Tracking Systems improve the economics of certain solar projects

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EXECUTIVE SUMMARY

Developers face a number of challenges when creating proposals for solar projects and with the recent cancellation of power purchase agreements (PPAs) awarded to recognised developers, none of these challenges is more relevant in today's market than the availability and acquisition of land. This consequently leads to the question of whether to employ a fixed-tilt (FT) system or a horizontal single axis tracker (HSAT) system to achieve desired energy targets.

SgurrEnergy India (SEI) recently addressed this question by performing an analysis comparing the popular FT system to the HSAT system often used in the U.S.

INTRODUCTION

Solar photovoltaic (PV) modules are secured on mounting structures that provide structural support and keep them oriented in a direction that allows them to receive maximum sunlight. The tilt angle is optimized for site conditions of the given location. In India, most of these systems are fixed tilt (FT) systems that do not move. However, PV panels can be mounted on tracker systems that move throughout the day to keep the PV panels oriented toward the sun and at the optimal angle for productivity. There is no other single balance-of-system (BOS) component that can increase a PV system's performance like a tracker. Tracking systems can increase generated output by 10% to 25% compared to FT mounting structures, but they can come with drawbacks in the form of site preparation costs and moving parts that can require specialized maintenance.

Within the tracker systems group, there are two main subcategories; single-axis trackers that turn on one axis and dual-axis tracking systems that turn on two axes. Single-axis trackers are further subdivided into vertical single axis trackers, tilted single axis trackers, and horizontal single axis trackers (HSAT). The following analysis performed by SEI focuses on comparing HSAT systems to FT systems.

COMPARING THE TWO SYSTEMS

The SEI analysis compares the price, components, and performance of a 1.9MW FT system to a 1.2MW HSAT system. Simulations of both systems were set up using identical conditions on a five-acre sample area in the high resource region of Bhadla in Rajasthan, India. SEI used the photovoltaic simulation software PVsyst to optimize the layout and operational parameters for each mounting system and simulated results were gathered for a one-year period.

The question of which system would be most economical yielded mixed results for the sample area. Although the FT system would generate approximately 34% more energy (P50 generation) than the HSAT system and deliver a superior ground coverage ratio (GCR), the higher capacity means that the FT system needs twice the number of inverters, which raises the installation price by INR 10 million. This suggests that the HSAT system could be the more affordable option, but the analysis did not consider the land specifications needed for an HSAT system to function at its best and, by extension, the potential site preparation costs.

The SEI analysis compared FT and HSAT systems by looking at the following key factors affecting solar project pricing and generation outcomes under identical conditions. These are:

- Energy yield
- Ground coverage ratio (GCR)
- Inverter loading
- Quantum of module
- Balance of system (BOS) cost

The plant layout was configured to account for the influence of land boundaries and general topographic conditions on system configurations. In certain cases, land conditions can have a significant impact on mounting system installation costs. For instance, since HSAT system function best on a land gradient of 3° or less, costly land levelling procedures could be required before installation at certain sites.
Simulation results were recorded and the key factors of the two systems were compared. Current market tariffs and rates were then applied to the simulated results.
In **Error! Reference source not found.** below, the main parameters of an FT system were compared with those of an HSAT system and presented as a percentage increase or decrease. Similarly, the financials were computed using current unit prices and tariffs
It must be stated that this is a high-level analysis that only considers basic assumptions. Unit prices and tariffs are vary widely based on product suppliers, installation regions, and local government policies.

Parameters	**Fixed Tilt System**	**HSAT Comparison** **Expenditure/revenue variation (INR)**[1]
Maximum DC capacity (number of modules)	48.89%	-188,16,000
Number of inverters	50.00%	-10,00,000
Inverter loading	-0.68%	-
Energy Generated	34.11%	5,88,75,126
Ground coverage ratio (GCR)	49.00	-[2]
Balance of System Cost (BOS)	343.91%	-4,03,86,386
Land development	-	-

The raw data for the data above is presented in Table-1.

Table-1: Comparison of the initial development costs of a fixed tilt (FT) system versus a horizontal single axis tracking system (HSAT) system

Parameters	HSAT	FT
Energy generated (kWh)	2,500,695	3,353,643
Lifetime energy generation[3] (kWh)	57,537,205	77,162,247
Ground coverage ratio (GCR)	38.3%	57.1%
DC capacity (kWp)	1,280	1,907
Number of module	4,000	5,960
AC capacity (kW)	1,000	1,500
BOS (INR)	11,743,158	52,129,544

[1] *Negative values indicate a higher expenditure for FT systems.*
[2] *Land prices fluctuate by state, utilization, social significance and topographic conditions.*

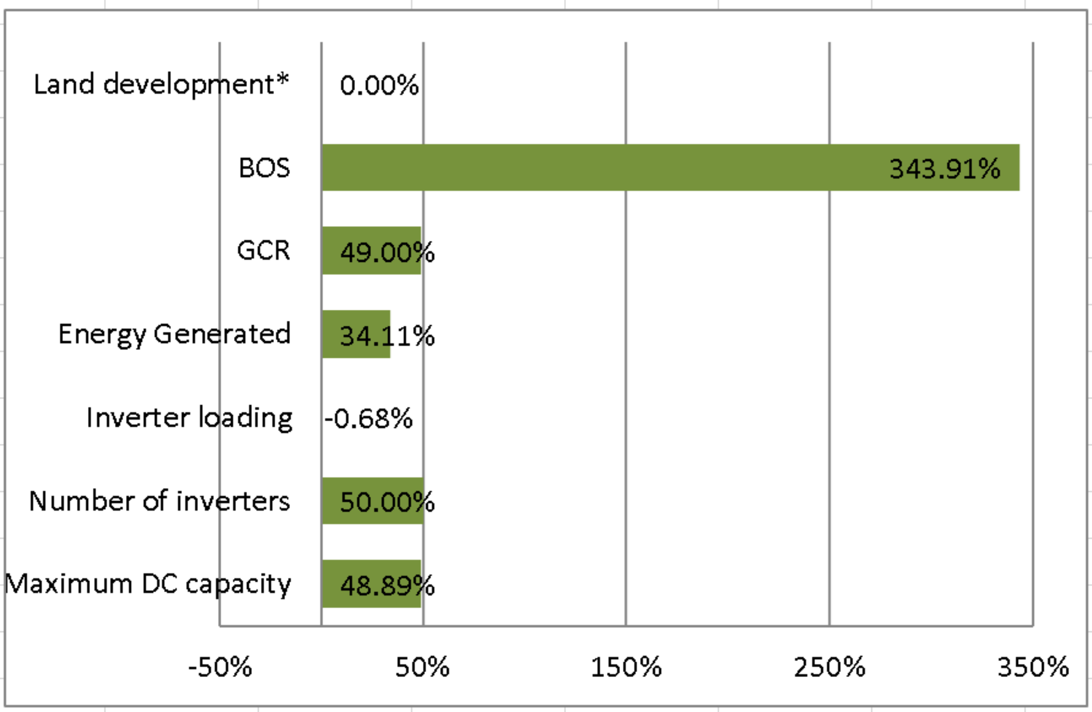

Figure 1: FT cost relative to HSAT

[3] Includes annual degradation

DECIPHERING THE DATA

SEI's analysis of the simulation information allowed the following deductions to be drawn:

- A FT system offers multiple module racking possibilities, with the possibility of achieving a higher DC power density in each area. Mounting options, such as tilt, are a function of the location of the project. In the simulation exercise, the FT system accommodated an array capacity that was approximately double that of the HSAT system on the considered land parcel. This extra FT installation capacity was made possible by an additional investment of close to INR 19 million, assuming a unit price of INR 30/Wp.
- Inverter loading is designed to handle the associated peak direct voltage (DC) capacity of a system. Since the FT system can accommodate almost double the array capacity of the HSAT system, it follows that the alternating current (AC) system would double too, meaning that twice the number of inverters will be needed for an FT system. **Using the current inverter rate of INR 2/W, the additional AC capacity required translates into an additional expenditure of INR 10 million for the FT system**.
- Ground coverage ratio (GCR) is defined as the ratio of the PV module area to the land area utilized. This ratio is ideally kept as high as possible. Tracking systems like the HSAT tend to use more land because units must be spaced out further apart to keep them from shading one another as they track the sun, which increases land use and the associated land costs for the developer. Tracker manufacturers recommend a maximum land gradient of 3° for deployment of HSAT systems, which means these systems may require additional land preparation costs for levelling, grading, and cutting. HSAT systems can be difficult to install in the randomly shaped plots typical of PV plants. Due to the tilt and the mounting arrangement chosen for the study, **the FT system returned a GCR that was almost double that of an HSAT system**.
- Although module prices still constitute a large chunk of total project cost, the drop in module prices in recent years has made the balance of system (BOS) cost an increasingly significant component of overall project cost. To quantify this expense, SEI's research considered the BOS costs of previously executed projects that were developed by different developers at different locations. Since it was possible to install a higher

peak capacity within the predefined land boundaries using FT architecture, this translated into a higher BOS cost for the FT system. In fact, the cost for the FT system was approximately 4.4 times higher than that of a comparable HSAT system.

- Return on investment (ROI) is represented by the energy generated. This parameter results from all project specifics ranging from the selection of the location, or solar resource, to O&M strategies like module cleaning. In the analysis, wherever possible, similar losses were considered so that performance could be evaluated on a level platform. In real plant design parameters, the actual generation ratio may vary. **In the analysis, the FT system generated approximately 34% more energy (P50 generation). This implies that the surplus generation of the FT system will be higher than that of the HSAT system over a 25-year period**. The study used an annual degradation guaranteed by most Tier-1 module manufacturers.
- Among other findings, it was discovered that the unit price of each system varies based on the manufacturer. For example, systems developed in China or made locally in India are less expensive than similar systems from European manufacturers. Another component affecting installation economics is the wide variation in tariffs for different areas. Though tight margins and higher land development costs for the HSAT system has made FT systems more popular, the study results indicate that there are instances where the HSAT system makes sense under current tariff structures.

Results showed that developing the 1.9MW FT system would be more expensive than developing the 1.2MW HSAT system. **However, the study did not consider land development costs or the long-term O&M cost of trackers.** Tracking systems tend to need maintenance more often due to their moving parts and in places where labor costs are high and spare parts are not readily available, this can meaningfully impact project economics. These factors could swing the outcome in favour of a FT system under a different set of conditions.

HSAT SYSTEM IS BEST UNDER CERTAIN CONDITIONS

The analysis found in favour of the HSAT system, but not without its caveats. Tracker technology is relatively new and the long-term performance of these systems is still being determined. Durability tests on HSAT components are addressing some of these concerns and manufacturers are building up their service capabilities. However, until those capabilities exist, the failure of a tracking system can cause longer than expected downtime due to reasons such as the limited availability of spare parts. No such drawbacks exist for FT systems under normal conditions. Module cleaning for HSAT systems could be simplified and made faster by optimally tilting the modules, but robotic cleaning is not yet available.

CONCLUSION

The question of which type of mounting system is best for a project must be evaluated on a case-by-case basis that takes various factors into account. What is most efficient and cost effective for one project may not be the best choice for another. Independent power purchase agreements (PPAs) would be wise to take these factors into consideration.

Figure –2: Solar PV plant with HSAT installation