

White paper

The Guide to Breaking Ground for Solar Projects: **Screws vs. Piles Foundation**





Choosing Your Solar Project Foundation Confidently

The idea that a building is only as strong as its foundation rings true in every industry, including solar. “Perfect” solar project sites can provide ideal foundation conditions but are increasingly harder to obtain and often come at a premium price. Developers may have to defer to more rocky and hilly terrain to take advantage of higher margins from discounted parcels of land. **However, if the appropriate foundation product is not deployed for such terrains from the outset, the project runs the risk of delays, higher costs, and lower returns.**

Selecting the right foundation for PV solar panels is crucial, with durability, installation speed, and terrain suitability all playing a part in ensuring solar projects are delivered on time and within budget. Foundation options in solar—such as ground screws and driven piles—offer different features and benefits to consider. The decision to use either can have varying impacts on schedules and budgets: one could be good for your project, but another could be better.



Ground screws

Screwed into the ground with special equipment. They're quick to install but require more screws than piles and have a higher upfront material cost.

So, are piles the better choice?



Driven piles

Affordable and reliable option. They have lower upfront material and construction costs on typical sites but are not ideal for rugged terrain.

So, are screws the better choice?



What also makes this decision a heavy one is the fact that the racking system—which includes the foundation material and foundation installation—often adds up to 20% of solar project budgets.

Then, there are the other factors that cannot be downplayed. There are weather changes, soil conditions, frost heave, and terrain to consider. Pull tests need to be undertaken to check for refusal risk. Product lead times can often derail a project timeline if not given due consideration. Add construction timelines and project schedules to this list, and suddenly the choice between screws and piles becomes all-consuming.

Engaging a foundation expert with experience across the solar project lifecycle is key to helping you make the best decision. Leveraging engineering expertise on each product's technical advantages and its application in different scenarios will help you optimize project costs, mitigate risks to project schedules, and maximize revenue.

The trick is figuring out how to weigh the costs and benefits properly to pencil out strong projects and deliver the best returns.

This white paper will guide you in understanding:

- 1 How a real-world case study in 'screws vs. piles' identified an optimized solar return—a return you can emulate now
- 2 How to decide between screws and piles for your project—and give you a checklist you can immediately apply to your upcoming projects
- 3 Ten key questions to ask when choosing your foundation expert partner

Are Screws or Piles Better for Your Project and Bottomline?

Driven piles are a standard option for cost-effective PV. From a material and construction perspective, they can be deployed quickly and reliably on typical sites. If your land parcel has soft soil and non-rugged terrain, driven piles are a good choice. However, they are not the most effective option for rugged or sloped terrain or in unpredictable conditions that can present costly and schedule-derailing refusals.

Ground screws have higher up-front material and construction costs but are better if you are working with a more challenging site—one with sloping terrain and high-refusal rocky soils. With ground screws, you can also bear higher loads with lower anchoring depths. With adaptable racking designed for flexible land use, ground screws can deliver reliable returns from unreliable sites.

The best way to determine the right option for your project—one that is optimized in terms of budget, timelines, and risk—is to compare it across project costs, schedules, terrain, soil, refusal risk, and other useful criteria:

What foundation is the best for different site conditions?

Site Considerations	Ground Screws	Driven Piles
Sloped terrain greater than 15%	☹️	
Soil with high refusal risk	☹️	
Soft soil with low refusal risk		✅
High corrosion risk	☹️	✅
Frost heave soil	☹️	
Flat land with low slopes		✅

What are the benefits of each foundation?



Ground Screws

- Less risk of refusals
- Fewer change orders
- Less risk of schedule delays
- Long product lifespan



Driven Piles

- Lower upfront material costs
- Lower upfront construction costs
- Long product lifespan
- Specialized equipment not required

Going through an iterative process (like these comparison tables) is well worth your time, given the complexity in every solar project. With so many considerations to weigh up, engaging the expertise of a racking partner with a broad portfolio and an objective, consultative approach to foundation options can make all the difference for your project.

Cost-Benefit Approach to Optimizing Solar Returns with Ground Screws and Driven Piles

Background

Where foundation options are concerned, we understand and advocate the importance of selecting the right ground-mount foundation in optimizing a project's cost and risk profile. In this case study, you will find an in-depth analysis on ground screws and driven piles.

Challenge

There are various costs and advantages to using ground screws and driven piles for solar projects. The key challenge in choosing the better foundation for your project site lies in determining the break-even point measured against crucial site conditions for both foundation options.

Ground screws present higher up-front material and construction costs but perform better when there are issues associated with subterranean conditions such as soft or hard soils, rocks, caliche, and boulders. On the flip side, driven pile foundations are a cost-effective option for typical sites with soft soils and more even terrain.

Choosing the right foundation is not an easy decision—there are many different scenarios and project drivers to consider. For example, end-of-year projects are often driven by compressed deadlines to get systems online in time to meet PPA production schedules. In contrast, other projects have time flexibilities but tighter budgets. The varied level of risk that developers are able to absorb also requires a case-by-case assessment.

To help you determine the best approach for your projects, we've gathered data from real-world scenarios to find evidence-based answers to two key questions:

1

How impactful are driven pile foundations and ground screws to the bottom line in solar projects?

2

What are the cost and schedule implications of using ground screws versus driven piles? At what refusal percentage do ground screws outperform piles?

Solution

To clearly identify a break-even datapoint that pinpoints where driven piles are the best option and beyond which ground screws would deliver a better result, we brought together the combined experience and field knowledge of lead engineers in solar foundation and racking installation to evaluate the costs and benefits of the foundations against two sites with different subterranean profiles.

Site 1	A 10 MW - site with soft soil
Site 2	A 10 MW - site with high refusal risk

Initial analysis identified that ground screws cost 26% more than driven piles but that 40% more ground screws could be deployed in a day than driven piles. Further investigation was required as to how refusal affected these figures.

While it was widely acknowledged that there were varying refusal risks in every land parcel, a mid-point 50% refusal risk assumption was selected as a working point for this study.

Comparison variables included component material costs, installation costs, and installation time. A baseline of resources was deployed for each type of foundation. The cost and schedule impact of remediating piles driven to refusal using different methods (standard drill-and-drive and cut and drill methods) were assessed to identify the break-even point within that environment where ground screws would deliver better results.

Results

1. How impactful are driven pile foundations and ground screws to the bottom line in solar projects?

A breakdown of cost, time, and outcomes in the use of ground screws vs. driven piles across two 10 MW site

When examining different ways to remediate refusals—which ground screws do not require—it becomes clear that piles can quickly erode budgets and schedules (see Figure A). Using a standard drill-and-drive method, remediation cost for a pile adds an additional \$250 per foundation to the initial \$68 per unit install price. They also require more time at the rate of 50 units per day. Scenarios that allow for a “cut and drill” remediation add \$75 per pile and 100 foundations per day to the schedule.

Figure A: Installation costs

Install Cost and Schedule		
Install Type	Price per Foundation	Daily Install Rate
Ground Screw Install	\$86	175
Pile Install	\$68	125
Pile Remediation (Drill/Drive)	\$250	50
Pile Remediation (Move and Redrive)	\$125	75
Pile Refusal (Cut and Drill)	\$75	100

Bear in mind that the delayed schedule has severe repercussions (see Figure B). When estimating the actual cost of delays, the team found that the impact on other contractors and additional ancillary services can cost up to \$25,000 per week—in this case exceeding \$100,000 in losses for the developer over a four-week period.

Figure B: Repercussive costs from project delays

Delay Cost	
Cost per Week	\$25,000
Weeks Lost	4
Total Loss	\$100,000

Figure C below highlights the advantages of using piles in a soft environment — and the risks they pose in a high-refusal project. But that same 10 MW project with a 50% refusal rate tells a different story; piles are no longer an effective option.

Figure C: Analysis of piles and screws in different environments

10 MW System	Foundation Material			Installation		Total	
	Unit Cost	Qty	\$	\$	Days	\$	\$/Watt
Soft Site - Piles	\$95.55	2,750	\$262,762	\$187,000	22	\$449,762	\$0.045
Soft Site - Screws	\$60.00	4,500	\$270,000	\$387,000	26	\$657,000	\$0.066
High Refusal - Piles	\$105.30	2,750	\$289,575	\$530,750	50	\$820,325	\$0.082
High Refusal - Screws	\$60.00	4,500	\$270,000	\$387,000	26	\$657,000	\$0.066

When comparing cost, time and outcomes across the board (see Figure D), it is clear that:

- Piles are effective in soft soil conditions with low refusal risk, delivering a better bottom line.
- Screws are more effective in high-refusal sites, delivering a better bottom line.
- Remediation cost for a pile increases project costs and adds additional time to project schedules.

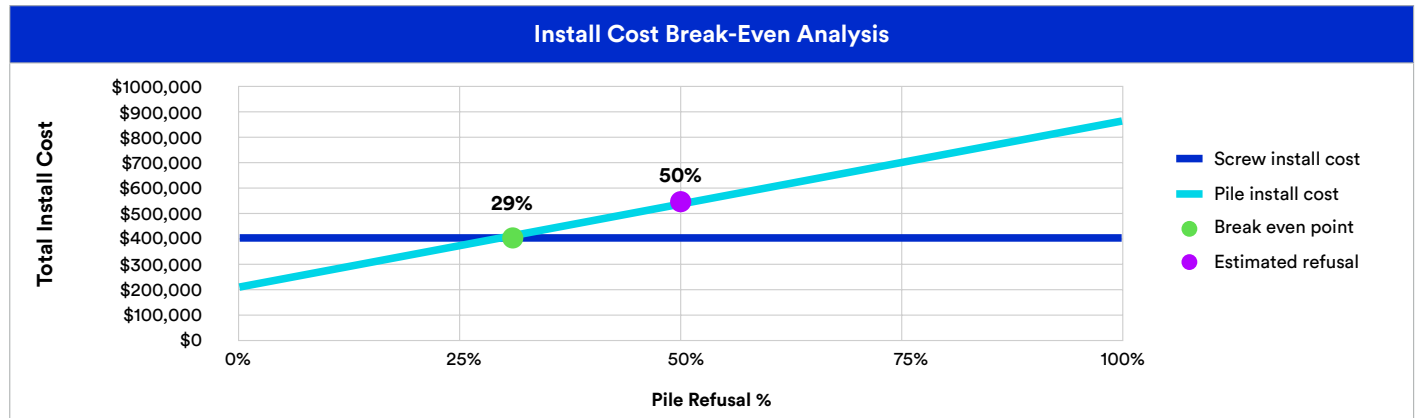
Figure D: Comparison summary (cost, time, outcomes) of driven piles vs. ground screws in a 10 MW site with differing soil

Product	Site	Cost	Total Cost	Time	Net Result	Outcome
Driven pile	10 MW Soft Soil	<p>Piles cost \$7.2K less than screws in material costs</p> <p>Piles cost \$200K less than screws to install</p>	Overall, piles cost \$207K less than screws	Piles took 4 days faster than screws to install	Piles have a \$0.021 per watt cost advantage over screws	Piles are more cost effective than screws on a soft site
VS.						
Ground screws	10 MW 50% Refusal	<p>Piles cost \$19.5K more than screws in material costs</p> <p>Piles cost \$143K more than screws to install</p> <p>Piles impact on contractors and ancillary services: Up to \$25K per week (up to \$85K for a 24-day delay)</p>	Overall, screws cost \$163K less than piles	Piles added 24 days to the project schedule	Screws have a \$0.016 per watt cost advantage over piles	Screws are more cost effective on a high-refusal site

2. What are the cost and schedule implications, and at what refusal percentage do ground screws outperform driven piles?

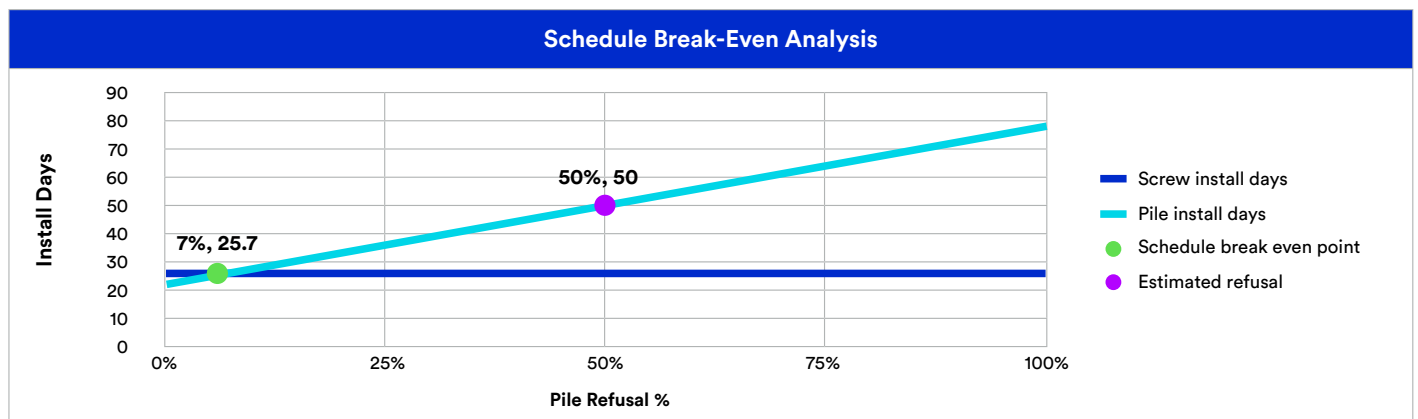
While a 50% refusal assumption was used in this study, it is not the norm. The question then becomes: At what refusal percentage do ground screws outperform piles? And what are the implications from both a cost and schedule perspective? The final step of the study involved identifying break-even points for both cost and installation time to determine an acceptable rate of refusal.

Figure E: Break-even analysis of installation costs—ground screws vs. driven piles



It can be seen from Figure E that installation costs alone indicate that a 29% refusal rate makes a site a good candidate for ground screws. Above this break-even point, the installation cost for driven piles would exceed the \$400,000 needed to install a ground screw system.

Figure F: Break-even analysis of project schedule—ground screws vs. driven piles



Refusals also impact schedules (see Figure F). In this scenario, both the pile and the ground screw systems would require a 26-day schedule, allowing for a refusal rate of up to 7%. Beyond that break-even point, each additional 15% of pile refusals would add another day to the schedule.

While a 29% refusal rate is the breakeven point in this scenario, we understand that every site is different, and each customer has their own set of goals and priorities. Although there is no one-size-fits-all, sites with a 20%-30% refusal rate require geotesting and engineering expertise, and a complete foundation portfolio to ensure you have the best solution for your project.

To understand how foundation decisions can immediately minimize risk, increase project efficiency, and maximize returns, it is crucial to engage a partner with varied experience, integrated portfolios, and expertise in solar project complexity.

When working closely with EPCs and developers to identify and source the most suitable options, the right foundation partner can help unlock the most value, delivering cost and schedule certainty on any site, anywhere, and under any conditions.

10 Questions to Ask When Choosing Your Foundation Partner

Deploying the foundation that suits your project and working with an experienced partner must go hand-in-hand to make sure you can unlock project value, manage project costs, and deliver your projects on schedule.

Here are ten key questions that you should ask when choosing the right vendor:

- 1 Do you have full spectrum solar experience that will give me confidence that you can understand my project needs and drivers, end-to-end?
- 2 Do you have experience installing different foundations?
- 3 What types of foundation products do you carry?
- 4 What land parcel conditions—soil, weather, terrain, refusal—and other criteria do I have to consider when choosing a product for my project?
- 5 How much of your product will I need?
- 6 What are the costs of your products?
- 7 What is your product's lead time?
- 8 How long does it take to install your product?
- 9 What are the potential risks I should consider?
- 10 Which foundation would you recommend for my project?



Ready to Break Ground with Terrasmart?

In the past, foundation selection was conducted based on assumptions and limited field data, with most implementing a default offering that was easily accessible or inexpensive with the hope of achieving higher margins. Now, with unbiased options geared towards improving solar structures, schedules, and cost, the potential to maximize revenue is much higher.

Starting your project on the right footing by getting foundation expertise ensures you set your project up for success from the outset. Choosing the right foundation product with the help of an expert partner ensures you stay on time, within budget, and unlock maximum project value, no matter how challenging your landscape.

Discover the best foundation for your solar projects. Contact us today.

About Terrasmart

Terrasmart, the renewable energy portfolio of Gibraltar (NASDAQ: ROCK) is a leading provider of solar racking technologies, electrical balance-of-system products, installation services, and project optimization software. Serving the commercial and utility sectors across North America, Terrasmart integrates products and solutions across the PV lifecycle to minimize risks and maximize returns. With over 19 GWs of solar deployed across 4600 PV systems, Terrasmart creates unique value for more profitable solar anywhere. Visit [Terrasmart.com](https://www.terrasmart.com).