/h, 3 s	110 km/h, 3s
Wind protection	0° wind stow	Self-stow at gradual wind speeds, software driven
Corrosion protection standard	C3, C4 / C5 opt.	C5
Coatings	DIN EN 10346	PER ASTM-A653 G90
Foundations	SIGMA foundation	Concrete piers
Electrical		
Power supply	AC powered	AC 400-500V
Drive type	Slew gear	Propr. slew gearless
Drive type accuracy	±0.2°	1°
Motor type	TGB 380 V, 370 W	410 W
Electronics and controls		
Solar tracking method	Astronomical	Astronomical & clock updates
Backtracking	Yes 3D	Yes
Sensors	Wind, inclination, temperature	Wind, snow
Communication system	Wire / e.g. GSM	RS485 / zigbee, ethernet
Safety position	0°	Self-stow
Nighttime stow	Yes	Yes
Installation, operation and service		
PE stamped structural calculations and drawings	Included	Included
Online training and system commissioning	Included	Included
Installation requirements	Special tools for precise and fast installation	Boomlift, crane
Monitoring	Yes	Yes
Module cleaning compatibility	Yes* <sup>1</sup>	Yes
Certificates		
IEC 62817	No* <sup>2</sup>	No
UL 3703	Yes	Yes
UL 2703	Yes	Yes
Warranty, time of delivery, distribution area		
Warranty - structure	10 years	20 years
Warranty - motor	5 years	20 years
Warranty - electronics	2 years	20 years
Time of delivery	3 months	4-5 months
Distribution area	EU, USA North and South, MENA, APAC	USA, Canada, Mexico
The most important benefits	• Bifacial optimized • Full-locking in all inclinations	• Gearless • 360° swivel • Long warranty of 20 years for all parts
Notes		
	*1 Three robots in evaluation; *2 In progress	*1 Full-tilt M18KD; M18KD-20 tilt up to 25° park. lots vers.; *2 Gearless hydraulic driven

## TaiyangNews Market Survey on Solar Trackers 2021

Company	Mounting Systems	Nexans
Product name	Sigma Tracker	Keylios
Available since	2016	2020
Tracking type	HSAT independent row	HSAT independant row
Bifacial enabled	Yes	Yes
Dimensions		
Typical row size	Max. 240 modules	34 - 45 modules
Total system size (length × width × height)	Approx. 120 x 4.2 x 2 m	34 - 45 x 4 x 2 m
Total system weight	~ 2,500 kg	~ 1,000 kg
General		
Modules supported	All types	c-Si, thin-film, some FS series
String voltage	1,500 V	1,000 / 1,500 V
Module configuration	2P, 3P, or 4H, 5H, 6H flex. string based config.	2P - configurable
Module attachment	Screws, clamps	Self-grounded, PowAR Cinch
Array height	2 m	Configurable
Bifacial features	Opt. no obstacle on entire module back-side	Yes
Ground coverage ratio GCR	Flexible	Config., 30% - 50%
Material	Cor. prot. coated steel, Al, plastic bear. mater.	Galv. steel, HDG, magnelis
Tracking range of motions	± 50° (opt. ±5°)	Max. 110° (±55), opt. (±60°)
Operating temperature range	-25 ~ 60 °C	-20°C ~ 55 °C
Mechanical		
Allowable wind speed & wind gust duration	90 km/h in tracking / 260 km/h in stow pos.	Config., compliant RFQ
Wind protection	-	Stow position
Corrosion protection standard	C3	C3 - Compliant with RFQ
Coatings	Z/ZM or acc. DIN EN 10346	DIN EN 10346
Foundations	Driven piles, concrete foundation, screw piles	HEA sections foundation part <sup>*1</sup>
Electrical		
Power supply	AC 400/230 V, 50/60 Hz, 0.55 kW	Self-powered
Drive type	AC asynchr. driven with Siemens VFD	Motor
Drive type accuracy	+/- 1,5°	<0.015°
Motor type	Asynchr. motor integr. gear chain drive	24V DC motor
Electronics and controls		
Solar tracking method	Astronomical adapt. backtracking	Astronomical algorithm
Backtracking	Yes	Yes
Sensors	Tilt, wind, snow	Wind, inclination, temperature, snow
Communication system	RS485 master/slave contr., SCADA, Modbus/TCP	Zigbee
Safety position	1°	0°
Nighttime stow	Yes	Yes
Installation, operation and service		
PE stamped structural calculations and drawings	Included	Included
Online training and system commissioning	Included	Included
Installation requirements	Standard tools	Workshop assembly
Monitoring	Sigma View, SCADA interface	Yes
Module cleaning compatibility	Yes	Yes
Certificates		
IEC 62817	Yes	Yes
UL 3703	No <sup>*1</sup>	No
UL 2703	No <sup>*2</sup>	No
Warranty, time of delivery, distribution area		
Warranty - structure	10 years	10 years
Warranty - motor	5 years	5 years <sup>*2</sup>
Warranty - electronics	5 years	5 years <sup>*2</sup>
Time of delivery	-	TBC
Distribution area	Global	EMEA, USA, Latina America, Australia
The most important benefits	<ul style="list-style-type: none"> <li>• No shading behind active module area</li> <li>• IEC 61817 certified</li> </ul>	<ul style="list-style-type: none"> <li>• Magnelis coating</li> <li>• IEC 61817 certified</li> <li>• Workshop assembly for faster installation</li> <li>• Lattice structure suitable for extr. undul. terrain</li> </ul>
Notes		
	*1 Planned; *2 Compliant	*1 112 piles / MWp; 56 concr. Beams/MWp for 450Wp; 2 Opt. Extension



**TaiyangNews Market Survey on Solar Trackers 2021**

Company	Nextracker	Nextracker
Product name	NX Gemini	NX Horizon
Available since	2019	2016
Tracking type	HSAT	HSAT
Bifacial enabled	Yes	Yes
Dimensions		
Typical row size	112 - 120 modules	78 - 90 modules
Total system size (length × width × height)	-	-
Total system weight	-	-
General		
Modules supported	Most utility-scale c-Si	Most utility-scale c-Si, FS series 6 & 4
String voltage	1,000 / 1,500 V	1,000 / 1,500 V
Module configuration	1P	1P
Module attachment	Self-grounding, el. tool-actuated fasteners*1	Self-grounding, el. tool-actuated fasteners
Array height	1.3 to 1.8 m (rotation axis)	1.3 to 1.8 m (rotation axis)
Bifacial features	Bifacial optimized	High-rise m. rails, bear./drivel. gaps, round torq. tube
Ground coverage ratio GCR	Config., 28-50%	Cofig., 28 - 50%
Material	Galv. steel	Galv. steel
Tracking range of motions	±50°	±60° / ±50°
Operating temperature range	Self-pow.: -30°C ~ 55°C / AC pow. -40°C ~ 55°C	Self-pow.: -30°C ~ 55°C / AC pow. -40°C ~ 55°C
Mechanical		
Allowable wind speed & wind gust duration	Config. up to 235 km/h, 3 s	Config. up to 200 km/h 3s
Wind protection	Int.wind stow self-lock., distrib. drive system	Intel. wind stow symm. dampers
Corrosion protection standard	-	-
Coatings	-	-
Foundations	150 piers/MW at 105 mi/hr wind stie	W6
Electrical		
Power supply	Self-powered*2 / AC-powered	Self-powered*1 / AC-powered
Drive type	NX patent-pending self-lock., distrib. drive	Non-backdriving slew gear
Drive type accuracy	-	-
Motor type	48V brushless DC motor	24V brushless DC motor
Electronics and controls		
Solar tracking method	Astron. algorithm, backtracking*3	Astron. algorithm, backtracking*2
Backtracking	Yes	Yes*3
Sensors	Weather station	Weather station
Communication system	Zigbee	Zigbee
Safety position	Yes various weather events stow. posit.	Wind, flood, snow, hurricane, hail stow avail.
Nighttime stow	Yes	Yes
Installation, operation and service		
PE stamped structural calculations and drawings	Included	Included
Online training and system commissioning	Included	Included
Installation requirements	Swaged fasteners & bolted connections*4	Swaged fasteners & bolted connections*5
Monitoring	NX Data Hub centr. data aggregation & monitoring	NX Data Hub centr. data aggregation & monitoring
Module cleaning compatibility	Comp. with NX qualified cleaning systems	Comp. with NX qualified cleaning systems
Certificates		
IEC 62817	Yes	Yes
UL 3703	Yes	Yes
UL 2703	Yes	Yes
Warranty, time of delivery, distribution area		
Warranty - structure	10 years	10 years
Warranty - motor	5 years	5 years
Warranty - electronics	5 years	5 years
Time of delivery	-	-
Distribution area	Global	Global
The most important benefits	<ul style="list-style-type: none"> <li>• Fully certified</li> <li>• NX self-locking</li> <li>• Wind-tun. aeroelastic tests</li> <li>• Intelligent wind stowing</li> <li>• Smart tracking</li> </ul>	<ul style="list-style-type: none"> <li>• Fully certified</li> <li>• Bifacial optimized</li> <li>• Wind-tun. aeroelastic tests</li> <li>• Intelligent wind stowing</li> <li>• Smart tracking</li> </ul>
Notes		
*1 Opt. clamping system; *2 NX integr. DC pre-combiner & power supply; *3 TrueCapture™ upgr. for terrain ad. backtr. & diff. track.; *4 No field cutting, drilling or welding.		*1 NX provided 30 or 60 W smart panel; *2 TrueCapture™ upgr. terrain adapt. backtr., diff. light; *3 Row-to-row backtracking avail. with TrueCapture™

**TaiyangNews Market Survey on Solar Trackers 2021**

Company	PVH	PVH
Product name	Axone Duo	Monoline 1V / 2V / 3H
Available since	2018	2020
Tracking type	HSAT dual row	HSAT independent row
Bifacial enabled	Yes	Yes
Dimensions		
Typical row size	Max. 120	Max. 40 / 40 / 90
Total system size (length × width × height)	-	120 x 2.5 x na m / 70 x 5 x na m / 70 x 3 x na m
Total system weight	-	For the typical row size
General		
Modules supported	All types	All types
String voltage	1,000 / 1,500 V	1,000 / 1,500 V
Module configuration	1P	1P / 2P / 3H
Module attachment	Bolts, nuts, rivet, clamps	Bolts, nuts, rivet, clamps
Array height	~ 1.4m <sup>†1</sup>	~1.4m <sup>†1</sup>
Bifacial features	Driveline gap, tor. tube-module space	Driveline gap, tor. tube-module space
Ground coverage ratio GCR	30 - 50%	30 - 50%
Material	Magnelis , HDG	Magnelis , HDG
Tracking range of motions	±60°	±60°
Operating temperature range	-40 ~ 80 °C	-40 ~ 80 °C
Mechanical		
Allowable wind speed & wind gust duration	200 km/h, 3s	200 km/h, 3s
Wind protection	Wind stow angle	Wind stow angle
Corrosion protection standard	C1 / C2 / C3 / C4 / C5	C1 / C2 / C3 / C4 / C5
Coatings	pregalv. steel, HDG, magnelis	Pregalv. steel, HDG, magnelis
Foundations	Cp, IPE, HEA profiles	Cp, IPE, HEA profiles
Electrical		
Power supply	Self-powered	Self-powered
Drive type	Slew drive	Slew drive
Drive type accuracy	±1.5°	±1.5°
Motor type	24V DC	24V DC
Electronics and controls		
Solar tracking method	Astronomical algorithm	Astronomical algorithm
Backtracking	Yes 3D <sup>*2</sup>	Yes 3D <sup>*2</sup>
Sensors	Wind	Wind
Communication system	LoRaWAN	LoRaWAN
Safety position	Diff. between exterior - interior rows	Diff. between exterior - interior rows
Nighttime stow	Yes	Yes
Installation, operation and service		
PE stamped structural calculations and drawings	Included	Included
Online training and system commissioning	Included	Included
Installation requirements	Assembly, power & comm. anntennas centr. controllers <sup>*4</sup>	Assembly, power & comm. anntennas centr. controllers <sup>*4</sup>
Monitoring	Yes	Yes
Module cleaning compatibility	TBD	TBD
Certificates		
IEC 62817 / UL 3703 / UL 2703	Yes / Yes / NA	Yes / Yes / NA
Warranty, time of delivery, distribution area		
Warranties - structure / motor / electronics	10 yrs / 5 yrs / 5 yrs	10 yrs / 5 yrs / 5 yrs
Time of delivery	2 - 3 months <sup>*5</sup>	2 - 3 months <sup>*5</sup>
Distribution area	Global	Global
The most important benefits	<ul style="list-style-type: none"> <li>• ArcelorMittal Magnelis coating</li> <li>• Smart control &amp; alarms incl. sandstorms</li> <li>• Bifacial otimized</li> <li>• IEC 62817 &amp; UL 3703 certified</li> <li>• Wind-tun. aeroelastic tests</li> <li>• Various opt. stow angles</li> </ul>	<ul style="list-style-type: none"> <li>• ArcelorMittal Magnelis coating</li> <li>• Smart control &amp; alarms incl. sandstorms</li> <li>• Bifacial optimized</li> <li>• 23.5% N-S slope</li> <li>• IEC 62817 &amp; UL 3703 certified</li> <li>• Wind-tun. aeroelastic tests</li> <li>• Various opt. stow angles</li> </ul>
Notes		
	*1 Rotation axis; *2 Opt. adapt. backtracking for undulated terrain; *3 Opt. snow, ultrasonic weather instrument; *4 Found. for contr. dev. tower, IP dev. Network; *5 1 <sup>st</sup> delivery	*1 Rotation axis; *2 Opt. adapt. for undulated terrain; *3 Opt. snow, ultrasonic weather instrument; *4 Found. f. contr. dev. tower, IP dev. Network; *5 1 <sup>st</sup> delivery

## TaiyangNews Market Survey on Solar Trackers 2021

Company	PVH
Product name	Monoline+ 1V / 2V
Available since	2021
Tracking type	HSAT independent row
Bifacial enabled	Yes
Dimensions	
Typical row size	1V max 100meters / 2V max 70 meters
Total system size (length × width × height)	1V 100x2.5m / 2V 70x5m
Total system weight	For the typical row size
General	
Modules supported	All types
String voltage	1,000 / 1,500 V
Module configuration	1P / 2P
Module attachment	Bolts, nuts, rivet, clamps
Array height	1V~1.4m 2V~2.2m* <sup>1</sup>
Bifacial features	Driveline gap, tor. tube-module space
Ground coverage ratio GCR	30 - 50%
Material	Magnelis , HDG
Tracking range of motions	±60°
Operating temperature range	-40 ~ 80 °C
Mechanical	
Allowable wind speed & wind gust duration	200 km/h, 3s
Wind protection	Wind stow angle
Corrosion protection standard	C1 / C2 / C3 / C4 / C5
Coatings	Pregalv. steel, HDG, magnelis
Foundations	Cp, IPE, HEA profiles
Electrical	
Power supply	Self-powered
Drive type	Slew drive
Drive type accuracy	±1.5°
Motor type	24V DC
Electronics and controls	
Solar tracking method	Astronomical algorithm
Backtracking	Yes 3D* <sup>2</sup>
Sensors	Wind
Communication system	LoRaWAN
Safety position	Diff. between exterior - interior rows
Nighttime stow	Yes
Installation, operation and service	
PE stamped structural calculations and drawings	Included
Online training and system commissioning	Included
Installation requirements	Assembly, power & comm. antennas centr. controllers* <sup>4</sup>
Monitoring	Yes
Module cleaning compatibility	TBD
Certificates	
IEC 62817 / UL 3703 / UL 2703	Yes / Yes / NA
Warranty, time of delivery, distribution area	
Warranties - structure / motor / electronics	10 yrs / 5 yrs / 5 yrs
Time of delivery	2 - 3 months* <sup>5</sup>
Distribution area	Global
The most important benefits	<ul style="list-style-type: none"> <li>• ArcelorMittal Magnelis coating</li> <li>• AI optimized tracking control &amp; alarms incl. sandstorms</li> <li>• Bifacial optimized</li> <li>• 23.5% N-S slope (in 2V each 20 meters)</li> <li>• High terrain adaptability in 2V for ~1% higher yield</li> <li>• IEC 62817 &amp; UL 3703 certified</li> <li>• Wind-tun. aeroelastic tests</li> <li>• Various opt. stow angles</li> </ul>
Notes	
	*1 Rotation axis; *2 Opt. adapt. backtracking for undulated terrain; *3 Opt. snow, ultrasonic weather instrument; *4 Found. for contr. dev. tower, IP dev. Network; *5 1 <sup>st</sup> delivery



**TaiyangNews Market Survey on Solar Trackers 2021**

Company	Schletter	Soltec
Product name	Schletter Tracking System	SF7/SF8
Available since	2018	2017 / 2020 SF8
Tracking type	HSAT, independent row	HSAT independent row
Bifacial enabled	Yes	Yes
Dimensions		
Typical row size	240	90 / 120 / 180
Total system size (length × width × height)	120 x 4 x 2.1 m	Dep. on configuration
Total system weight	~ 3,600 kg	Dep. on configuration
General		
Modules supported	All types	All types
String voltage	1,000 / 1,500 V	Max. 1,500 V
Module configuration	2P (2 x 120), H4 (4 x 60)	2P
Module attachment	Self grounding, clamps, nuts/bolts, opti. rivets	Fasteners, rivets, bolts, washers, nuts
Array height	~ 2.1 m	1.8 - 2.1 m <sup>*1</sup>
Bifacial features	Elevation and gaps	Higher, 15 cm gap torque tube & slew drive <sup>*1</sup>
Ground coverage ratio GCR	Flexible, free to define	30 - 50% conf.
Material	Galv., magnelis, Zn-Mg coated, high-strength steel	Galv., pre-galv. steel
Tracking range of motions	±60°	± 60°
Operating temperature range	-10 ~ 55 °C	-20°C ~ 55 °C <sup>*2</sup>
Mechanical		
Allowable wind speed & wind gust duration	170 km/h - 220 km/h <sup>*1</sup> , 3s	Acc. local codes
Wind protection	Wind stow ±9°	Dy-WIND self-powered
Corrosion protection standard	C2 high / C3 low, C3 medium, up to C4	C3/C4
Coatings	DIN EN 10346/ ZM, high resistancy coatings	DIN EN 10346/ ASTM A123/ ISO 1461
Foundations	Customized project optimized foundation design	W8 sections
Electrical		
Power supply	AC powered, opt. self powered, 24 V	Self-powered <sup>*3</sup>
Drive type	Back-driving, electrical slew gear	Slew drive
Drive type accuracy	± 1.5°	± 2°
Motor type	DC 24V brushless	DC
Electronics and controls		
Solar tracking method	Astronomical algorithm with GPS	TeamTrack™ with NREL SPA data
Backtracking	Yes 3D	Yes
Sensors	Wind, inclination, temperature, snow	Meteor. station, wind, temperature, flood, snow, hail
Communication system	Wired (RS-485 cable) / wireless zigbee	Full wireless
Safety position	9°	45°-50°
Nighttime stow	Yes	Yes
Installation, operation and service		
PE stamped structural calculations and drawings	Optional	Included
Online training and system commissioning	Optional	Included
Installation requirements	No special equipment required	No special tools, 17% N-S; unlim.E-W
Monitoring	Yes, optional	Yes TMS
Module cleaning compatibility	Yes, e.g. sunbrush	Yes face-to-face contr, comp. rob. tools
Installation, operation and service		
IEC 62817	Yes	Yes
UL 3703	Yes	Yes
UL 2703	Yes	NA
Installation, operation and service		
Warranty - structure	10 years	10 years <sup>*4</sup>
Warranty - motor	5 years	5 years <sup>*4</sup>
Warranty - electronics	5 years	5 years <sup>*4</sup>
Time of delivery	1.5 - 2 months <sup>*2</sup>	Dep. on location
Distribution area	Global, supply chain in EU, USA, China	Global
The most important benefits	<ul style="list-style-type: none"> <li>Fully certified</li> <li>No shading behind active module area</li> <li>Patented self-locking mechanism"</li> </ul>	<ul style="list-style-type: none"> <li>Bifacial optimized</li> <li>IEC 62817 &amp; UL 3703 certified</li> <li>Wind-tun. aeroelastic tests</li> <li>Smart tracking</li> </ul>
Notes		
	*1 For the first batch; *2 Opt. Ind. designed projects with 257 km/h	*1 Better module cooling, optim. algorithm; *2 Opt. -40°C ~ 5°C; *3 Opt. 120/240 Vac, 24 Vdc cable; *4 Extendable

**TaiyangNews Market Survey on Solar Trackers 2021**

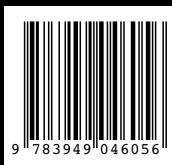
Company	Soltigua srl	STI Norland
Product name	iTracker WL, iTracker Duetto, BiTracker	STI H-250
Available since	2007	2017
Tracking type	HSAT	HSAT dual row
Bifacial enabled	Yes - BiTracker	Yes
Dimensions		
Typical row size	Max. 90	120
Total system size (length × width × height)	~100 x 2.4 x 1.35 / 1.55 m* <sup>1</sup> at 0° pos.	~70 x 8.25 x 1.47* <sup>1</sup>
Total system weight	Dep. on configuration	~2,000 kg
General		
Modules supported	All framed modules	c-Si, thin-film, some FS series
String voltage	1,000 / 1,500 V	1,500 V
Module configuration	1P, 2 in landscape* <sup>2</sup>	1P, 4 x 1,500 V
Module attachment	Bolts, opt.rivets, opt. clamps	Fasteners, rivets, bolts, nuts
Array height	1.35 monofacial / 1.55 bifacial* <sup>1</sup>	Rot. axis 1.31m / top of panel 1.47m* <sup>1</sup>
Bifacial features	Gap tor. tube & module	Bearing, split bushing & arm and rod
Ground coverage ratio GCR	-	Dep. on project
Material	HDG steel, aluminum, stain. steel, plastic	Galvanized steel* <sup>1</sup>
Tracking range of motions	± 55°, opt. ± 60°	± 55°
Operating temperature range	-20 ~ 50 °C	-10 ~ 60 °C
Mechanical		
Allowable wind speed & wind gust duration	80 km/h in operation, 200 km/h in stow	Acc. local codes
Wind protection	Wind stow	Stow 25°* <sup>1</sup>
Corrosion protection standard	C2* <sup>3</sup>	C2 / C3 / C4 / C5* <sup>1</sup>
Coatings	ISO 1461/ASTM A123, ISO 3575	ISO 1461
Foundations	Rammed piles	W6, perfil C
Electrical		
Power supply	Self-powered, opt. AC from grid	AC, self-powered
Drive type	Slew drive	Slew drive
Drive type accuracy	± 1°	± 0.2°
Motor type	DC 24V brushed	DC 24 V
Electronics and controls		
Solar tracking method	Astronomical, 3D backtracking	USNO SPA
Backtracking	Yes 3D backtr.	Yes 3D
Sensors	Wind, temperature, snow	Wind, inclination, temperature, motor current
Communication system	Soltigua wireless SubGHz* <sup>4</sup>	Zigbee, RS-485 cable
Safety position	30°- 45°, config.	Config.
Nighttime stow	Yes	Yes
Installation, operation and service		
PE stamped structural calculations and drawings	Included	Included
Online training and system commissioning	Included	Included
Installation requirements	No	15% N - S; 10% E - W
Monitoring	Yes, SCADA, remote control	Yes
Module cleaning compatibility	Maintenance position possible	Yes, manual, automated
Installation, operation and service		
IEC 62817	Yes	Yes
UL 3703	No* <sup>5</sup>	Yes
UL 2703	No* <sup>5</sup>	Yes
Installation, operation and service		
Warranty - structure	10 years	10 years
Warranty - motor	5 years	5 years
Warranty - electronics	3 years	5 years
Time of delivery	~2 - 3 months	2 months* <sup>2</sup>
Distribution area	Global	Global
The most important benefits	<ul style="list-style-type: none"> <li>• IEC 62817 certified</li> <li>• Sub-GHz wireless architecture radio network</li> </ul>	<ul style="list-style-type: none"> <li>• Fully certified</li> <li>• ±0.2° drive accuracy</li> <li>• Wind-tun. aeroelastic tests</li> </ul>
Notes		
	*1 site spec. at 0° pos. chord cent. 1.35m monof. / 1.55m bifac.; *2 2P are not offered currently; *3 30a guarant.; opt. higher categ. prot.; *4 radio network 1 annt./track centr. receivers; *5 iTracker compl. to Eurocod.	*1 adaption dep. on project *2 1 <sup>st</sup> delivery

**TaiyangNews Market Survey on Solar Trackers 2021**

Company	TrinaTracker	TrinaTracker
Product name	Vanguard 550 2P	Agile 550 1P
Available since	2020	2021
Tracking type	HSAT indepent row	HSAT dual row
Bifacial enabled	Yes	Yes
Dimensions		
Typical row size	120 (2 x 60)	120 (2 x 60)
Total system size (length x width x height)	6.7 x 4.78 x 2.56 m	6.75 x 7.38 x 1.45 m
Total system weight	3,200 kg	3,000kg
General		
Modules supported	All framed modules	All framed modules
String voltage	1,500 V	1,500 V
Module configuration	1P , 2 x 1,500	1P , 2 x 1500
Module attachment	Bolts, rivets, clips	Bolts, rivets, clips, trina clamp
Array height	-	-
Bifacial features	-	-
Ground coverage ratio GCR	31 - 37%	40 - 48%
Material	Steel S275 & S355, HDG, Z275 (G90), ZM310	Steel S275 & S355, HDG, Z275 (G90), ZM310
Tracking range of motions	± 55°	± 50°
Operating temperature range	-30°C ~ 60°C	-30°C ~ 60°C
Mechanical		
Allowable wind speed & wind gust duration	162 km/h, 3s	162 km/h, 3s
Wind protection	Stow 0°*1	Stow 0°*2
Corrosion protection standard	Up to P4	Up to P4
Coatings	ISO 1461, EN10346 - EN14713	ISO 1461, EN10346 - EN14713
Foundations	W sections	C section
Electrical		
Power supply	AC, self powered or string powered	AC, self powered or string powered
Drive type	Multidrive linear actuator	Linear actuator
Drive type accuracy	-	-
Motor type	DC brushed 24V	DC brushed 24V
Electronics and controls		
Solar tracking method	STA high diff. irradi. & SBA undulating terrains	STA high diff. irradi. & SBA undulating terrains
Backtracking	Yes	Yes
Sensors	Wind,opt.: snow, pyranometer	Wind,opt.: snow, pyranometer
Communication system	RS485, Zigbee or LoRaWAN	RS485, Zigbee or LoRaWAN
Safety position	0°	0°
Nighttime stow	Yes	Yes
Installation, operation and service		
PE stamped structural calculations and drawings	Optional	Optional
Online training and system commissioning	Included	Included
Installation requirements	15% N - S	15% N-S, 8% E-W
Monitoring	Yes, TrinaTracker cloud	Yes, TrinaTracker cloud
Module cleaning compatibility	Yes, cleaning robots ECOPPIA T4	Yes, cleaning robots ECOPPIA T4
Installation, operation and service		
IEC 62817	Yes	No*2
UL 3703	No*2	No*2
UL 2703	NA	NA
Installation, operation and service		
Warranty - structure	10 years	10 years
Warranty - motor	5 years	5 years
Warranty - electronics	5 years	5 years
Time of delivery	2 months*2	2.25 months*2
Distribution area	Global	Global
The most important benefits	<ul style="list-style-type: none"> <li>• Bifacial optimized</li> <li>• Intelligent wind stowing</li> <li>• Wind-tun. aeroelastic tests</li> <li>• AI based tracking</li> </ul>	<ul style="list-style-type: none"> <li>• Intelligent wind stowing</li> <li>• Wind-tun. aeroelastic tests</li> <li>• AI based tracking</li> <li>• Supports 600+ Wp panels</li> </ul>
Notes		
	*1 v ≥40km/h, ±30°;v ≥50km/h, ±15°; 3:v ≥60km/h, 0°; *2 in progress; *3 FOB, afterwards 15-20MW/ week	*1 v ≥40km/h, ±30°;v ≥50km/h, ±15°; 3:v ≥60km/h, 0°; *2 in progress; *3 FOB, afterwards 15-20MW/ week



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