Overcoming subsurface challenges and risks

Subsurface challenges and risks are compounding as optimal land is less available for utility-scale photovoltaic (PV) solar sites. Without proper planning and consideration of a project's specific subsurface challenges, costs can rapidly balloon, and developers and engineering, procurement and construction contractors (EPCs) can be left scrambling to remediate subsurface issues. In this article, FTC Solar discusses different subsurface risks and presents the inherent advantages of the Voyager single-axis tracker versus the leading single-axis tracker competition.

To help showcase these advantages, we outline two real-world project case studies featuring varying subsurface conditions.

Subsurface challenges

An ideal location for a utility-scale solar power plant features flat, geometrically even plots of land with consistent, low-corrosion, cohesive soils, or clays, to a decent depth beyond the required pile embedment. These project conditions will typically result in the most economically installed solar power plant, with direct-drive foundation posts being the best-in-class foundation solution. However, the availability of land, interconnection, solar resource, and offtake sources doesn't often allow real-world projects to encounter these idealized site conditions.

Specific to subsurface challenges, shallow bedrock, caliche, glacial till, and a wide variety of geological conditions can quickly add substantial costs to the foundation requirements for a given project. A wide variety of options are available to deal with non ideal soil conditions, but despite what other solution providers claim, alternatives such as predrill, concrete caissons, and ground screws will all come at a substantial cost premium versus a direct-driven pile.

Common mitigation options for bedrock and refusals

These include ground screws, drill and grout and pre-drill and drive. Given the specific nature of the soils, these alternatives are often viewed as necessary, and an 'it is what it is' mentality is taken. While this approach isn't necessarily wrong, it is imperative to look at other levers available to help mitigate cost increases. One of these important levers is the single-axis tracker's technology selection.

Tracker architecture's impact on subsurface risks

Market-leading tracker technologies vary widely in design. The most common differentiating aspects of a single-axis tracker are one module in portrait (1P) versus two modules in portrait (2P); centralized versus decentralized drive systems and controls; number and type of foundations to support the tracker row; and wind stow approach.

The Voyager tracker was designed from the ground up by a team of industry veterans who have had many gigawatts (GWs) of experience developing, designing, installing, and owning and operating utility-scale, single-axis-tracker solar power plants.

One key design aspect of the Voyager system was to significantly reduce the number of piles versus what is commonly employed. The fundamental logic for this key design requirement is that the fewer piles required to be installed, the lower the installation cost of those piles, both in best-case scenarios, direct drive with low refusals, and with compounded advantages in worst-case scenarios, that is 100% pre drill into bedrock. When comparing Voyager with other common tracker architectures, note the substantial

Pile per MW comparison of Voyager versus Competition

Tracker Model	Modules in Portrait	Number of Modules per Row	Number of Piles per Row	Modules per Pile	Piles per MWdc assumes 500-watt module
Voyager	2	112	7	16.0	125
Competitor #1	1	84	11	7.6	262
Competitor #2	1	112	15	8.6	232

Pile type comparison of Voyager versus Competition

Tracker Model	Pile Section Size	Pile Embedment (ft)
Voyager	W8	8
Competitor #1	W6	6.5
Competitor #2	W6	6.5

decrease in piles per megawatt (MW) required for Voyager versus other leading single-axis-tracker architectures.

Note that just comparing pile counts is not the whole story. Pile type, e.g., W6 versus W8 sections and pile embedment, 6 feet versus 10 feet, are also important to consider. As part of the evaluation, FTC Solar compared the design characteristics of these different architectures and found that both competitors #1 (1P) and #2 (1P) most commonly use W6 pile sections, whereas Voyager uses W8 sections. These differences are mainly attributed to the load profile deltas between 2P and 1P tracker architectures.

Capturing these differences is important in providing accurate estimations of the actual cost differences between these tracker architectures when dealing with challenging subsurface conditions, as shown in detail below.

Pile refusals and rework

Pile refusal is essentially what it sounds like, in the act of driving a pile into the desired location, the pile refuses to obtain the specified embedment depth required. There are a number of reasons for refusal, and they most commonly involve hitting a subsurface obstruction or bedrock. When pile refusal occurs, the pile is typically flagged for future testing and remediation. The testing involves performing an on-site load test to determine whether the post can withstand the design loads at its reduced embedment. Based on the results of this load test, there are two common workstreams.

1 Pile passes the load test

This is the best-case scenario, as the pile can stay in place, and only rework is required. This rework typically entails cutting the top of the pile and providing new holes for the required mechanical attachment points of the tracker.

2 Pile does not pass load test

This is the worst-case scenario, as the pile will need additional structural reinforcement to meet the load requirements. Often, the pile will be collared, which involves digging and pouring a rebar-reinforced concrete collar around the pile. Other common rework involves extracting the refused pile, and drilling and grouting a new pile in its place.

Both options add substantial cost to the originally intended solution.

For purposes of FTC Solar's cost estimation models, rework of the pile is assumed to take three person-hours. In addition, when refusal is encountered, we assume that 50% of piles will pass load testing and only require rework, and the other half will require a concrete collar.

Project case studies

FTC Solar has built some very useful tools to help quickly evaluate project-specific subsurface risks and benchmarking comparisons. These models can show the relative value differences that Voyager has over different competitors to help our customer arrive at the best-levelized cost of energy (LCoE) design for their project sites.

Case 1 Project A: Great soils, low refusals

		2P Voyager	1P Competitor	Delta
Project Size	MWdc	84.8	84.8	0
Row Count	#	1,429	1,905	476
Post Quantities				
Posts per Row	#	7	11	4
Total Posts	#	10,000	20,952	10,952
% Post for Predrill	%	0%	0%	0%
% Refusal on Direct-Driven Post	%	5%	4%	-1%
Predrill	#	0	0	0
Refusals on Non-Predrill Piles	#	500	838	338
Predrill + Refusals	#	500	838	338
Reduction	%			42%
Savings				
Pile Install Unit Cost	$/Pile	$74	$64	-$9
Predrill Unit Cost	$/Pile	$345	$328	$0
Refusals Unit Cost	$/Pile	$520	$450	-$70
Pile Install	$	$740,000	$1,340,928	-$600,928
Predrill	$	$0	$0	$0
Refusals	$	$260,000	$377,100	-$117,100
Total Cost	$	1,000,000	1,718,028	-718,028
Total Cost	$/w	$0.0118	$0.0203	-$0.0085

Case 2 Project B: Difficult soils with low-lying bedrock, that is hard, consolidated rock beneath surface soil, throughout the site with a high refusal rate

		2P Voyager	1P Competitor	Delta
Project Size	MWdc	84.8	84.8	0
Row Count	#	1,429	1,905	476
Post Quantities				
Posts per Row	#	7	11	4
Total Posts	#	10,000	20,952	10,952
% Post for Predrill	%	100%	80%	-20%
% Refusal on Direct-Driven Post	%	0%	0%	0%
Predrill	#	10,000	16,762	6,732
Refusals on Non-Predrill Piles	#	0	0	0
Predrill + Refusals	#	10,000	16,762	6,732
Reduction	%			42%
Savings				
Pile Install Unit Cost	$/Pile	$74	$64	-$9
Predrill Unit Cost	$/Pile	$345	$328	-$17
Refusals Unit Cost	$/Pile	$520	$450	-$70
Pile Install	$	$0	$0	$0
Predrill	$	$3,450,000	$5,497,936	-$2,047,936
Refusals	$	$0	$0	$0
Total Cost	$	$3,450,000	$5,497,936	-$2,047,936
Total Cost	$/w	$0.0407	$0.0648	-$0.0242

Conclusions and key takeaways

PV project developers and EPCs require nimble solutions that can address a major variable cost problem for utility-scale solar, subsurface soil conditions. The most effective way to reduce these costs is to use fewer foundations. An inherent aspect of Voyager is that it has far fewer posts relative to the competition, with seven posts per row. This translates to a more than 50% reduction in the number of posts compared with leading 1P competitors; a project with 10,000 posts using 2P Voyager would require ~20,952 posts using a 1P competitor.

The pile installation savings with Voyager, using the prior project case studies, are expected to be between 0.01 $/watt and 0.025 $/watt versus the leading competition.

FTC Solar's Voyager system checks all the boxes for a truly optimized PV tracker solution that also helps mitigate subsurface risks. With fewer piles per MW than both competing 1P and 2P solutions, Voyager reduces costs with clear-as-day simple math.

To download FTC's White Paper 'FTC's 2P Tracker Voyager's advantage to subsurface challenges & risks' go to:

http://www.ftcsolar.com/pilereduction