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Solar Shading Analysis Matters Now More Than Ever

November, 2023

Why Solar Shade Analysis Matters Now More Than Ever

From SunEyes and LiDAR to drones; how technology is narrowing the gap between forecasted and actual production.

Solar contractors have been conducting solar shading analysis for over five decades. Why does it matter now more than ever?

81% of site surveyors say on-site data is higher quality than remote data. Over 90% conduct on-site surveys before construction, underscoring the importance of seeing a project firsthand prior to install day. Yet over three-quarters take shortcuts due to the risks of being on roofs.

This explains why 50% of solar contractors use only remote shading techniques.

Relying solely on remote imagery magnifies project issues at the micro and macro levels. First, two-thirds of Contractors report having to revise at least 25% of their projects, which can cost hundreds to thousands of dollars, and result in large amounts of wasted time. Providing good data consistently produces the most accurate results.

Second, since 2015 projects have missed their production forecasts by an average of 8%. Improper shading calculations play a role and will have negative implications: i) trust is eroded among home and property owners, who could doubt that projected production will match the actual system output; ii) the liability of production guarantees will come due; and iii) reputational hazard for individual companies and the solar industry at large can take form.

The first mainstream solar shade tool dates back to the 1970s. Handheld tools like the Pathfinder and SunEye became prominent in the early 2000s. These tools are physically clunky and require climbing on a roof to capture accurate data. In the 2010s, remote imagery and LiDAR (Light Detection And Ranging) started offering greater efficiency, but at the cost of reduced precision.

Nearly one-third of projects where remote shade studies are conducted result in production values being off by 10% or more versus the reality on-site.

The solar industry must prioritize safety, as well as accuracy and efficiency. The confluence of several new technologies — cloud computing, drones, and photogrammetry — makes this possible. Scanifly's patented viewshed technology is of equal accuracy to the Solmetric SunEye and used by Contractors around the world. It is accepted by all major US regulators and lenders, including NYSERDA, MassCEC, CEC, and Austin Energy.

This ebook dives into why shading analysis is so crucial, a brief history of shading tools, why shade analysis matters, how to conduct a thorough analysis, and how technology is enhancing vegetation management strategies.

A Brief History Of Solar Shading Tools

To understand the future of shade analysis tools, it's important to know how the tools we use today evolved.

2000s: Solar adoption began to take off in the early 2000s. The most common shading tools were handheld hardware like the Solar Pathfinder and Solmetric's SunEye. Both tools collect a hemispherical view of an area, capturing all possible causes of shade, like trees or other surrounding obstructions. From there, the tools differ.

The Solar Pathfinder consists of a dome made of transparent material (typically plastic or glass) mounted on a flat surface, such as a tripod or base. As the sun shines, the dome reflects the image of the surrounding landscape onto the diagram inside. This reflection allows you to see how nearby objects, such as trees, buildings, or terrain features, cast shadows on the potential solar installation area. The surveyor then traces the perimeter of the reflected objects on the provided Sunpath Diagram to determine the times of day and year when shading might occur on the solar array.

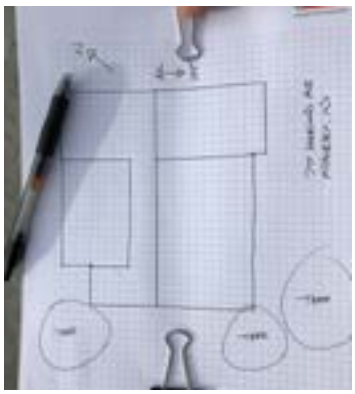
Solar Pathfinder Tripod Kit

Solar Pathfinder Dome

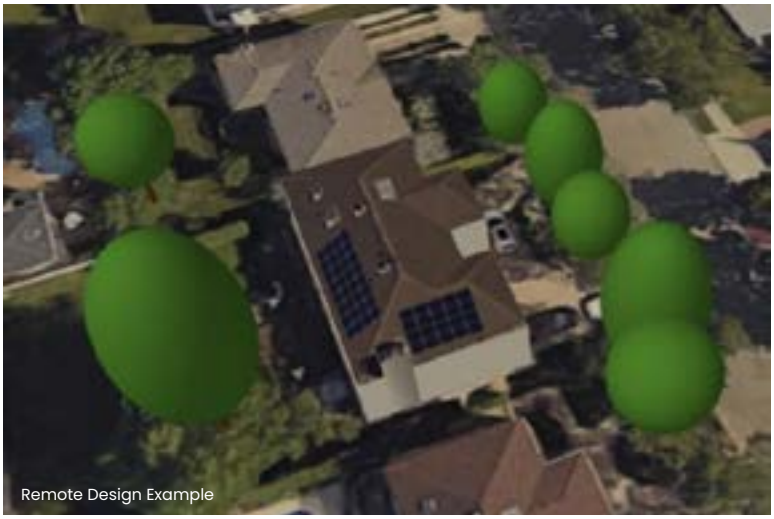
Sunpath Diagram

Solmetric digitized the Pathfinder's process when the SunEye 110 was introduced. The transparent hemispherical dome was replaced with a fisheye camera lens with the same field of view as the Pathfinder. The digital camera approach enabled the Surveyor to take a picture of the viewshed being analyzed, then use Solemtric's post-processing software to automatically and manually mask objects in the sun's path. The more modern SunEye 210 was introduced shortly after the 110, and is still used today.

The Pathfinder and SunEye still exist in a very similar form to the original*. While these tools are very accurate, they can be cumbersome and pose safety risks as Surveyors often climb on the roof to collect data. Finding replacement parts or full units can be difficult, expensive, and take weeks; in fact, a new SunEye is more expensive than a new drone (more on that later).



*Solmetric has announced the SunEye 360 coming soon as of October 2023.


Remote Design Example

2010s: In this decade, aerial and satellite imagery grew in popularity as a "good enough" and very efficient way to get site context. Improvements in satellite imagery made it possible to use them for shading analysis, particularly with Google's Project Sunroof democratizing how to figure out what projects are viable for solar. Other generic design software also added shadow-rendering tools, making a remote shade analysis possible for the first time in the early design stages of a project.

Later, LiDAR data, made publicly available by the U.S. Geological Survey (USGS), was incorporated as a reference to perform remote shade analysis. The data is obtained by third parties contracted by the USGS. LiDAR is captured using 3D scanners that incorporate lasers, Inertial Navigation Systems, and GPS/GNSS to transmit laser pulses to acquire depth and reflectivity information in the form of a point cloud. The end result offers an improvement over 2D aerial imagery by outlining the heights of vegetation and structures.

For solar applications, LiDAR and remote aerial imagery, while safer and faster, still have limitations compared to on-site tools: **maps can be outdated, lack full territorial coverage, and more subtle obstructions are hard to identify due to sparse spatial resolution.** The majority of errors include incorrect tree heights, missed vent pipes, and misjudged roof planes. Further, new construction projects rarely have any data.

2020s: Technology recently evolved again with three notable advancements converging together:

- **Cloud computing:** The ubiquity, ease, and continual cost compression make it much easier to process large data sets without being tied to a location.
- **Drones:** A new aerial perspective offered by low-cost, off-the-shelf, commercial drones (e.g. unmanned aerial vehicles (UAVs)) creates site data that has better resolution and is more real-time than satellite or aerial imagery.
- **Photogrammetry:** The opportunity to automatically construct — unobstructed or fabricated by a human — a to-scale digital replica of the environment within inches of reality is revolutionizing engineering, gaming, and many other industries.

The goal for this next phase of solar shading is to combine the precision of on-site hardware, like the Pathfinder and SunEye, with the efficiency and safety of remote mapping and software solutions. Scanifly's patented viewshed technology strikes this balance:

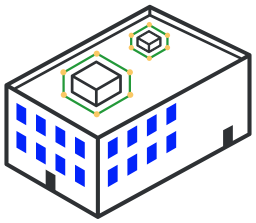
1. Instead of going on the roof, solar Surveyors can now fly a drone in less than 15 minutes taking pictures of the site's features.
2. Imagery is then uploaded to Scanifly's software, which automatically makes a 3D scene of the existing property using cloud computing and internal photogrammetry processing.
3. In Scanifly's software, PV system Designers can select any location in the 3D scene to generate hemispherical viewsheds — similar to the SunEye — to calculate on-site shading, including average solar access and total solar resource factors.
4. Contractors can export shade data and a share report to submit for rebates and permits.

Why Shading Analysis Matters In Solar

Where Shading Comes From

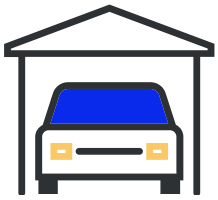
For residential and most commercial solar projects, shading can come from a variety of sources:

Trees / Vegetation
Existing and new trees, and how they grow over time; taller vegetation around a property also has an effect.



Obstructions
Vent pipes, HVAC systems, chimneys and other roof and building protrusions.

Roof Types
Roof structures, heights, steepness, and other characteristics (e.g. dormers, gables, etc.) and how they relate to each other.



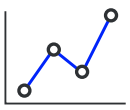
Outbuildings
Garages, sheds, or other buildings on the property.

Neighborhood Buildings
Any buildings near the project site depending on their position and height.

Neighborhood Features
Existing or future-planned buildings, topography and foliage.

Who Shading Impacts

Three major project stakeholders care about accurate shading for different reasons:



Solar professionals, including Contractors, use shade analysis to enhance the accuracy of a production forecast; some also provide production guarantees to stand behind those estimates. Contractor reputations, and in some cases liabilities, are at stake if production falls short.

Homeowners and project owners need reliable production estimates to forecast utility bill offsets (i.e. customer savings), payback periods and the return on investment of a PV system.

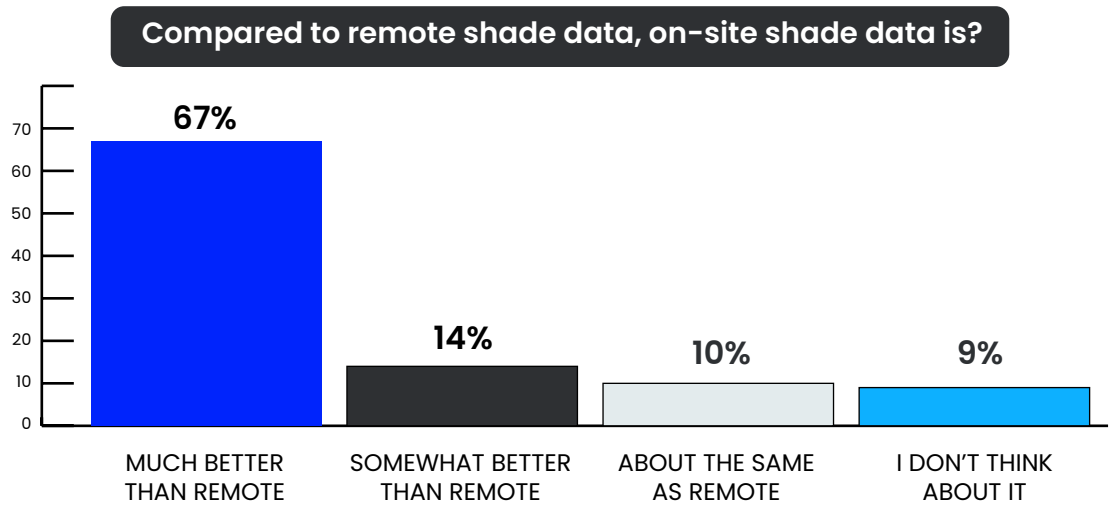
Governments and other local bodies, where applicable, provide incentives, but want to verify that projects are viable. Some authorities having jurisdiction (AHJs) have specific rules for solar projects that need to be followed.

Scanifly remains the only drone-based solar software to be reviewed and validated by major regulators and lenders across the United States, including:

- New York State Energy Research and Development Authority (NYSERDA)
- Massachusetts Clean Energy Centre (MassCEC)
- Rhode Island Chamber of Commerce
- California Energy Commission
- Energy Trust of Oregon
- Austin Energy
- Oncor Energy

Challenges With Existing Tools

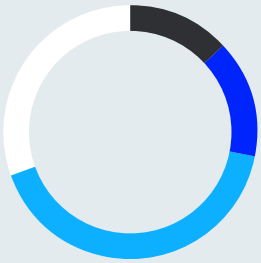
Site Surveyors (or sales reps in some cases) are responsible for collecting the majority of technical project data. They overwhelmingly acknowledge that on-site data is far superior to remote data. This underscores the importance of using on-site shading tools, like the Pathfinder, SunEye or Scanifly. 98% of projects have on-site surveys conducted prior to their installation, with 50% or so being done pre-contract signature.



Surveyors also acknowledge that the manual process of an on-site assessment can be cumbersome and dangerous:

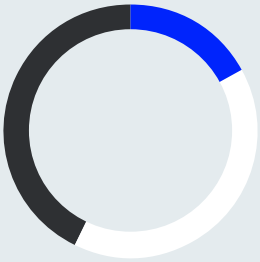
- 76% take shortcuts when they are surveying alone, including not climbing on certain roof planes or missing measurements.
- 60% say they don't feel safe on roofs, with 43% saying they never feel fully safe.
- 56% say their least enjoyable part of a survey is climbing on ladders or capturing roof data.

What part of the site surveying process do you like the least?



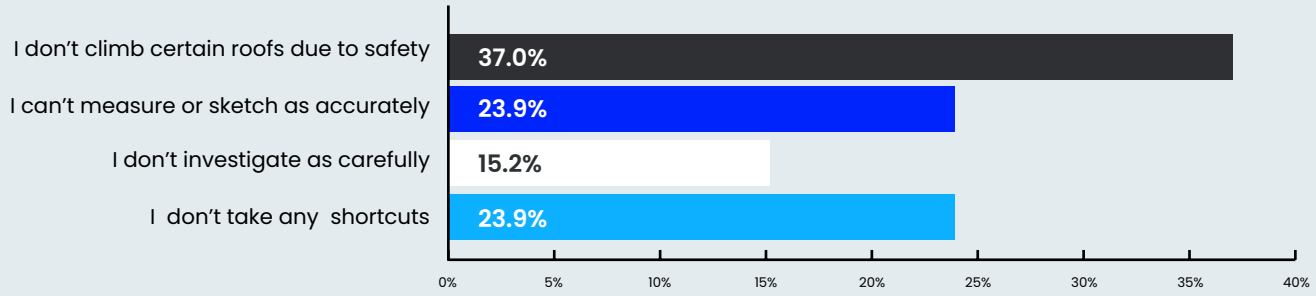
- **30.3%** WALKING AROUND
- **41.4%** CAPTURING ROOF DATA
- **15.2%** CLIMBING ON LADDER
- **13.1%** OTHER

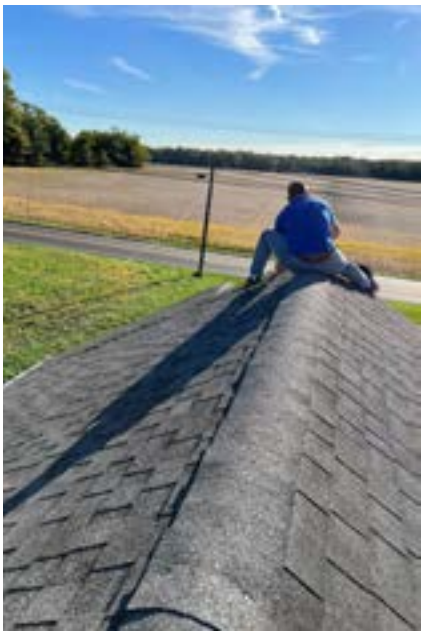
How safe do you feel climbing on a pitched roof?



- **42.6%** NEVER FULLY SAFE
- **40.4%** USUALLY SAFE
- **17.0%** RARELY SAFE

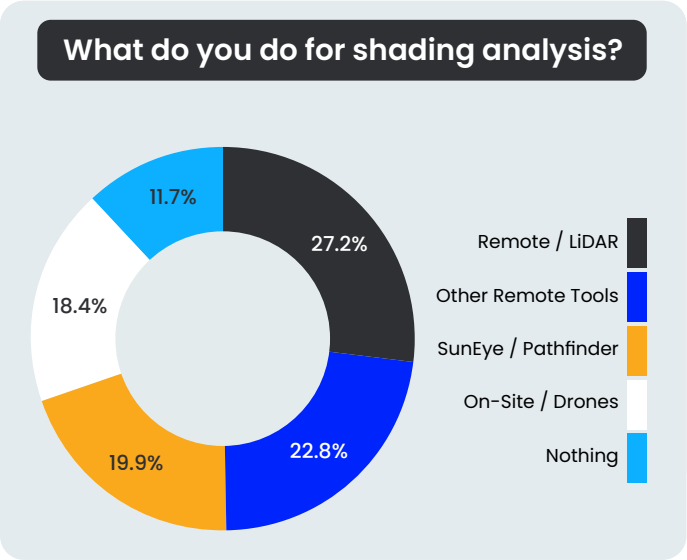
What shortcuts do you take when surveying alone?

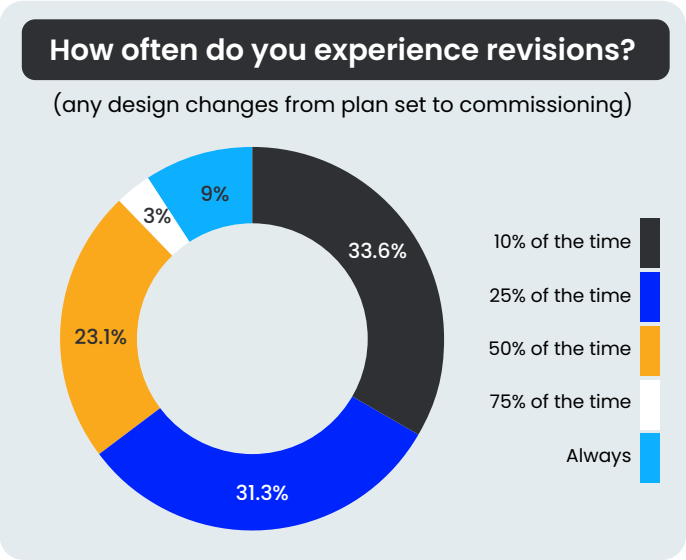




While on-site data is superior to remote data, the safety issues with roof climbs make it unappealing. This explains why the majority of Contractors settle for remote and/or LiDAR-based shade analysis instead of on-site tools. The thought is that "accurate enough is good enough."

Yet the theme of relying on remote data or collecting poor on-site data persists across the site survey process, including gathering roof measurements, determining on-site obstructions, and conducting a real-time shade analysis. This can have major impacts on project quality and revision rates as projects near installation; **two-thirds of project Designers had to rework at least 25% of projects.**





Revisions can have a grave impact on a final shading analysis. For example, if a Designer's layout is incorrect due to survey data collected, panels may have to be moved to fit the desired system size or offset. This can lead to panels being placed on an adjacent roof plane with inferior shading, for instance. Modules might even go on an adjacent building or garage, or, at worst, be removed outright. All of these outcomes can negatively impact the solar array's shading analysis, and therefore production estimate and offset.

To be further illustrative, let's say a remote survey conveyed the wrong tree heights and a faulty shade analysis led to a 20% delta between forecasted and actual production. With the average solar production per house in the United States being 10,950 kWh per year, that would hypothetically translate to only generating around 8,760 kWh annually.

20%+
Delta for remote versus on-site shading

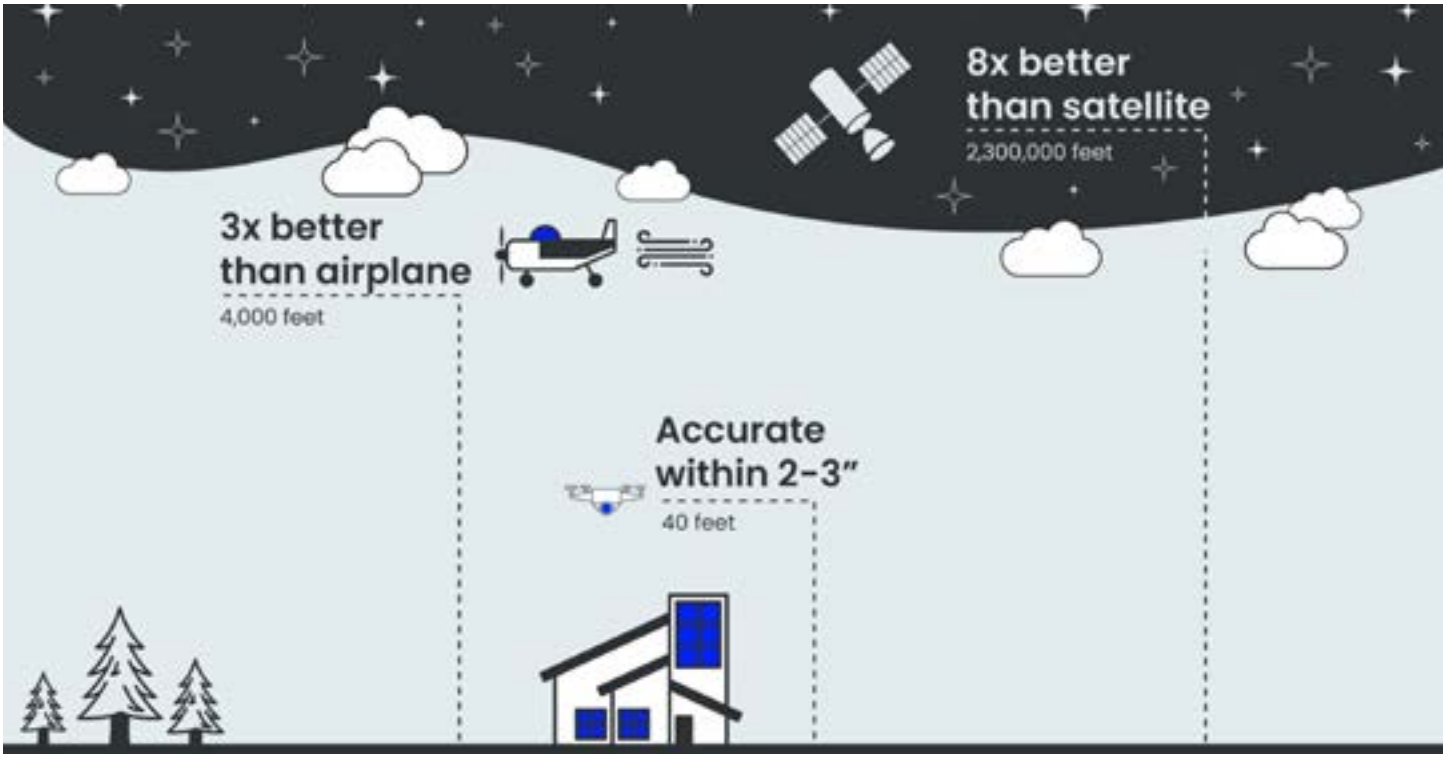
$12,000 Lifetime Loss
Estimated lifetime financial loss (from lost solar production) for residential homeowners due to inaccurate shading analysis

Therefore, with the average solar project lifespan of 25 years and the average kWh cost in the United States of 23 cents, the 20% miss would cost the system owner over $12,000 — and that's assuming electricity rates never change (which is not the case; electricity prices have consistently risen over the years).

How To Do a Shade Analysis Right

Optimizing your shade analysis requires multiple factors: 1) comprehensive real time data, 2) safe data acquisition (i.e. minimizing or eliminating roof time), and 3) efficient pre and post data capture processing.

Collecting on-site data with drones is the best way to achieve this balance.



Data Quality

Drone data resolution is up to 8x better than satellite imagery. The cameras have 20+ megapixel lenses and are capturing data from 20-100 feet above a property.

Satellite imagery is taken from a mile or two away, resulting in two main issues: First, it can be very pixelated and grainy. Second, the picture will have a slant if it's not orthorectified correctly, which results in a lot of guesswork for Designers. That means obstructions, vent pipes, and other details like tree canopy diameter won't be modeled accurately.

Data Recency

Drone data is usually captured at the same time as when a Surveyor collects the electrical and structural information of a property.

Often satellite imagery and LiDAR are outdated by years. Satellite imagery, for example, might miss details such as a tree growing or being cut down, or a new structure being added or removed on the property edge. New construction simply shows up as undeveloped land. Other imagery, such as aerial data from airplanes, may be more updated, but still has latency issues.

Data Coverage

Drone imagery is always available because it is typically collected during the on-site survey. The only exception is a no fly zone adjacent to a military base, over an airport, or in Washington DC. Even in these circumstances, a Surveyor can mostly get a waiver with enough time.

Conversely, satellite imagery decreases in quality the more rural a location is. Similarly, LiDAR becomes more sparse or non-existent outside of major metro areas.

Site Context

Drone imagery, especially captured from an oblique angle, gives the best perspective of an entire property. Taken further, when geo-tagged drone data is input into a photogrammetry engine to construct a virtual, to-scale model of the property, the site context becomes even more photorealistic.

Satellite imagery is projected from a top-down perspective. As a result, it is informative for identifying the location of most, but not all, objects. It struggles to show the heights of objects or obstructions. As a result, tree heights might be wrong — or worse, distorted to show a better shade environment. LiDAR helps with z-axis measurements and site context, but has limitations. While 3D satellite data is available in some cases, it lacks granularity and other important details.

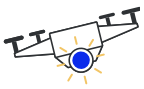
The Best Tool For Shading Is The Safest And Most Accurate

Scanifly developed a patented drone-based shade analysis solution, which provides the same on-site accuracy of the hand-held Pathfinder and Solmetric SunEye, without going on the roof, and with the ease of a software solution.

In direct comparison with a SunEye, Scanifly's virtual solar viewsheds are within 1% of SunEye readings.

0	<1%	15 min
Roof climbs required with Scanifly	Delta comparing Scanifly data to SunEye readings	Time required to collect data with Scanifly

How Scanifly Works



Fly: Fly a drone on-site for approximately 10 minutes, capturing several hundred pictures (i.e. JPEGs) of the property across two concentric circles. Any drone that takes geotagged images can be used.

Capture: Utilize Scanifly Mobile to photograph, take video, and annotate all the information related to the electrical system, structural integrity, and other property and safety considerations of the site. The app automatically digitizes all site information, and can be streamlined with a templated and customizable checklist.

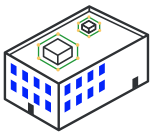
Design: After the on-site data (e.g. drone images and other media) is uploaded and processed to Scanifly's cloud, which is an automatic 30-minute process, a photorealistic 3D model will be created. Then PV system Designers conduct a full system layout, including defining roof segments, identifying obstructions and fire setbacks, conducting an approved on-site shading analysis, and placing arrays across the property.

Engineer (Plan Sets & Stamping): Upon completing the system layout, export files to CAD or SketchUp. From there, Scanifly Design Services can produce an AHJ-approved full plan set, inclusive of stamps, in under 48 hours.

Currently, Scanifly's shade analysis has been used to accurately design thousands of projects around the world.

Specifically, Scanifly's shading analysis comes with multiple capabilities:

Tree and Vegetation Heights: Easily determine the exact size, height, and density of vegetation on or around a proposed site. You can import specific species of 3D trees into the Scanifly model.



Rooftop Obstructions: 3D map all vent pipes, attic fans, HVAC systems, parapets, and any other structures that could cause even the slightest shading, so you can work with real-world context.

Tall Objects or Structures: Avoid estimating the heights and sizes of anything on-site. By utilizing drones and Scanifly's software, users can quantify the impact of all objects and structures on system production.

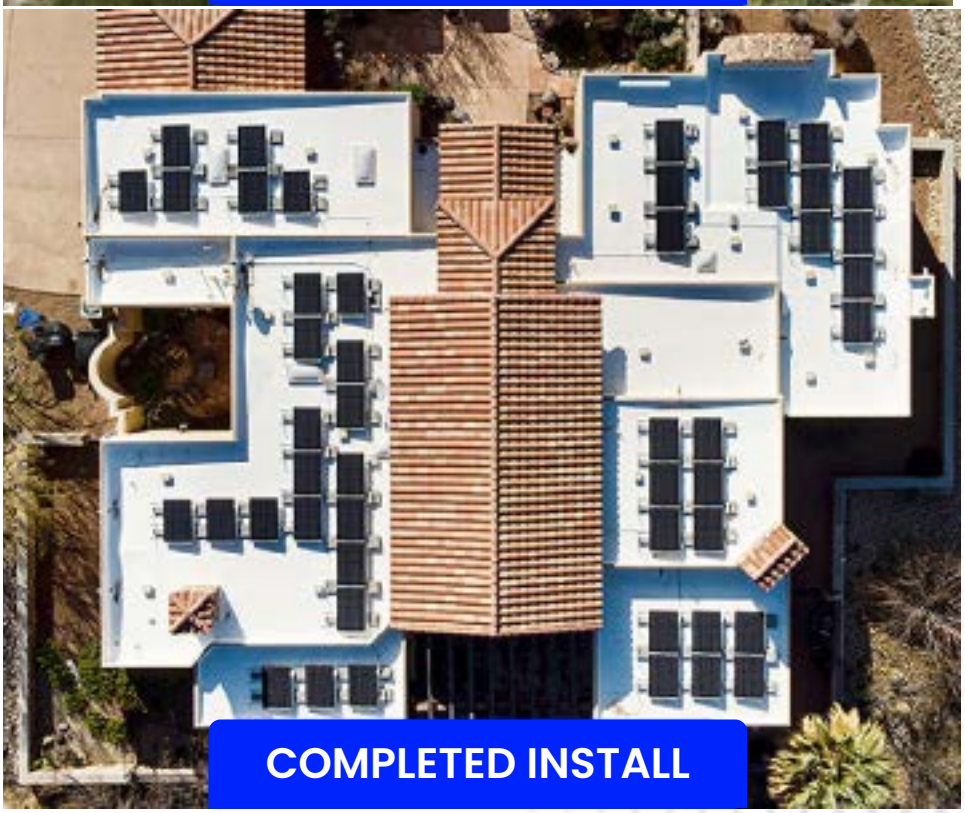
Adjacent Buildings: Scanifly's software performs shading analysis inclusive of any objects 3D mapped by the drone's camera.

New Construction: Create the most up-to-date maps and accurate 3D models of newly completed sites, including surrounding vegetation and structures. In some locations, such as California, shading analysis is mandatory for approval by local AHJs or regulatory bodies to obtain financial incentives and a certificate of occupancy.

Inter-row Spacing: Simulate shadows between each row of a system to determine optimal spacing.

How Accurate Is Scanifly?

Scanifly's software platform is quantitatively accurate within 2-3 inches across the X, Y, and Z axis of the to-scale, photorealistic 3D model. Anecdotally, layouts designed in Scanifly will perfectly match the final layouts completed on install day. Contractors that use Scanifly's technology experience zero redesigns, revisions, or as-builts from panel layouts.



Where Shade Analysis Is Less Critical But Still Important

In some contexts, a comprehensive shade analysis is a matter of company reputation. In that sense, analysis is not strictly essential, but still valuable.

No shade issues: If the project is in an open desert or large field with no trees nearby (even when estimating peak height of trees farther away), you may not need to conduct a shade analysis. Typically, in these areas, homes are either one-story with a flat roof or more spread out, where surrounding structures don't cause shade. However, a basic, quick shading analysis is good for validation and to ensure you don't stumble into any unexpected shade issues.

No government incentives or rebates: Most programs are based on production and offset percentages. If this doesn't factor into your project(s), you may not need to present a comprehensive shade analysis with production impact data.

No financing: Similar to government programs, solar financing can sometimes be based on production and offset, which an inaccurate solar shade analysis will impact. If the project owners aren't financing — or financing is not contingent on production — shade analysis in some places, becomes slightly less relevant.

New construction: You have to be careful with new construction. Many times, new home builders will plant baby trees with fast growth rates to fill in the community quickly (more on tree growth rates later). As a result, it might be effective to model a tree's anticipated height since it will likely cause shading issues from years five to 25. Further, you'll need to consider neighboring houses that may not have been built yet (for instance, a two-story neighbor to a bungalow).

A Quick Guide To Vegetation Management

Vegetation management, especially trees, is an important part of the solar process. Remote imagery's top down perspective makes it very difficult to estimate tree type, size, and growth rate — or plan for removal.

4 Steps To Removing Trees In Designs (And Measuring Solar Production Impact)

An interesting dichotomy often presents itself in a solar project: many people want to go solar, at least partially, for environmental impact. Yet maximizing solar production might require removing trees that would otherwise shade the array. As a result, many Contractors need to discuss tree removal with project owners. That's why Scanifly has a feature where Designers can remove trees in a solar site plan — and understand how that will impact solar production.

It's a simple four-step process:

1. **Measure Trees with a Drone:** Do this during the on-site survey, capturing dimensions and the current state of the tree.
2. **Capture Site Context:** Information like access points on the property, elevation, and water conservation locations.
3. **Estimate Production in Scanifly:** Mark all trees and obstructions using Scanifly's annotation feature. Then use the occluder tool to estimate solar production after removing a tree.
4. **Make a Removal Plan:** Create a keep-out zone in Scanifly that indicates where you want to remove trees. Then you can share the plan with experts as needed (e.g. tree surgeons) to properly plan removal.

Understanding 6 Common Tree Species

Trees are not the natural enemy of solar production — many species can (and do) create beauty on a project site without harming production. The key is understanding the different kinds of trees as it relates to their growth rates, canopy sizes, and canopy density.

Dormant deciduous trees pose a particularly interesting challenge, since they lose their leaves annually throughout the entire United States and much of the world.

BIRCH
Avg Annual Growth: 1’-2’
Avg Total Height: 30’-70’
Canopy Density: Light-Moderate
Commonly Found In: MN, NH, FL, TX

OAK
Avg Annual Growth: .5’-2.5’
Avg Total Height: 50’-100’
Canopy Density: Moderate-Dense
Commonly Found In: VA to FL & TX

POPLAR
Avg Annual Growth: 2’-3’
Avg Total Height: 50’-150’
Canopy Density: Moderate-Dense
Commonly Found In: Different types all over the US

ASH
Avg Annual Growth: 1’-2’
Avg Total Height: 50’-80’
Canopy Density: Moderate-Dense
Commonly Found In: MN, NH, FL, TX

MAPLE
Avg Annual Growth: 1’-2’
Avg Total Height: 30’-100’
Canopy Density: Dense
Commonly Found In: NE, Midwest & FL to TX

BEECH
Avg Annual Growth: .5’-2’
Avg Total Height: 50’-80’
Canopy Density: Dense
Commonly Found In: Midwest, AR, OK, TX & FL

5 Factors For Picking Solar-Friendly Tree Species

If your customers are in a position where they get to pick trees for their property, you have an opportunity to choose species that won't impact solar production.

The key is to choose based on the core factors that matter for solar:

- **Leaf size:** Small leaves mean more sunlight will get through even in full bloom when compared to broad-leaf trees.
- **Wood strength:** Hardwood trees will offer a bit more security — they are less likely to fall down in strong winds or have branches rip off, potentially damaging your roof and solar panels.
- **Growth speed:** From a solar perspective, the best trees are slow-growing with predictable growth patterns.
- **Maximum height:** Ideally, you want a species that doesn't naturally grow taller than your roof height.
- **Native to your geography:** Whenever planting a tree, pick a native species first — they will be best equipped to handle local weather and seasons.

From there, you want to ensure you're planting as far away from the project site as you can and avoiding the sun-exposure sides of the property when possible.

The Future Of Solar Shade Analysis

The solar industry has grown to over 4% of the US energy mix and is the top new energy source added to the grid the last few years. While the first terawatt of solar power took nearly 70 years to install, the next terawatt will take just 2-3 years.

The 2010s for US solar was about growing as fast as possible, with a very sales-first ethos. The rise of remote imagery-based tools facilitated this scaling, which was underpinned by an “accurate enough” mentality. Many Contractors have now been operating for over a decade prioritizing business optimization. As this continues, the 2020s in solar will be focused on operations, whereby Contractors seek to simplify their workflows, iron out years-tested processes, and seek technology to fill labor gaps. And as a result, the theme of business maturation will extend to the tools Contractors use.

The solar industry — dubbed the “solar-coaster” — has experienced a handful of boom-and-bust Contractors using fly-by-night sales tactics. Few things are more dangerous to the industry’s sustainability and reputation than Contractors promising much more production than a system will actually produce. The last thing a customer wants is to be promised a high offset and no utility bills, and then get stuck paying the utility each month. Some Contractors have even been found guilty of taking advantage of consumers with these practices. This poses a big risk to the longevity of the industry.

Leveling up shading analysis practices is a big part of this. First, collecting on-site shade data in the safest way possible (i.e. with a drone) can become the industry standard. The vast majority of Contractors already do pre-construction on-site surveys, so why not get the most recent and highest quality data with the widest coverage possible?

Leaning into the latest technology like Scanifly can also ensure that revision rates are near zero. Avoiding hiccups in the project’s survey, design and construction stages improves the development process for everyone involved. Scanifly’s shading tools ensure that production simulations are as close to reality as possible. This allows homeowners and project owners to achieve the forecasted project economics they signed up for.

Finally, vegetation management will be a part of the equation as well. Understanding, planning and modeling tree growth rates, or analyzing tree cutting prior to doing so, all fit into the equation for accurate shading and production assessments. It is never a good thing when solar and trees conflict, as both are solutions for improving the environment.

The solar industry has been incredibly resilient and adaptive. In the face of an ever-evolving regulatory, political, and incentive landscape, Contractors, who are the backbone of the industry, have adopted new technology to level up their businesses. With Scanifly’s advancements, solar shading tools can be perfectly accurate as well as efficient and safe. And finally, Contractors now have a turnkey solution to deliver maximum value to their customers.