WHITEPAPER

Drones shine bright in the solar industry

Solar energy steadily increasing usage, reducing costs, & increasing speed

48%
Usage in all project stages

75%
Reduction in survey costs

87%
Overhead cost reduction

Drone technology has been increasingly adopted across many industries in recent years. Due to improvements in photogrammetry and drone technology coupled with scaling pilot skills, the time and costs to perform large-scale surveys is far less when compared to traditional land surveys.

This white paper presents the findings from a series of discussions with leaders at solar energy industry companies on the topic of using drones. While not exhaustive, the general consensus demonstrates a wave of usage and interest in drone technology for all project stages.

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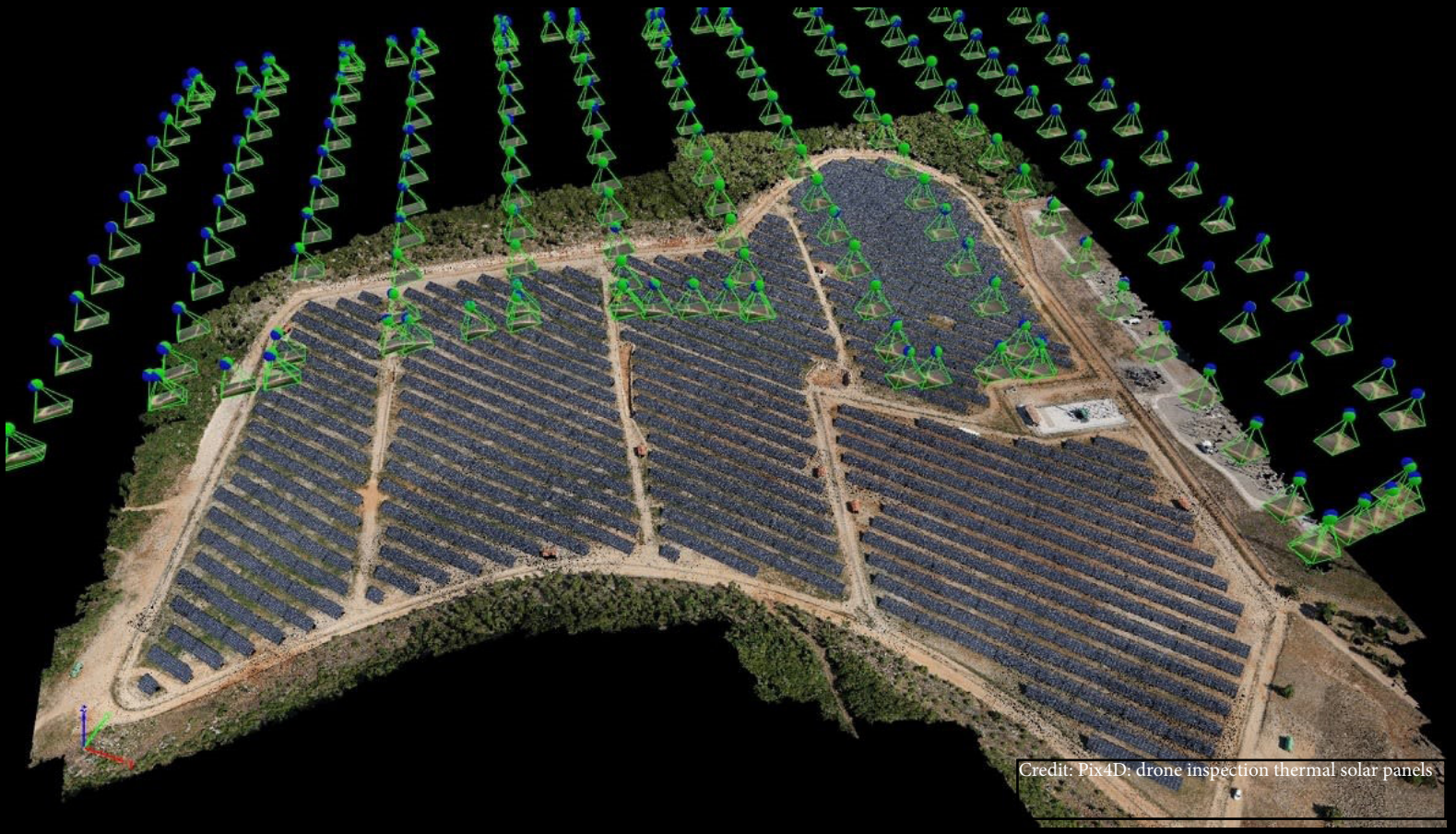


Drones shine bright in the solar industry

Executive summary and key takeaways

Drones are ready to be deployed at scale by solar companies. Their ability to provide insights on large-scale terrains or solar plants makes them an ideal candidate to assist solar companies in the design and operation of plants. However, their actual deployment by solar companies is not as widespread as one may think.

In this research, inflights documented the current attitude of solar installers towards using drones at various stages of the life cycle of solar installations. Using interviews with representatives of the solar industry, this research confirmed that commercial-scale solar companies are excited to use drones as a key tool for various use cases. They are used for a variety of use cases, ranging from business development to design, surveying, construction management and site monitoring. The most common use case is the obtaining of detailed site-information, both for ground-mounted systems and rooftop installations. In this context they are cost-effective when compared to traditional methods, generating the highest cost savings for complex and large terrains.

Nevertheless, doubts about regulation and the ability to easily source and integrate drone-services in the existing workflow remain some of the main reasons for many experts not to launch experiments with drones. As a result, only 47% of solar companies have actively started using them.

As the solar industry is expected to remain a competitive market where cost savings and efficiency gains are important, further development of the drone ecosystem for the solar industry can be expected. Drone service providers will continue to work on smoothening the whole experience of using drone services. Optimizations are possible to enable seamless sourcing, hereby optimizing the whole ecosystem, providing end-to-end services starting at convenient procurement of services to seamless execution of the flight and postprocessing of the data.

Drones - the state of the industry

In a recent report[1], Goldman Sachs highlighted the stellar evolution of drone technology in recent years. Comparing drones to other technologies such as the internet or GPS that had been developed initially for military purposes and that have now found their way to the general public, the bank expects drones to be put to work in commercial applications. The corresponding market opportunity for drones is "too large to ignore". This is confirmed by McKinsey, a consultancy, claiming that the GDP impact of drones will be $46[2] billion by 2026 in the USA alone.

Drones are indeed used more and more in business. However, as Bloomberg points out, the companies that try to build a viable business offering drone services have not always been successful.[3] McKinsey presented in its 2017 report on drones some of the key hurdles that drones and drone companies need to overcome to enable deployment at scale. The firm highlights three hurdles to the deployment at scale of drones.

"We actively follow the evolutions of the drone technology, but we are unsure of the regulation and how the processing of the data works."
- Yellow Door Energy

1 Goldman Sachs - Drones: Reporting for Work
2 McKinsey, Commercial drones are here: The future of unmanned aerial systems
3 Bloomberg - Drone Bubble Bursts, Wiping Out Startups and Hammering VC Firms

A first hurdle often cited is the regulatory framework. For drones to meet business requirements, they often operate in airspace that must be shared with others. In 35% of countries, this framework is still missing[4] and in those countries where a framework is in place, the regulations sometimes change resulting in uncertainty for businesses and clients.

Another challenge cited is the need for an integrated ecosystem that performs all the steps required to successfully use drones in business; from flight planning to data collection and processing. While the hardware to operate drones has become commoditized, there is a lot of demand for experts that are capable of providing end-to-end drone services.

Finally, like other innovations, drone applications are often required to demonstrate their return on investment before companies agree to allow projects to take place at scale.

Given the potential challenges related to the industrial use of drones, in 2017 Gartner estimated that drones required another 2 to 5 years to reach full potential.[5] Today in 2020, it is interesting to assess and document the progress of the deployment of this new technology.

4 UAV Coach - The 15 Countries Where Drones Are Banned
5 Gartner Research - Hype Cycle for Emerging Technologies 2017

Drones in the solar industry

This document specifically focuses on the deployment of drones in the solar energy industry. Use cases in this industry are well documented describing how drones can be utilized during each of the main phases of the lifecycle of a solar power plant. During early project phases, drones can be a useful alternative or complement to traditional land surveying techniques. During the later stage of construction, drones can be used to monitor project progress and adherence to the plan. Finally, once launched, drones are used to conduct operational inspections.

The market for solar companies is booming. Solar companies are expected to install stellar amounts of solar panels every year. The International Energy Agency expects solar companies to triple the world's installed capacity of photovoltaic panels between 2018 and 2022, reaching 880GWp of installed capacity. To do this, solar companies will cover terrains the size of 1000 soccer pitches every day with solar panels.[6]

Companies need to find ways to do this as efficiently as possible. Indeed, many companies are struggling to be profitable and are looking to reduce costs according to McKinsey, a consultancy firm.[7] As the cost of the solar modules is expected to drop, it will become increasingly important for solar installers to reduce all other costs, the so-called Balance Of System Cost which includes costs for planning and inspections of sites.[8]

As described above, drones can help. It would be useful, however, to document the detailed contribution that drones bring to each project's bottom line. This would allow teams to answer specific questions. For instance:

- In which circumstances do companies deploy drones?
- Which use cases are easier to implement and which ones are difficult?
- What are some of the struggles faced by project managers?

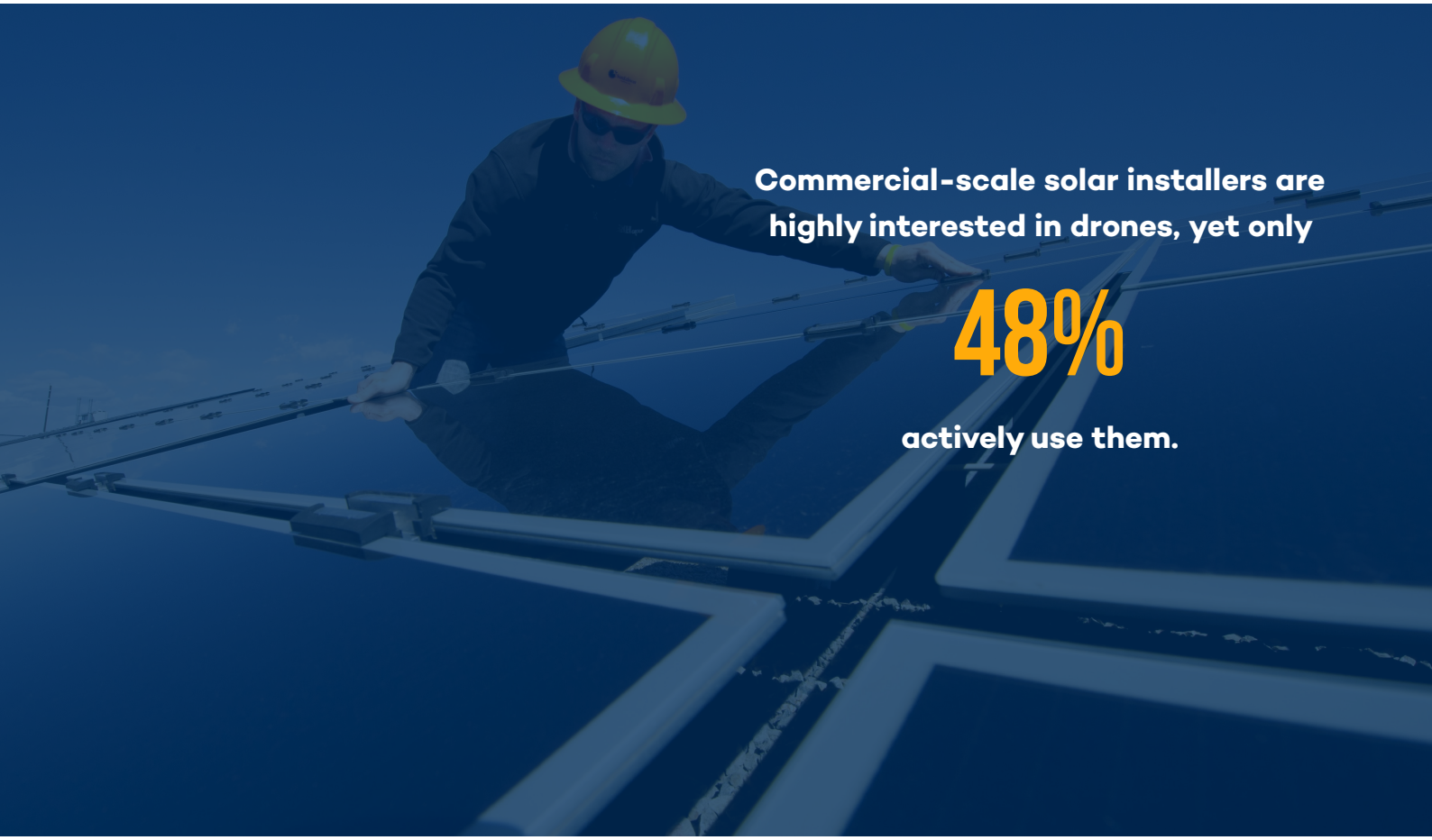
6 Carbon Brief Org - IEA: Renewable electricity set to grow 40% globally by 2022
7 McKinsey Report - How Solar Energy Can Finally Create Value
8 Rocky Mountain Institute / Georgia Tech Research Institute - Reducing Solar PV Soft Costs
9 EPC: Engineering, Procurement and Construction

Scope and methodology of this study

To answer some of these questions, inflights conducted 30 interviews with various stakeholders at 26 companies in the solar industry. The interviewees originated from different companies in the solar value chain, ranging from investors to developers and EPC contractors and operators. Talking to us from their offices in 12 different countries across Europe, the Middle East and Africa, these experts provided us with a global view on their experience with drones.

This paper aims to summarize the main takeaways from those interviews.

Solar industry adoption



The first question answered by our interviewees was whether or not drones are part of daily practice. Like many things in business, the answer was: “it depends.”

Those companies that focus on installing solar panels on residential buildings report that the size of the projects is often too small to justify the investment of flying drones. For such smaller projects, designs are typically made using readily available data obtained from Google Maps or satellites. Operational inspections on such installations are also kept to a minimum.

The story for commercial solar installers is different as is illustrated in Figure 1. These companies install solar panels on terrains from 1ha and more or on roofs starting at 0.5 ha. It is important to note though that, while 88% of participating commercial solar companies report

being interested in using drones in their activities, only 48% actively use them. 16% of these companies use drones systematically on every project.

> **"We don't require a high level of data precision for residential projects."**
>
> - Beauvent

All commercial players are interested and 48% actively use drones

Question: What is your level of usage of drone technology?

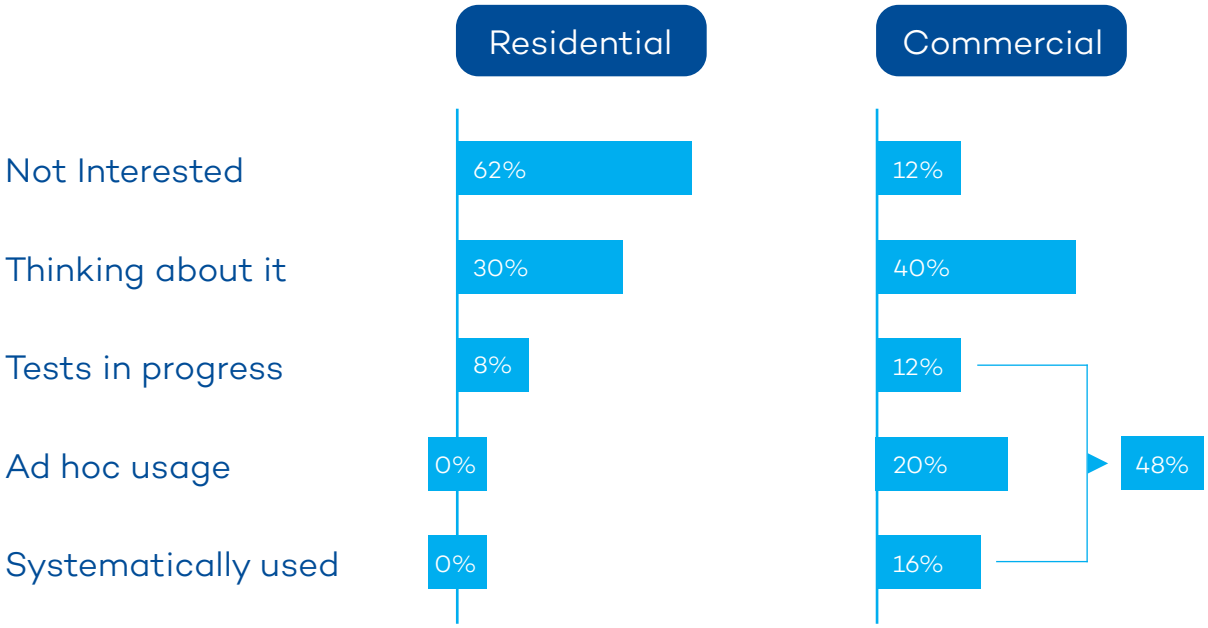


Figure 1: Use of drones by solar companies

Given the high level of interest in using drones, it is interesting to understand why over half of the participants haven't started their deployment. The interviews reveal 2 main reasons:

Some companies feel that the specific projects they deliver don't lend themselves well to the use of drones. For example, they build solar installations exclusively on new buildings where "As-Built" drawings are considered reliable or they focus on rooftops that have a straightforward layout. Although these companies recognize the value of drones, they feel they haven't come across the right project to test this new technology.

Other companies cite the above-mentioned hurdles related to drone use. Unsure about the applicable regulations,

the hassle of finding a reliable pilot and the complexity of processing the data generated by drones results in some companies not leaping. This illustrates the importance of accompanying the clients in their discovery of new technologies.

Drones are most relevant during the design stage

As expected, solar companies take a deliberate approach to deploying drones when and where they provide the most value. They deploy them for specific use cases and evaluate their added value.

> **"Whenever high resolution measurement is needed, we try to use a drone"**
>
> - Total Quadrant

The interviews allowed gathering a detailed opinion from experts on those use cases that provide the most value. The interviews provide us with insights on which use cases solar companies deploy drones and how the operational cost is reduced for each use case.

Drones are most relevant during detailed design stage

Question: Where in the value chain do you use drones? What is the impact?

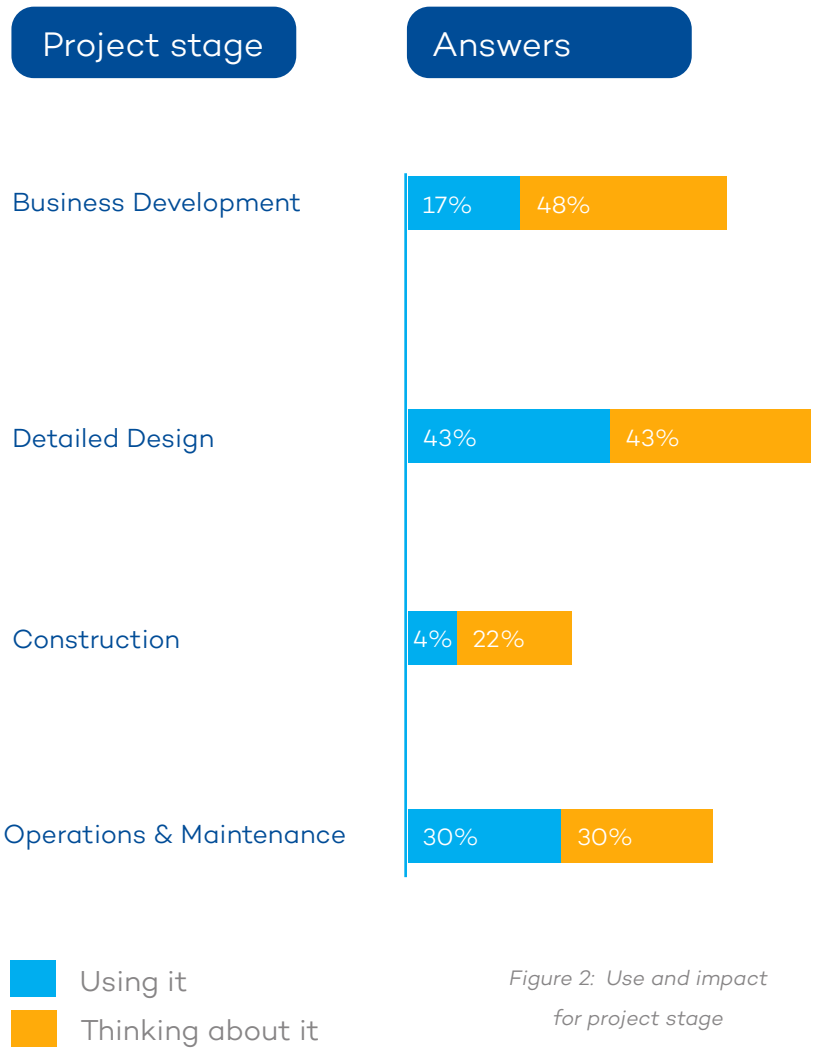


Figure 2: Use and impact for project stage

How drones reduce operational cost

Reduce **travel time** and **cost** to provide decision makers with site information
Provide **safer work environment**

Provide designers with **more detailed site data** to improve **solar panel positioning**
Reduce **travel time** and **cost**

Provide objective and accurate project **progress reporting**
Detect **deviations** from schedule or plan

Reduce inspection cost with more detailed thermal and visual drone data
Provide **safer work**

> **"To install innovative bi-facial solar panels, we require additional information on the properties of vegetation that we can only obtain using drones."**
>
> - BP Lightsource

From Figure 2, it is clear that drones are most often deployed during the design phase. This comes as no surprise as detailed 3D models can be generated fairly easy using drone data. Designers operating in the hilly Southern provinces of Belgium, for instance, point to "**accurate contour lines that are critical for good project design**."

The importance of drones at this stage will probably be reinforced over time as companies begin to realize the benefits for terrains with complex topography.

The use case of performing site surveys before the actual design of the plant starts is less common. At this stage companies are not yet sure whether they will fully develop the site, so often the budget available for surveying at this stage is smaller. Nevertheless, some solar companies are strongly convinced by the value of this use case as:

1. It reduces the HSE risk for employees as pointed out by an installer based in the Middle East: "**We systematically check the structural integrity of the roofs we build on. However, our business development people have to assess sites before we can do this structural integrity analysis. This is an important risk and drones could reduce our exposure**".

2. It reduces travel times to remote sites as pointed out by an investor in Kenya: "**We invest in projects around Africa. The logistics of going to different sites are costly and time-consuming.**"

Another fairly common use case is the utilization of drones for inspections while the site is in operations. Drones equipped with thermal cameras can detect overheating panels. Additionally, drones could potentially be used to detect other damage to solar panels or to identify cleaning requirements. Drone users are convinced by the added-value of this use case. A Belgian Solar Installer pointed out that, however, some reports contain false positives: "**the data processing software is very good at identifying defective panels, but produces false-positives for underperforming assets.**"

The return on investment for deploying drones is also dependent on the configuration of the solar panels: "**If in a large solar plant a few panels underperform due to overheating, it is sometimes not worth it to fix them, especially if their underperformance doesn't affect other panels. If, however, due to an anomaly a whole string of panels stops working, drone monitoring is valuable**."

The final use case that is on our interviewees' minds is the use of drones

for the monitoring of the construction progress. Is construction progressing as planned and are the panels installed exactly according to the detailed design? Although there may be value in this use case, most interviewees point out the strong trust they have in their project managers or designated EPC-firms. "**Our project managers report on their work in a traditional way, but we work with them for many years. Even though they are far away, we see no issues here,**" said an investor from Kenya.

Drones reduce land surveying costs

At this point in the document, it is important to distinguish between a traditional land survey and a 3D drone mapping. While both perform the act of surveying land, a drone produces a computer-generated 3-dimensional map. The terminology for surveying land with a drone is, therefore, referred to as 3D drone mapping and not drone surveying or the like.

For the land surveying stage, even the most ardent advocates of drone mapping for solar installers recognize the need to consider alternative tools. The interviewees pointed to 4 main alternatives that meet installers' needs for land surveying:

1. Conventional surveying techniques using theodolite, laser scanners and GNSS Systems
2. Government-sponsored programs that provide LIDAR data in many countries (e.g. 18 of 27 European countries)[11]
3. Satellite data from programs such as ALOS PALSAR[12]
4. Well-known platforms such as Google Maps

As the latter 3 techniques are essentially free, these are alternatives to be considered by solar installers when projects do not call for more precise measurements.

All interviewees use traditional land surveying techniques to some extent. Typically these services are outsourced to specialized contractors. These land surveying techniques are, generally speaking, significantly more expensive and take longer than 3D drone mapping.

> **"The as built drawings of roofs are very often outdated or wrong, so we systematically obtain an updated measurement of the roofs."**
>
> - Générale du Solaire

It should be noted that the prices for conventional land surveying services vary widely. Prices depend on the land size, terrain homogeneity or complexity, the geographical location, and the requirements for precision measurements. While the cost for a drone mapping is also affected by terrain size, the faster execution time to survey land reduces the costs significantly. Terrain homogeneity has less of an impact for the execution of a drone mapping, but it does affect the cost of the data processing for the computer-generated 3D models. Both land surveying and drone mapping are affected by geographical location. Depending on the country and, or specific location, both may need permits or are limited by government regulations. Both techniques can produce precise and accurate measurements, but it takes significantly more time with traditional land surveying. Instead of days or weeks when compared to traditional land surveying, 3D drone mapping can achieve the same or better results in hours.

Despite these large variations, the data collected shows a clear trend in favour of 3D drone mapping to conduct land surveys. The cost savings are greatest when the terrain surveyed is either very large (50 ha in the below example) or when the terrain is complex, thus requiring a lot of manual effort when using traditional land surveying techniques. The data obtained from interviewees is summarized in Figures 3.1 and 3.2.

11 Archaeology of Slovenia
12 ALOS-2 - The Advanced Land Observing Satellite-2

Drones reduce surveying costs of ground mounted sites by up to 83%

Average cost to survey ground mounted site, Thousand EUR per project

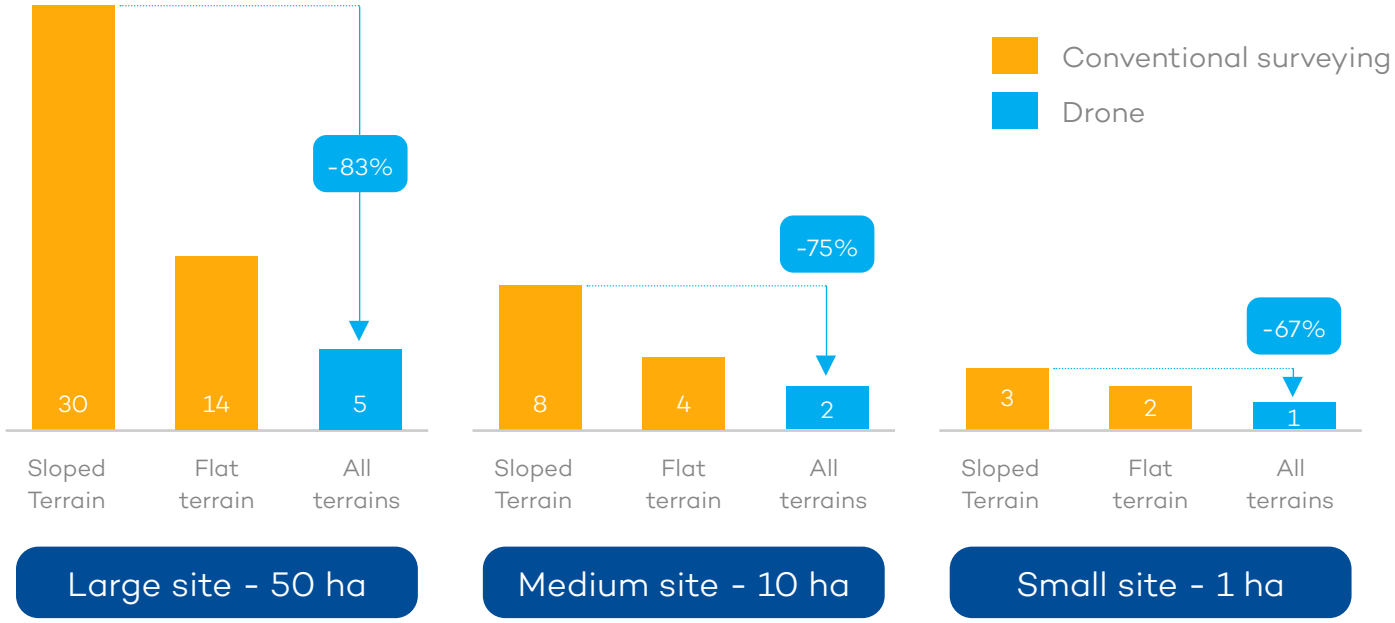


Figure 3.1: Summary of cost data obtained for surveying ground-mounted sites

Drones reduce surveying costs of rooftop by up to 87%

Average cost to survey rooftop, Thousand EUR per project

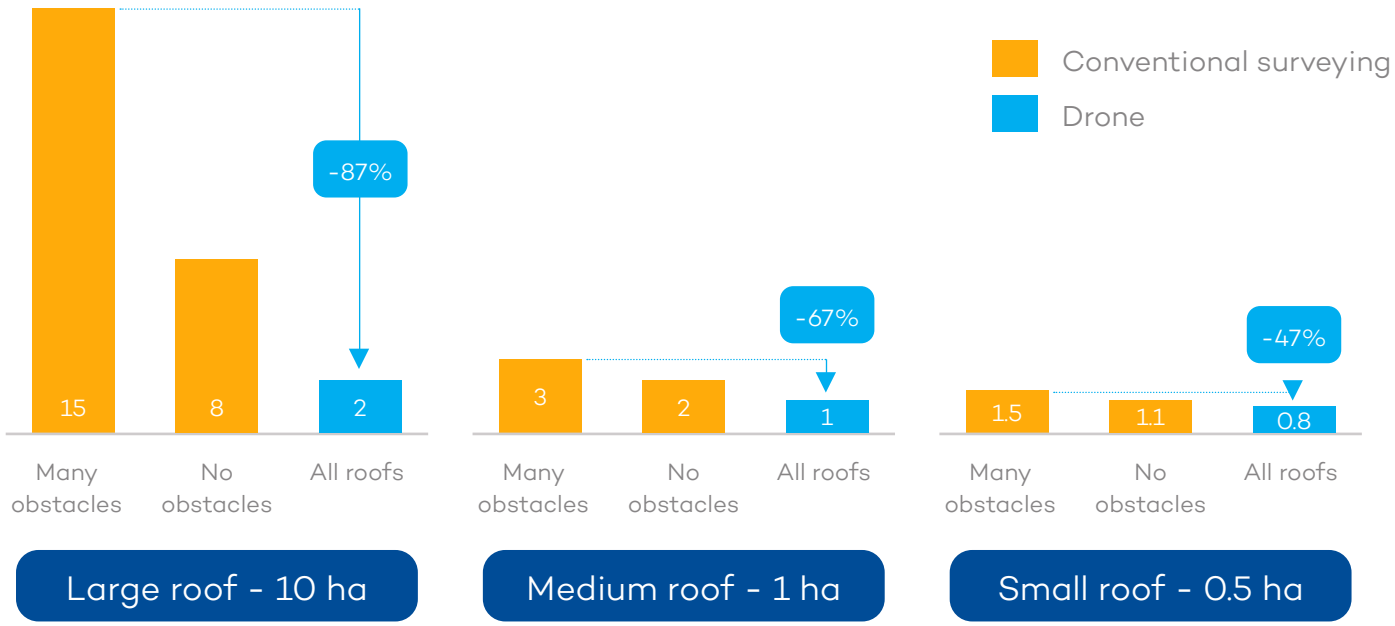


Figure 3.2 Summary of cost data obtained for surveying roof mounted sites

Drones reduce time to execute surveys

Automated drone pilot sourcing reduces lead times, sometimes by more than

50%

As commercial solar PV (photovoltaic) projects take months and, in some cases, up to 5 years to complete, solar installers rarely consider the lead times to obtain surveyor services. Furthermore, solar installers at this scale have typically implemented mature procurement processes that enable them to source contractors in a fairly reliable way. Nevertheless, typical lead times easily mount up to 2 months, especially for projects that are large or remote.

> **“We have a global need for surveying and the difficulty is making the trade-off between drone photogrammetry / LiDAR versus traditional surveying. Especially when you factor in costs, time to execute, and availability of these services in a global context.”**
>
> - Engie

The lead time for a land survey using 3D drone mapping is typically much shorter. The time to survey even large sites (for example 50ha) is typically not more than 1 day, so the execution time mainly depends on the availability of a drone pilot. The weather can sometimes be a dealbreaker when scheduling a drone flight. However bad weather conditions rarely delay a drone flight by more than a few days. More significant is the time spent on sourcing, negotiating prices, and scheduling of a drone flight. In some cases a specific permit to execute the survey is required. When working with an independent drone flight operator, these steps in the process can take nearly as much time as traditional land surveying. Finding a pilot, negotiating the price and scheduling can take weeks or more. The good news is that this process can be optimized using a drone pilot network: by using standard rates as well as automated pilot sourcing from a drone pilot network and flight scheduling, lead times can be reduced significantly.

Reduction in overhead costs

As long as the lead times are not on the critical path for project delivery, optimizing the lead time for obtaining the data from land surveying may not be a priority for solar installers. Nevertheless, it is important to be aware of the hidden cost that these lead times entail. To complete this research, inflights conducted a simulation of the associated overhead to manage a land survey (either executed conventional sourcing or using an automated platform). These overhead costs can be significant. By using a drone network as described above, significant savings in these overhead costs can be realized.

> **"Some of our project managers use drones for every project, but others haven't tried it yet"**
>
> - Dauvister

Figure 5 below provides an estimation of typical overhead costs when procuring surveying services using a traditional approach versus the overhead costs when procuring using a drone pilot network.

Using drone pilot network reduces overhead cost by up to 87%

Estimated overhead cost, Hours per project

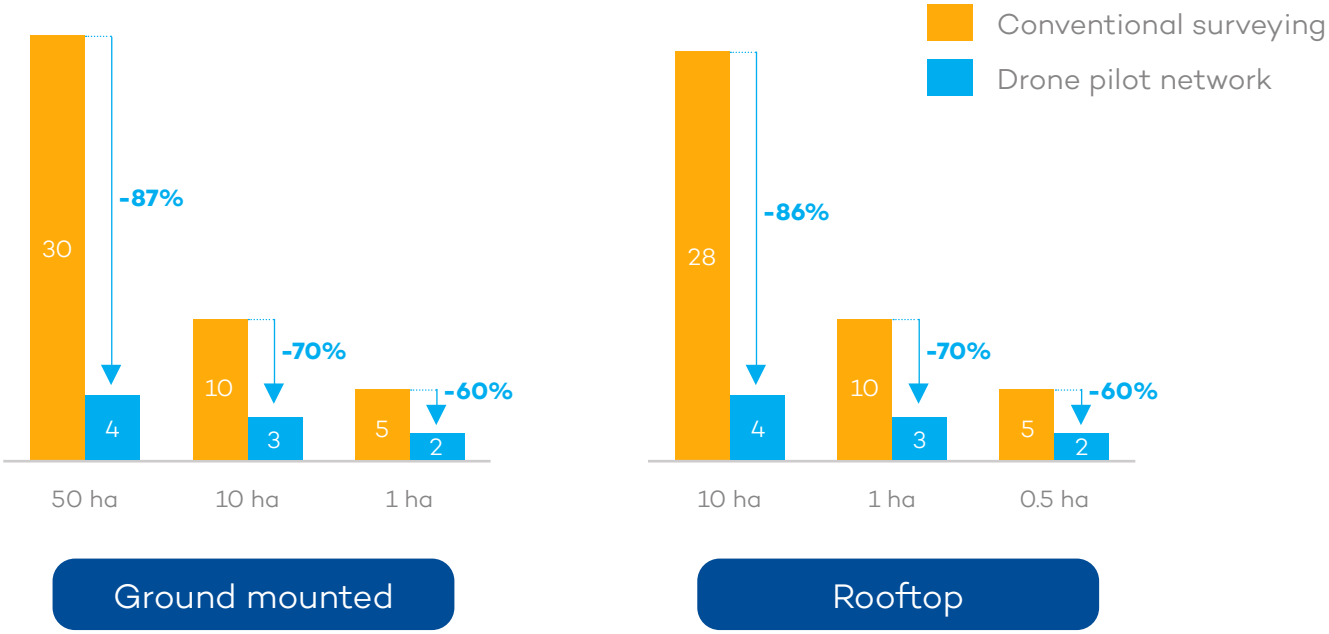


Figure 5: Estimation of hidden overhead costs associated with managing surveying service providers

Conclusion and outlook

In conclusion, the discussions with solar installers proved that the time is right to integrate drones as part of daily practices in the solar industry. Commercial-scale solar installers are very much eager to explore the use of drones and opportunities exist for anyone who is able to ease some of the hurdles.

Moving forward the drone technology is expected to continue to evolve. Drones will be equipped with batteries with a larger storage capacity and further automation in the drone operation can be expected. The key challenge however will be the development of easy to use solutions for existing and new use cases. This includes further facilitating the procurement of drone services, but also further development of the solutions that process the data gathered by drones.

We extend our appreciation to all participants.

inflights