Ebook

A Quick Guide to Utility-Scale Photovoltaic Plant Design

RatedPower

A PART OF ENVERUS

It is no secret that the **climate crisis has reached a <u>tipping point</u>**, meaning the transition to green and renewable energy sources has become imperative.

Solar photovoltaic **(PV) energy is a robust and promising green, renewable energy source enjoying a <u>boom in recent years</u>.** This comes in the form of both residential and commercial solar solutions, as well as utility-scale ventures.

This guide will give an overview of the key considerations for designing your next utility-scale solar PV plant.

Table of contents

RatedPower
A PART OF ENVERUS

01. What is a utility-scale photovoltaic power plant?

Before we talk about how to design a solar installation, let's briefly understand what is meant by "utility-scale." Unfortunately, finding a universal description is complicated. **A utility-scale solar plant is usually defined by its installed capacity, but there are variants** when it comes to deciding on the minimum.

Definitions of utility-scale power plants range from 1MW (Solar Energy Industries Association) to 5MW (National Renewable Energy Laboratory) to 10MW of installed capacity, with some thresholds starting as high as 20-25MW.

One differentiating factor, regardless of size, is that utility-scale plants typically produce energy to supply the grid. This is unlike most residential and commercial solar installations who will use most of the energy they create, putting any excess back into the grid to reduce energy costs.

In order **to design a utility-scale solar plant, some fundamentals need to be considered,** which we will cover in this guide. Read on to find out.

02. Site selection

RatedPower
A PART OF ENVERUS

The **first consideration** when designing a utility-scale PV plant is choosing the site where it will be located. There are **several factors** that must be considered when selecting an optimal location for a solar array.

Weather conditions are, of course, key. High levels of solar irradiance are needed for solar panels to operate in the most efficient manner possible. As such, locations with extended sunlight hours and those at higher altitudes are ideal for mitigating atmospheric disturbances.

Additionally, **shading** must also be taken into account when choosing a site. If an installation is built in a location with a lot of sunlight, but half of the site is covered by topographical shade most of the day, the effectiveness of the plant will be drastically reduced.

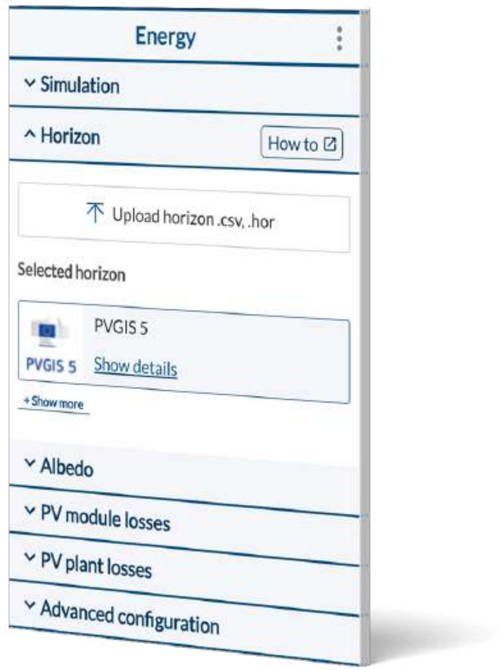
It is critical to determine the level of shading at a given site to ensure that solar energy is generated most efficiently and effectively.

You can simplify this process with **RatedPower's Horizon Importer**, which allows you to import the horizon profile of your chosen site and model shading losses quickly and accurately.

Google Earth and other sources of open-source topographical data can give you a clear idea of your initial solar site design; however, **visiting the physical site to gather more extensive information is the most effective way to ensure your solar plant is a goer.**

The land you have earmarked for your plant should be checked and tested to **ensure the soil is suitable to carry the load of solar panels** or whether there are layers of rock that would prohibit the use of mounting structures.

As well as checking the makeup of the soil, **it is also essential to investigate how even the plot is.** Leaving out this step could increase costs down the line, as it may have to be leveled or, even worse, unable to be used at all, thus reducing the plant's overall capacity.



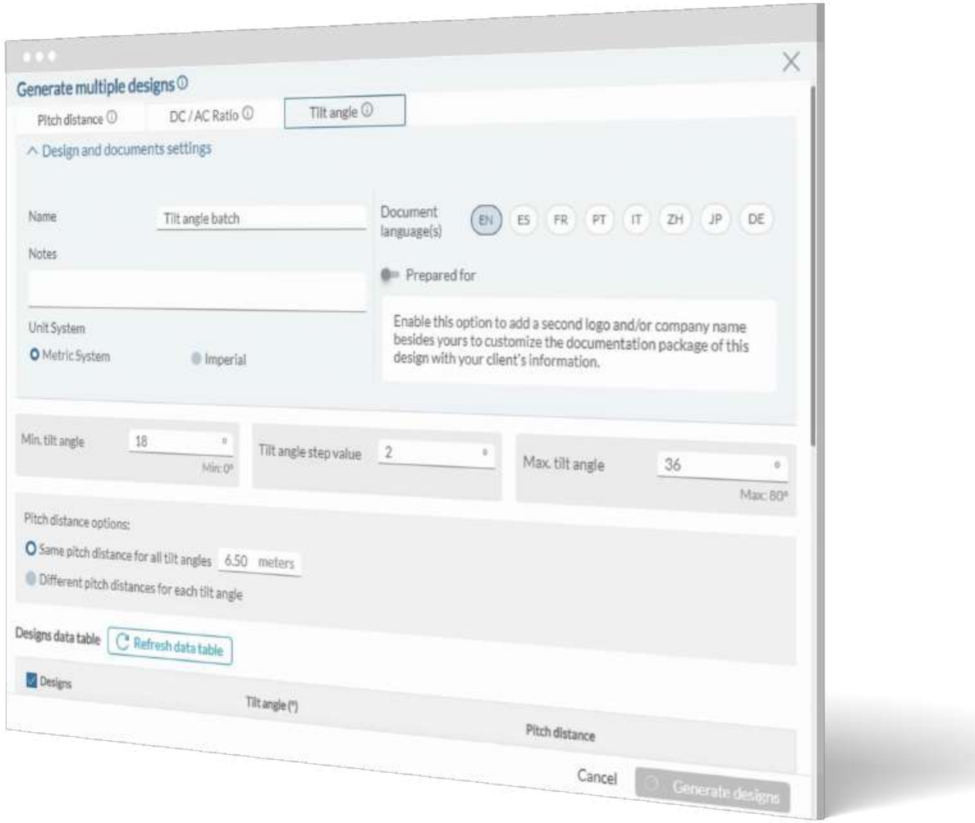
03. Solar module configuration

Once the site is selected, the next step is determining **the best way to configure the solar modules with the goal of maximizing solar irradiance** and, in turn, power generation. Things to consider include:

Tilt angle – Panels should be tilted at an angle to maximize the sunlight they receive. This can be enhanced by using trackers.

Orientation – Panels should be oriented to allow as many hours amount of sunlight to be in contact with the solar cells.

Structure spacing – If modules are not adequately spaced from one another, they can shade neighboring panels and reduce their efficiency.



RatedPower
A PART OF ENVERUS

04. Technology

With the site and layout selected, it is time to consider **the technology you want to use in your solar project.** Again, there are several things to consider here.

Solar modules – The solar modules you choose for your installation will significantly impact its performance. There are a few different types of solar modules on the market, each with benefits and drawbacks.

Module materials

- **Monocrystalline & polycrystalline silicon:**

The most common type of solar modules, silicon-based panels offer a good balance between cost, efficiency, and longevity. Monocrystalline cells provide higher efficiency and lifespans but come at a greater cost.

- **Thin-film:**

These panels are flexible and thin. They are cheaper, have a shorter lifespan and lower efficiency making them less suited to smaller areas and often chosen for larger installations. This is because you would need to install more panels to achieve the same energy as crystalline silicon solar panels.

Bifacial modules vs Monofacial Cells

While monofacial photovoltaic cells have a full-area aluminum rear contact and an opaque back surface field, the rear side of bifacial cells is only partially covered with metallization. Although this rear side is not as efficient as the front side, bifacial technology allows an average energy production gain of between 3% to 10% and up to 30% depending on factors such as the albedo, the elevated height of the structure, and the Ground Cover Ratio (GCR).

According to data from the 2023 Trend Report that analyzed thousands of projects carried out in pvDesign, simulations using bifacial panel modules have become more and more common, with a percentage climb from 30.4% in 2020 to 56.94% in 2021 and 71.87% in 2022.

Inverters

When PV modules convert sunlight into electricity, the electricity is produced in direct current (DC). The problem with this is that most grids operate using alternating current (AC) electricity. In turn, this means that any generated electricity must be converted from DC to AC before the grid can use it.

This is done through the use of inverters. It is important to consider the efficiency of your inverters, the load they will have to withstand, and the environmental conditions of your site, such as average temperature, when selecting which inverters to use. Read on to explore a detailed comparison between Central and String Inverters.

71.87%

of simulations in pvDesign used bifacial panel modules during 2022

Central vs String Inverters

Central Inverters	String Inverters
Large, more power	Smaller, less power
Fewer central inverters needed per site	Positioned across a plant, but providing security against excessive losses in the case of failure
Longer wires and work out cheaper overall	High and low temperature support

Deciding on which inverter is better for a project depends on many factors. Still, with pvDesign software, you can conduct instant comparisons on your site to discover which option is the most suitable.

Mounting structures

Solar modules must be mounted on structures in order to operate. Proper selection of both structure type and layout is crucial in optimizing the functioning of a PV installation. The mounting structures that support solar PV panels can be fixed in place or they can include a motor to change the orientation of the modules to track the sun. There are advantages and disadvantages to each design depending on the project.

Trackers:
Horizontal single axis trackers (HSAT) rotate on a single fixed axis with motor-powered tubes. The PV panels are mounted on the tubes, which rotate from east to west on a fixed axis throughout the day to track the sun's movement across the sky and maximize solar generation.

Fixed:
Rather than using a tracker structure that adjusts the angle of PV panels to follow the sun during the day, a fixed-tilt structure angles panels towards the equator, so the angle depends on the latitude of the site. Panels are tilted south in the northern hemisphere and north in the southern hemisphere.

East-West:
In east-west systems, solar panels are installed with half of them facing towards the east and half facing towards the west. Panels can be placed back-to-back to reduce the space between rows and allow for more modules to be installed to increase the total installed capacity.

Structure position

Here, you can choose to rotate or offset your structures, thus optimizing the layout with respect to the parcel's borders. You have four options to choose from:

- Standard: structures will follow their usual axis direction.
- Rotated: structures are rotated in blocks.
- Offset: rotates the axis of the block while keeping the structures aligned.
- Turning angle axis: structures are rotated while keeping the block aligned.

Choosing PV structures: Trackers vs Fixed vs East-West

Read our in-depth guide comparing the advantages and disadvantages of different mounting structures here.

Read more

05. Storage solutions

BESS

Some utility-scale PV plants will contain storage solutions on-site, allowing for excess energy to be stored. BESS is **the most popular type of storage and holds massive potential moving forward.** However, storage is not a critical aspect of utility-scale plant design and will not be suitable for all projects.

Transformers

There are **two main types** of transformers found in PV installations – **distribution transformers and grid transformers.** Depending on whether your installation is connected directly to the grid, to a storage system, or to a transition grid will determine which type of transformer is best for your purposes.

06. Overhead power lines

When designing overhead lines, you need to take into account **several factors** concerning the **positioning of the components:**

Geometry
The geometry of the tower top is crucial to the design of an overhead line. Several top tower types and geometries worldwide incorporate different safety clearances for various voltage levels and regulatory requirements.

Sag and span
The sag is the distance (vertical) between the highest point of the electrical tower or pole and the lowest point of the conductor between two electrical supports. The horizontal distance between supports is the span.

Connections
The forces on tower connection points are an important consideration. Calculating forces considers wind and ice loads, maintenance, and conductor tension.

Route
The overhead line route is key to the project's permit and approval process.

Cost
The cost of installing an overhead line depends mainly on the conductors' cross-sections, the towers' height, and their foundations.

07. Get in touch

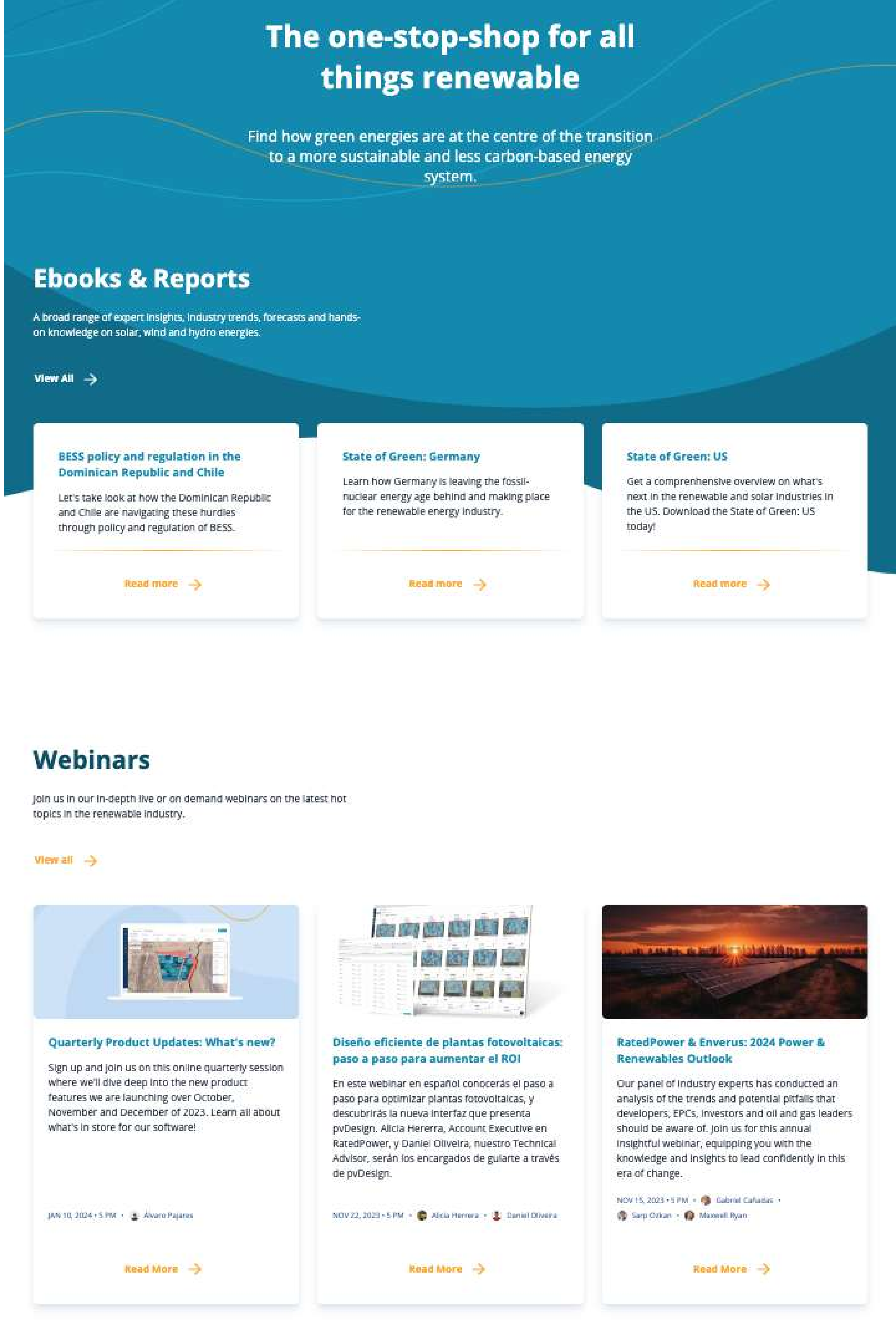
RatedPower
A PART OF ENVERUS

This guide has covered just some of the key considerations when designing a PV plant but there are many other elements that go into building a PV plant. Luckily **pvDesign takes a lot of the guesswork out of these decisions** allowing you to design multiple plants in minutes and compare and contrast these variables.

If you would like to speak with our team please get in touch to book a demo.

If you're looking for more information and tips for designing your next utility-scale installation, **make sure to head over to the RatedPower resources page for everything green energy.** We also have a series of webinars and explainer videos, sharing our expertise and showcasing our design tool, pvDesign, over on our YouTube channel!

Get in touch



RatedPower
A PART OF ENVERUS

Crafted solutions for every solar professional

And if you are looking to try out pvDesign for yourself, book a demo today and take your PV designs to the next level!

Discover pvDesign