NEXTracker™
A Flex Company

Maximizing PV System Performance with Single-Axis Trackers

A GTM EXECUTIVE SUMMARY

DAN SHUGAR | Founder & CEO, NEXTracker

VENKATA ABBARAJU | Senior Director of Product Development, NEXTracker

DUSTIN SHIVELY | Director of Engineering, Clēnera, LLC

SCOTT MOSKOWITZ | Scott Moskowitz, Senior Analyst, Solar, GTM Research (now WoodMackenzie Power & Renewables)

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Overview

The global utility-scale PV tracker market has blown up in the last five years. Once considered too expensive compared to fixed-tilt racking systems and suitable only for very specific (usually sunny and flat) environments, trackers have gone mainstream and are now more or less expected as part of utility-scale solar projects around the globe.

The success of trackers and their prospects for continued growth is the backdrop to this webinar as panelists discussed the ever-increasing imperative for continued yield gain.

As part of his introductory remarks Dan Shugar, Founder and CEO of leading tracker company NEXTracker, noted the price of a power purchase agreement (PPA) that 8 Minute Energy had signed for a 300-megawatt project in 2018: just over $23 per megawatt hour.

"That's just staggering," said Shugar, noting that it puts solar lower in price than gas, coal and nuclear. But these ongoing price reductions also pose a challenge, asserted Shugar, who was a pioneer of the backtracking algorithm in the early 1990s. "There's really only so much you can keep squeezing out," he said. "We really need a healthy and vibrant industry. And today a lot of the industry is not generating sufficient profit."

Which is why a focus on yield is so important, and why optimally designing and building utility-scale solar projects that use single-axis trackers is vital.

Key Takeaways

The panelists on the webinar shared their extensive real-world experience building utility-scale solar projects using trackers and outlined best practices for maximizing yield, including:

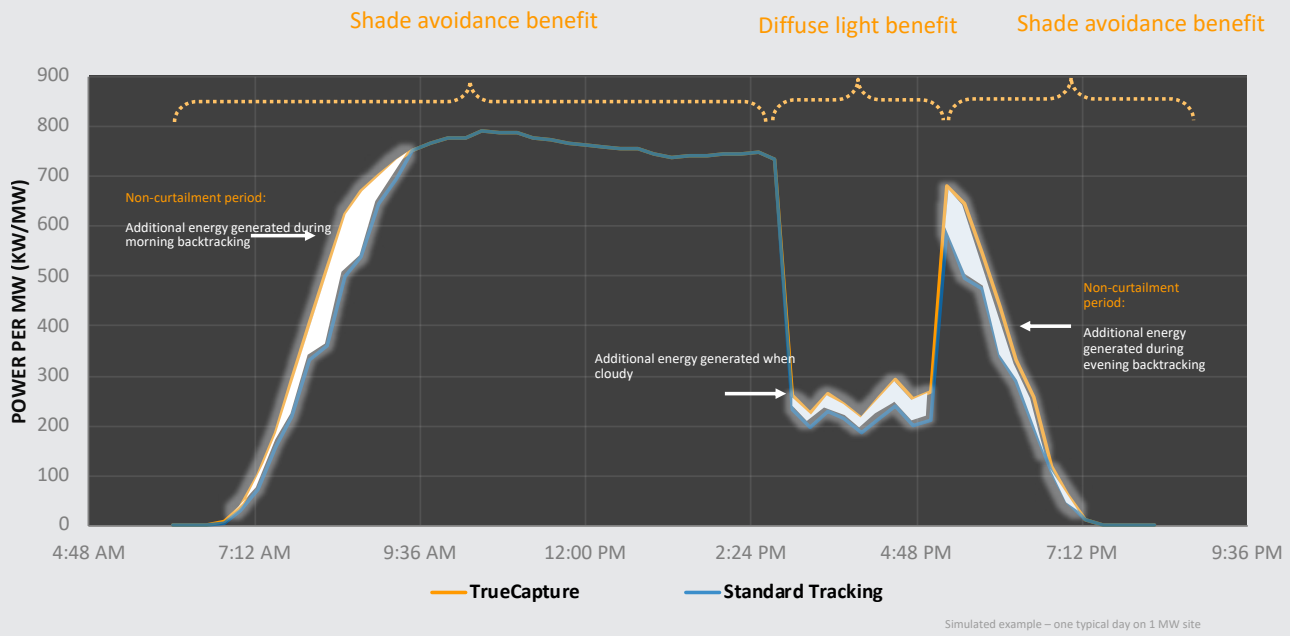
- Globally, WoodMac estimates tracker installations at nearly 28 gigawatts by 2022
- Trackers now offer smart control system, software and machine learning that respond to the unique terrain and conditions at each project site.
- Smart controls like TrueCapture can increase yield gain by 2 to 6 percent.
- Bifacial modules with trackers produce 14 percent more energy than monofacial modules with trackers.

Real-world conditions demand continuous adjustments. The original backtracking algorithm that Shugar helped pioneer works great to maximize yield when a utility-scale solar project is located in a flat and sunny location. With solar projects being developed literally everywhere on the globe, those optimal conditions simply aren't going to be the norm for most EPCs and developers. "We've known for decades there's better ways to do this," said Shugar.

That better way involves a smart control system, software and machine learning that respond to the unique terrain and conditions at each project site. Venkata Abbaraju, Senior Director of Product Development at NEXTracker, works on control systems for the company showed images of projects where terrain undulations resulted in row-to-row shading when standard tracking was used. By contrast, the control system for TrueCapture adjusts to both weather and terrain conditions in order to maximize yield.

> **"Both technologies work in tandem. Depending on weather conditions, if it's cloudy it goes to diffuse tracking and if it's sunny it does row-to-row tracking," he said. "This improves PV system performance in real-world conditions where undulations and cloudy conditions exist."**

Truecapture Energy Yield Benefit

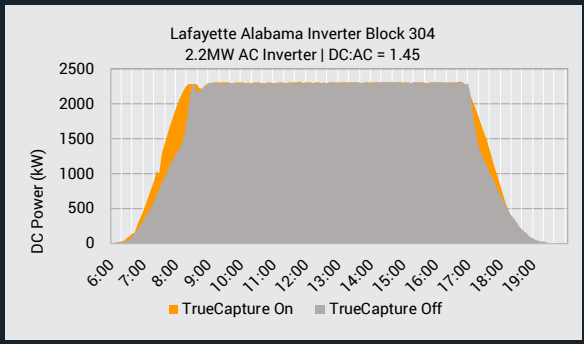


Real-world experience. Dustin Shively, Director of Engineering at utility-scale developer Clenera, highlighted his company's experience deploying a tracker more suited to rolling terrain.

Clenera developed a 115-megawatt power plant on about 1,100 rolling acres in Alabama. Shivley noted that using traditional backtracking would not have addressed row-to-row shading. But in order to test the difference it would make to use TrueCapture compared to traditional backtracking, Clenera enabled its use on some power blocks at the plant and not at others. Over the course of a few days the difference was significant.

"In this case, it's about 4.3 percent more energy production when the row-to-row tracking was enabled; 4.3 percent is huge," he said. "If we're talking about these very competitive PPA rates and ever-reducing levelized cost of energy, anything you can do to eke out more energy from the facility the better." Over the course of a few months, Clenera found that the use of TrueCapture resulted in about a 3.3 percent increase in energy gained. This did not include the TrueCapture feature that would respond to diffuse light conditions. NEXTracker says that these real-time adjustments based on actual weather and shading conditions elevate production by 2 to 6 percent depending on the project.

ALABAMA 115MW DC SITE: REPRESENTATIVE CLEAR SUNNY DAY:



TrueCapture Generated 4.3% More Energy Production (R2R Only)

Bifacial modules and trackers are a powerful combination. Shugar has been interested in the potential of bifacial modules to elevate energy production since he was first exposed to the technology in 1990, while he was working

“The industry finally is moving toward bifacial at scale.”

at Pacific Gas & Electric. Since then, bifacial modules have been included at projects including Nellis Air Force Base, which former President Barack Obama visited in 2009, and Springs Preserve in Las Vegas. Those were modest forays into the potential of bifacial modules, but things are a lot different today. “The industry finally is moving toward bifacial at scale,” he said.

The rising interest in bifacial modules has influenced the design of NEXTracker products. “We conceptualized our tracker around bifacial design,” Shugar said. “We wanted a balanced tracker. We’re suspending eight modules, plus or minus, between our piers. So there’s no shading on the back from piers and springs and dampers and things like that.”

In addition, NEXTracker has been testing bifacial modules on single-axis trackers at its Fremont, Calif. headquarters. Abbaraju discussed a test of bifacial modules and monofacial modules made from the same cells and mounted on trackers side-by-side. The result: nearly 14 percent more energy was produced by the bifacial modules.

Use bifacial modules with frames. The webinar wrapped up with NEXTracker’s recommendations for maximum yield gain using bifacial modules and trackers.

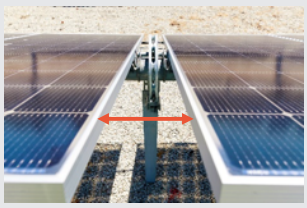
A big one: always use modules with frames. “The frame provides value. It can be a thin frame and an optimized frame, but you need a frame that reduces slippage, risk of damage and then long-term durability,” said Shugar. “The frames speed installation and improve module reliability.”

NX HORIZON: CONCEPTUALIZED AS A BIFACIAL TRACKER

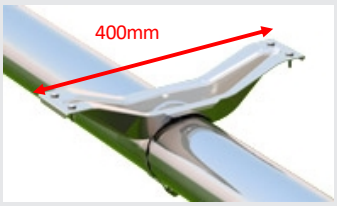
1 One-in-portrait for maximum albedo capture

2 Round torque tube, small 5” diameter, reflective

Tube has negligible impact on backside performance



3 Modules suspended between piers and bearings



4 Rails: 400mm long, tapered, modules elevated from tube

Speakers

Dan Shugar
Founder & CEO,
NEXTracker

As founder and CEO, Dan Shugar has led NEXTracker to achieve the #1 market share position with over 17 GW of solar trackers delivered worldwide; manufacturing in and serving five continents. NEXTracker was acquired by Flex, a $25B company, in Sept 2015 for $330M. Before NEXTracker, he served as CEO for PV manufacturer Solaria Corp, and previously President of SunPower and PowerLight Corporations. Dan Shugar has been active in renewable energy since 1988, when he worked at PG&E and managed their solar R&D team. He has invented various PV system applications, holds multiple U.S. patents and has published more than 50 technical papers. Shugar earned a BS in electrical engineering from Rensselaer Polytechnic Institute, an MBA from Golden Gate University, and is registered Professional Engineer.

Dustin Shively
Director of Engineering,
Clenera, LLC

Dustin has developed, engineered, permitted, financed, and constructed over 1,500 MW of wind and solar energy projects. After completing B.S. and M.S. degrees in Mechanical Engineering, Dustin has gained experience in the renewable energy industry ranging from project development, design, and management to energy modeling, storage, and optimization. In total, he has contributed to the success of over 30 solar and wind projects across North America, totaling 1,250 MW, and representing total investments of more than $2 billion. His previous roles have consisted of independent engineer and energy systems engineer. He is also an Adjunct Professor instructing senior and graduate level courses in Thermodynamics and Renewable Energy Systems.

Venkata Abbaraju
Senior Director of Product Development,
NEXTracker

Venkata Abbaraju is the Sr. Director of Product Development at NEXTracker. Venkata drives NEXTracker's Tracker Control Systems and Software products, such as TrueCapture smart control system and bifacial technology product roadmap. Mr. Abbaraju's career has focused on accelerating the development and supporting the adoption of solar energy. His first few years in the global solar industry were spent testing solar equipment at the PV testing lab in Arizona State University (ASU) followed by his tenure at TUV Rheinland PTL. After TUV Rheinland, Mr Abbaragu served as Product Development Engineer with PrimeStar Solar, a CdTe PV panel manufacturer which was later acquired by GE Energy. While at GE Energy, Venkata was responsible for developing innovative and differentiated products, and establishing manufacturing process challenges. Subsequently, Venkata worked at Yingli as Director of Engineering support in the Americas region, focusing on pre-sales, product management, and after-sale support. Venkata holds a Masters of Engineering in Industrial Quality and Reliability from Arizona State University and a Bachelor's in Mechanical Engineering from Andhra University in India.

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