How to Perform a Solar Site Survey: Costly Solar Mistakes Related to Solar Site Survey

The Definitive Guide to Solar Site Survey

If you want to know in advance how your solar panel system is going to look like, how to make it achieve the optimal performance, and also:

- *How to assess whether your location is solar-ready,*
- *How much space you need to place the solar panels,*
- *What is the best orientation of your roof,*
- *How to avoid shading from any nearby obstacles,*
- *What direction to mount solar panels,*
- *What angle to mount solar panels*
- *What is solar panel mounting structure and how to choose the optimal mounting for your solar panels,*
- *Costly Solar Mistakes Related to Solar Site Survey*

This **definitive guide to solar site survey** will provide you with all the necessary practical info.

Here you will find described some commonly valid principles that will help you ensure the optimal performance of your solar panel system thus maximizing the amount of solar-generated electricity.

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The below-provided guidelines apply both to residential (home, office) and mobile solar panel systems (motorhome, caravan, camper, RV).

Also, you should mind that it is in your interest to be equipped with some essential knowledge about how to survey your site and also about orientation, tilt angle and optimal mounting of the solar array.

If you decide to have your site surveyed, be sure that the solar vendor you select relies on your unawareness of such info and most probably will use certain non-effective shortcuts just to perform the solar system installation in due time thus neglecting some important energy efficiency issues.

Is your building solar-ready?

Even if your area and location have a good solar potential, your building might not be suitable for installation of a photovoltaic system.

Your building is prepared for installing a solar system if:

- You have already made it energy-efficient.
- The roof of your building (or your yard) is unshaded, at least during the sunny hours (normally six) of the day.
- Its roof has a Southern (or Northern, if you live in the Southern hemisphere) orientation.
- The roof is in a good condition.

How to assess your location for the solar resource?

The spot where you intend to install photovoltaic solar array should have:

a) A clear and unobstructed access to the sun throughout the day (between 9 a.m. and 3 p.m.) and throughout the year.

This means lack of any obstacles between the sun's rays and the solar array's surface – trees, chimneys, lamp-posts, neighbor buildings, etc.

It should be noted that a spot may be unshaded during one part of the day and shaded during another part of the day.

Furthermore, a site unshaded in summer might be shaded in winter, as the low position of the sun in winter casts longer shadows.

b) Preferably a South-facing (or North-facing, if you live in the Southern hemisphere) roof.

True South (or True North, if you live in the Southern hemisphere) orientation is not mandatory.

A somehow Southeast or Southwest (for the Southern hemisphere Northeast or Northwest, respectively) facing roof is also acceptable.

It has been proven that deviation within 20-30 degrees of the True South (or True North, if you live in the Southern hemisphere) results in less than 10% degradation of PV array's performance, which is fairly acceptable.

Pure Eastern or pure Western orientation not recommended, since as a rule, solar photovoltaic panels should be exposed to direct sunlight for at least 6 hours a day.

You should mind that installing a solar pv system on a roof facing East or West might result in 20% degradation of system performance, which is a serious compromise!

The roof can be either sloped or flat. Flat roofs allow easier to implement the desired tilt angle of the PV array, but a sloped roof will do as well.

c) Enough space for placing solar panels

The area you need for your PV system depends mainly on:

- How much energy it is designed to produce
- Types of PV panels you are going to install (monocrystalline, polycrystalline or thin-film)

- The size of the PV panels (to a lesser extent since, as a rule, PV panels do not vary much in size).

The less efficient photovoltaic panels you use, the greater the area you need for your solar array but also the lower the costs.

Monocrystalline panels are the most efficient solar panel type while thin-film panels are the least efficient ones.

Why does the condition of your roof matter?

A PV system can be installed on any roof type.

Regarding roof mounting, there are two options for installing PV panels – either mounting the solar panels on the roof or replacing the roof tiles with PV panels.

As a rule, roofs with composition shingles are the easiest to work with, while those with slate are the most difficult ones.

Here are the drawbacks in case of photovoltaic panels mounted on the roof:

- Panels must be removed upon performing any roof repair or replacement activity.
- Installation of brackets and racks could cause roof leaks.
- Roof warranty may be affected.
- Some people might find this unattractive.

However, roof-integrated installation costs amount up to 40% more compared to roof-mounted installation.

If your roof is relatively old and is to be replaced in the near future, in order to minimize any redundant costs, a smart idea would be to replace it at the time the solar power system is being installed.

If you have a new roof, you should consult both your PV provider and roof repair company how the installation of a solar power system will affect your roof warranty.

Certainly, solar panels can be placed on the ground as well, on a fixed or tracking mount.

Performing a site survey is the starting point for launching every photovoltaic system.

When searching for a proper site to install the solar array, you should consider:

- The orientation towards the sun
- Lack of any shading obstacles (during the whole day and throughout the whole year!)
- Minimization of the length of the DC cables between the PV array and the inverter
- Aesthetics
- Protection from theft and vandalism
- Easy access for installation and maintenance of the PV array.

To make better use of this guide, you should be familiar with some fundamental issues, such as azimuth and tilt angle:

Azimuth is the angle between the direction perpendicular to the array's surface and the True North.

Tilt (elevation) is the angle measured between a mounted PV panel and a horizontal ground surface:

As a rule, solar arrays are recommended to install on roofs facing True South (for North America – USA, Canada and Europe) or True North – if you live in the Southern hemisphere, e.g., Australia, New Zealand, South Africa.

Installation of panels on roofs facing North (or South – if you live in the Southern hemisphere) is NOT recommended.

What is to be done during a site survey?

Step 1: Assess any possible shading by nearby objects

The solar array should be provided with clear and unobstructed access to sunlight between 9 a.m. and 3 p.m. every day, throughout the year.
Shading is not recommended, at least between 9:00 a.m. and 3:00 p.m.

Mind that even small shadows can affect severely the power output of the PV array.

To achieve the maximum of your shading analysis, perform the survey during a bright and sunny day, preferably in summer when trees have their full foliage mass.

During the site survey, you should be looking for the following obstacles:

- Buildings – you should be informed whether a new building is not being planned nearby, throwing shade to your site
- Chimneys, power lines, poles, hedges and neighboring roofs
- Trees – if you're performing your site survey in winter, remember that in summer trees look different than in winter
- Hills and other earth obstacles – mind that in winter sun is much closer to the horizon than in summer.

A site that is unshaded during a part of the day might be partially shaded during other time of the day.

Similarly, if a site is unshaded in summer, it might be shaded in winter, since in winter sun is lower than in summer (and close to the horizon) and casts longer shadows.

Tips on how to avoid shading

a) Determining the optimum distance between a photovoltaic solar panel and a direct shading object:

L = (Ls * d) / ds,

where:

-L is the optimum distance between a PV panel and a direct shading object, m
-Ls is the distance from the Earth to Sun, km

-d is the thickness of the shading object, m
-ds is the diameter of the Sun, km

Since the distance from the Earth to the Sun is 150 million km, and the diameter of the Sun is 1.39 million km, the above formula could be simplified as follows:

L= 108 * d,

where L is in m and d is m.

b) Determining the tilt angle to avoid shading of a nearby obstacle

Here is a practical formula for tilt calculation upon a shading obstacle in front of the PV panels.

Regarding cast-shading objects, it should be noted that in winter months the arc of the sun is the lowest over the horizon.

Therefore, while an object is not a shading obstacle in summer, the same object could cast a shadow in winter!

c) Placing the PV panels to avoid inter-row shading

To avoid any inter-row shading, you should place two individual neighbor rows at a space that is at least 3 times the maximum height of a tilted row.

Step 2: Determine the area available on your roof

Usually, access space around the panels adds up to 20 % to the required area for placing PV panels.

Don't try to use every last square inch on your roof to install a solar PV array because:

- The PV array gets challenging to install.
- The PV array gets hard to maintain.
- Wind loading at the edge of the roof increases.
- From a regulatory point of view, you could violate specific provisions for providing space for fire-fighters and other staff that might need to access the roof area.

Consider the dead spaces around the array.

These are the spots that are either shaded or need to be provided between the panels.

Step 3: Determine orientation and tilt angle

Use a compass to check what direction your roof faces and a spirit level to measure the angle of the roof from the horizontal.

If your site is located in the Northern hemisphere, you should look towards the South, East, and West.

If your location is in the Southern hemisphere, you should look towards North, East, and West.

If you live near the equator, you should look towards East and West.

The ideal roof for mounting your PV array is a roof facing South if you live in the Northern hemisphere and facing North if you live in the Southern hemisphere.

Things, however, are not as crucial as they appear.

You can get 90-95% of a PV panel's full power if it is located within 20 degrees of the sun's direction.

This means 20 degrees to the East or to the West of the full South.

Here are some tips regarding what is the best angle and direction and angle for mounting a solar panel.

Recommended limits for mounting PV array within:
– Azimuth: ±30 degrees East and West of due South

– Tilt angle: ±15 degrees from latitude

A practical rule for determining the optimal orientation:

At solar noon (the time when the sun is highest above the horizon) place a straight object, such as a pencil or a ruler, perpendicularly to the surface of your photovoltaic solar panel.

If the panel is perpendicular to the sun, you'll see no shadow.

Otherwise, the object will throw a shadow, and you have to make some kind of adjustment to position the PV panel optimally.

What is the best angle to mount solar panels?

- For maximizing the PV power output in summer, adjust the tilt of the array at the value of the latitude minus 15 degrees.
- For maximizing the PV power output in winter, the optimal tilt angle is latitude plus 15 degrees.
- For maximizing the PV performance for the greatest number of hours during the year, mount the PV array to a tilt angle equal to the local latitude.

What if you select a tilt angle other than the local latitude?

- If your PV array is tilted at an angle lower than local altitude, your system will produce maximum possible power in summer but will underperform in winter. For grid-connected systems this is not a critical issue – on one hand, the building is connected to the grid and on the other hand, there is less sun in winter anyway.
- On the opposite, if your PV array is tilted at an angle higher than local altitude, your system will produce the maximum possible power in winter but will underperform in summer.
- Of course, if it is technically feasible, you can choose to set one tilt angle value in summer and another one in winter. This is recommended for off-grid systems (described in the next chapters) where maximum performance is targeted throughout the whole year.

Reduce the array's power output in summer or in winter?

This depends on the type of your solar power system.

If you have an off-grid (stand-alone) system, it's unlikely that you'd prefer less power output in winter, especially when it's cloudy, and there are less Peak Sun Hours (PSH) than in summer.

With an off-grid solar power system, and no opportunity to connect to the grid, it's normal to struggle for high power output both in summer and in winter to meet most (if not all) of your energy needs.

If you have a grid-tied system, however, we would expect you not bother to fight for high PV array performance in winter.

First, you are connected to the grid, and your household power needs are satisfied. Second, in winter it's often cloudy, and PSH is lower than in summer.

Therefore, you're likely to have lower expectations about your incomes from exporting electricity to the grid!

Step 4: Choose a solar panel mounting method of the solar array

There are the following types of mounting methods:

- Roof mounting
- Pole mounting
- Ground mounting
- Facade mounting

Flat roof/ground mounting gives you the most freedom to optimize the position of the PV array according to the solar resource.

There are four types of flat surface mounted racks:

Fixed racks:

- Fixed at one orientation facing due South
- Slope (tilt angle) equal to the site latitude.

Manually adjustable racks:

- Allow changing the tilt angle

- Usually, the tilt angle is changed at the beginning of every season
- Result in 12% power increase compared to fixed mount system.

Single axis tracking racks:

- Follow the sun from east to west every day
- Require additional components and maintenance
- Increase the power output by 25% compared to the fixed mount system.

Dual axis tracking racks:

- Continually orient the PV panels perpendicular to the brightest part of the sky
- Require additional components and maintenance
- More common than single axis tracking racks
- Increase the power output by more than 30% compared to the fixed mount system.

The other types of mounting give you less freedom since you are not able to orientate the PV array in order to receive the maximum amount of irradiation.

As mentioned above, however, the orientation is more important than the tilt, so performing an evaluation of the site from a solar point of view gives you an opportunity for compromise.

Regarding mounting constructions for residential solar panel systems, mind that:

- Not every mounting construction is suitable for any kind of panel, while certain kinds of panels are designed for a specific mounting method.
- It's a good plan to ask the supplier of the PV panels to install them on the roof.
- To ensure sufficient cooling of the PV panels, enough room should be provided beneath them.
- A design visa and/or a building permit might be required.
- All the necessary construction regulations must be complied with.

To get the details on solar panel mounting, please refer to Solar panels mounting exposed

Summary of the Most Common Costly Solar Mistakes Related to Solar Site Survey

Performing a site survey is the starting point for launching every photovoltaic system.

When searching for an appropriate site for installation of PV modules, the following is to be considered:
• Orientation towards the sun
• Lack of any shading obstacles (during the whole day and throughout the whole year!)
• Minimization of the length of the DC cables between the PV array and the inverter
• Aesthetics
• Protection from theft and vandalism
• Easy access for installation and maintenance of the PV array

Certainly, the greatest mistake is to completely neglect the need for site survey and expecting that a solar vendor will do that for you. Yes, they will…but why not be better prepared to:
– Abandon your solar project due to bad location,
– Learn the performance limits of the system that will be installed at your site,
– Find out how much your solar project will cost, or
– Avoid getting ripped off by an unconscious solar vendor?

1) Ignoring the influence of the nearby objects
The PV array should be provided with clear and unobstructed access to sunlight between 9 a.m. and 3 p.m. every day, throughout the year. Mind that even small shadows can affect severely the power output of the PV array.

To achieve the maximum of your shading analysis, do the survey during a bright and sunny day, preferably in summer when trees have their full foliage mass.

During the site survey you should be looking for the following obstacles:

• Buildings – certainly you should be informed whether a new building is not being planned nearby, throwing shade to your site;
• Chimneys, power lines, poles, hedges and neighboring roofs;
• Trees – if you're performing your site survey in winter, remember that in summer trees look different than in winter;
• Hills and other earth obstacles – mind that in winter sun is much closer to the horizon than in summer.

A site that is unshaded during a part of the day might be partially shaded during other time of the day. Similarly, if a site is unshaded in summer, it might be shaded in winter since in winter sun is lower than in summer (and close to the horizon) and casts longer shadows.

2) Underestimating the roof condition

Solar systems can be installed on any roof type.
There are two options for installing solar modules – either mounting them on the roof or replacing the roof tiles with solar modules.

As a rule roof with composition shingles are the easiest to work with, while those with slate are the most difficult ones.

If solar modules are mounted on the roof, this has the following drawbacks:
• Modules must be removed upon performing any roof repair or replacement activity;
• Installation of brackets and racks could cause roof leaks;
• Roof warranty may be affected;
• Some people might find this unattractive.

Roof-integrated installation costs amount however up to 40% more than roof-mounted installation.

If your roof is relatively old and needs to be replaced in the near future, in order to minimize any redundant costs a smart idea would be to replace it at the time the PV system is being installed.

If you have a new roof, consult both your PV provider and roof repair company how the installation of a PV system will affect your roof warranty.

Certainly, PV modules can be placed on the ground as well, on a fixed or tracking mount.

3) Miscalculating the available roof area
Usually, access space around the modules adds up to 20 % to the required area for placing solar modules.

Don’t try to use every last square inch on your roof to install a solar array because:
• The array gets difficult to install;
• The array gets hard to maintain;
• Wind loading at the edge of the roof increases;
• From a regulatory point of view, you could violate some provisions for providing available space for fire-fighters and other personal that might need to access the roof area.

Consider the dead spaces around the array. These are the spots that are either shaded or need to be left between the modules.

4) Choosing the wrong orientation and tilt of the solar array
For grid-direct systems, the orientation and tilt angle of the solar array is usually subject of roof orientation and slope.

Use a compass to check what direction your roof faces.

Use a spirit level to measure the angle of the roof from the horizontal.

If your site is located in the northern hemisphere, you should look towards the south, east, and west.

If your location is in the southern hemisphere, you should look towards north, east and west.

If you live near the equator, you should look towards east and west.

The ideal roof for mounting your PV array is a roof facing south if you live in the northern hemisphere, and facing north if you live in the southern hemisphere.

Having chosen the right orientation, you have three options for tilting the solar panels, certainly, if your roof or installation area permits:
• For average yield throughout the year;
• For maximum yield in winter;
• For maximum yield in summer.

Solar energy differs from month to month and from season to season.

This is also true for sun's position in the sky.

That is why you have to choose in advance between the above-mentioned options.

For example, if your solar panels are tilted for maximum production in winter, it means that the chosen tilt ensures solar rays to fall almost perpendicularly onto solar panels only in winter.

For average yield throughout the year, your solar panels should be tilted to an angle equal to the latitude (in degrees) of your location.
For maximum yield in winter, your solar panels should be tilted to an angle equal to the

latitude of your location minus 15 degrees.
For maximum yield in summer, your solar panels should be tilted to an angle equal to the latitude of your location plus 15 degrees.

How to find fast and easy the latitude of your location?

Just go to Wikipedia and search for your location. Then look at the top of the right corner where location's coordinates are reported. The first left number is the latitude of your location, followed by the longitude. If you cannot find your city in Wikipedia, just find the closest big city to it.
Let's imagine that you live in Birmingham, Alabama (USA), and you are curious to find what tilt angels should be for the three available options:

From Wikipedia we get:

So the latitude of Birmingham is 33.525°. Therefore the three solar tilt angles for the three above described options are as follows:
– For average yield throughout the year: -33.5°
– For maximum yield in winter: -18.5°
– For maximum yield in summer: -48.5°

6) Improperly chosen mounting of the solar array
There are four types of mounting methods:
• (Sloped-) Roof mounting,
• Flat roof/ground mounting,
• Roof-integrated mounting and
• Wall mounting

The PV array mounting type should be selected by carefully considering:
• Orientation towards the sun
• Site shading
• Weather at the location
• Roof material and bearing capacity (in case of roof mounting)
• Soil type and condition (in case of ground-mounting)

Regarding solar array mounting constructions, mind the following:
• Not every mounting construction is suitable for any kind of module, while certain kinds of modules are intended for a specific mounting;
• It's a good plan to ask the supplier of the PV modules to install them on the roof;
• To ensure sufficient cooling of the PV modules, enough room should be provided beneath them;

- A design visa and/or a building permit might be required
- All the necessary construction regulations are to be complied with.

11) Ignoring the benefits and drawbacks of solar tracking [1]

Use of solar tracker is another option for squeezing more power from the sun. A solar tracker follows the sun position and movement in the sky and ensures maximum collection of sun energy by solar panels.

The average efficiency of solar tracker is reported to increase the total production yelled of 25-45%.

Although adding to the overall system costs, residential solar trackers do not need much maintenance.

More important however is that every solar tracker is a potential point of failure.

Furthermore, a solar tracker consumes extra power.

What you should also have in mind is that there might be some local regulations that prohibit the use of solar trackers.

Solar trackers are recommended especially in cases of limited space where the customer wants to achieve maximum solar array performance.

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Sources:

Source:
1. http://energyinformative.org/solar-panel-tracking-systems

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Lacho Pop, MSE, holds a Master's Degree in Electronics and Automatics. He has more than 15 years of experience in the design and implementation of various sophisticated electronic, solar power, and telecommunication systems. He authored and co-authored several practical solar books in the field of solar power and solar photovoltaics. All the books were well-received by the public. You can discover more about his bestselling solar books on Amazon on his profile page here: Lacho Pop, MSE Profile

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