RatedPower

A Buyer's Guide to Utility-Scale Solar Software

Index

1. What is solar software?

Utility-scale solar farms will play an essential role in enabling the transition to green as countries around the world move to reduce their carbon emissions and address climate change.

The digitalization of solar energy systems is key to scalability for utility-scale projects to manage resources effectively. The advanced data and analysis capabilities digital tools provide enable project developers and operators to take advantage of economies of scale and maximize their return on investment.

1.1 Introduction

Solar photovoltaic (PV) software is a design tool that assists solar development, construction and engineering companies to plan their PV projects for optimal energy efficiency, from the design phase through to construction and operation.

Software packages can help organizations to design layouts, optimize the configurations, track the cost of materials and installation, create energy consumption estimates, and plan the integration of energy storage systems. Companies can then use the designs in sales proposals and follow up with leads faster. The modeling functionality saves companies time and money with accurate remote site assessment that allows them to assess a project site without leaving the office.

When it comes to utility-scale installations, developers, utilities, IPP, and other solar engineering firms face particular challenges as projects increase in size. The sharp decline in the cost of solar equipment over the past decade has made it more viable to develop projects with large installed capacities of hundreds of megawatts. But with bigger project portfolios, those working in the space need to manage and interpret growing volumes of data to ensure they keep on top of their operations.

Solar software systems help industry stakeholders streamline their repetitive tasks by automating the design process and allowing them to manage project requirements on a single dashboard.

For systems that are operational, project operators can identify assets that may be underperforming and gain visibility into maintenance requirements, allowing them to reduce downtime and the impact on revenue.

2. Understanding the solar software landscape

2.1 PV lifecycle stage & PV market segment

There are a variety of options available for solar software packages. For clarity sake, we'll categorize them based on two variables:

→ **PV lifecycle stage:**

The buyer also needs a specific set of tools depending on where they sit in the solar project lifecycle, from development through to the operation and maintenance and end-of-life phases.

→ **PV market segment:**

The requirements of a prospective solar software buyer will vary dramatically depending on the size of their projects. In this regard, we'll find PV software for residential, commercial and industrial (C& I), or utility scale.

The tables below will help you navigate PV software alternatives which are a fit for both — the market segment you, as a professional serve, and the lifecycle stage your team specializes in.

Scientific literature usually split PV plant lifecycle in three stages[1]: Project, operation and end-of-life phases. This guide will focus in the project stage, where you can find the following areas:

- **Site selection:** Accessing and review resource, grid and geospatial data, such as topography or meteo data streams.
- **Pre-planning:** Concept, feasibility study, financing and funding, permits & licensing.
- **Energy estimates:** Financial modelling, CAPEX, OPEX and energy output.
- **Design & Engineering:** Specification, outline & detailed design.
- **Construction:** Procurement, logistics, site preparation & environment mitigation, mounting structures & assembly subsystems, certification & commissioning, connection to power grid.
- **Asset management**

[1] Source: Prepared by RatedPower based on Camarinha-Matos, L.M., Oliveira, A.I., Ferrada, F. and Thamburaj, V. (2017), "Collaborative services provision for solar power plants", Industrial Management & Data Systems, Vol. 117 No. 5, pp. 946-966. https://doi.org/10.1108/IMDS-06-2016-0246

Residential

	Site selection	Pre-planning	Energy estimates	Design & Engineering	Construction	Asset management
Homer			●			
PVsyst			●			
AutoCAD		●		●	●	
PVSol		●				
Helioscope		●	●			
Aurora Solar		●	●			●

C&I, small utility-scale (<1MW)

	Site selection	Pre-planning	Energy estimates	Design & Engineering	Construction	Asset management
Homer			●			
PVsyst			●			
AutoCAD		●		●	●	
PVSol		●				
Helioscope		●	●			
Aurora Solar		●	●			●
Anderson Optimization	●		●			
SolarGIS	●		●			
Enian						●

Utility-scale (>1MW)

	Site selection	Pre-planning	Energy estimates	Design & Engineering	Construction	Asset management
RatedPower's pvDesign	●	●	●	●	●	
Homer			●			
PVsyst			●			
AutoCAD		●		●	●	
Anderson Optimization	●					
SolarGIS	●		●			
Enian						●
PlantPredict		●				
PVcase		●		●		
Terabase		●	●			
SunDAT		●	●			
Solarfarmer		●	●			
SAM		●	●			
Civil 3D		●		●		

While some apps are versatile enough to serve two or even the three segments, this guide will focus its analysis on the solar software available for the utility-scale segment at the project stage.

2.2 Solar software types of buyers

Developers, utilities and IPPs

Developers use software to scope out the suitability of a plot of land and make the basic engineering and energy yield estimates. It helps them find investment opportunities faster. That is the same use case for solar software as many utility companies and independent power producers (IPPs).

Without specialized software, they need to use a range of applications to gather documents to apply for permits. Solar software can generate a pack of engineering documentation for developers to send to their off-takers or EPCists, including bill of quantities, design drawings, lists of cables, and electrical diagrams.

EPC contractors

Engineering, procurement, and construction (EPC) contractors need to keep the levelized cost of energy (LCOE) tight by minimizing engineering and construction plant costs.

Solar software can help them to customize their input to generate technical documents, including cost analysis and energy yield simulations. Engineering teams can carry out feasibility analysis and plant designs, saving money by doing the work in-house rather than outsourcing.

Engineering companies

Solar software helps engineers get the job done faster. They can speed up time-to-design and reduce their LCOE, maximizing energy production while minimizing construction costs.

With solar software, engineering teams can increase their throughput of designs and studies. Meaning more time for finding the best solution for each project and producing higher quality results.

PV equipment manufacturers

Solar equipment manufacturers use software to check the energy performance of their equipment. It helps them create designs that demonstrate how they differentiate their products from the competition.

3. Utility-scale solar design and engineering software stacks: what types are there?

Regardless of the type of business, there are some common features you need to be able to work on a solar project — and technically document them so it can be used down the project pipeline:

- Layout and equipment definition.
- Electrical and civil setup.
- Energy yield forecasting.
- Financial analysis.
- Permits and administrative documentation.
- Grid access and interconnection.
- Compatibility of input file types among your tech stack and results shareability.

To do this, there are tools available that any solar company can use, regardless of the market:

- Microsoft Office suite (Excel, Word, etc.)
- Google Earth and other mapping tools (QGIS)
- Computer-aided design (CAD) software and other Autodesk products (AutoCAD Civil)
- Meteorological and topography databases (Open source like NASA, PVGIS or proprietary)
- PV energy yielding tools (PVsyst, pvDesign)
- Calculators
- SAM, as NREL's

Most companies tend to use a combination of these tools. They provide limited automation, so teams need to spend many hours planning projects.

Some companies also opt to buy specialized solar PV software, such as pvDesign from RatedPower, PVcase, or Helioscope. Smaller teams can be more willing to automate their processes to increase throughput. The cost of specialized software depends on the target market. For example, software for the residential market is likely to be cheaper than software for the utility-scale market.

The size and scope of the projects will also have a bearing on the design and analysis tools they choose. For example, Helioscope and Aurora are cloud software packages used for commercial, industrial, and residential projects. PVcase and PVCAD (PVComplete) are AutoCAD plugins used for some large commercial and industrial installations, as well as utility-scale plants. Other cloud base web applications for large scale PV projects are Terabase Energy —an stand-alone platform for design and engineering— or PlantPredict —an energy modelling tool, acquired in 2021 by Terabase.

Depending on the grade of sophistication, you'll find four main types of technology stacks for solar PV software, ranging from general applications to fully customized packages.

Option 1: Old school software stacks: an easy-to-implement option which does not scale

A basic software stack may be composed of generic desktop applications that are not specific to the solar industry, like Microsoft Excel and AutoCAD.

These programs are cheaper to procure but they require manual development work to run complex calculations.

These technology packages are the most flexible. They can be used for many different projects and produce customized results. However, they do not offer any solar-related features, such as shading analysis and component layout.

Most companies will use AutoCAD to some extent, which is a general CAD software package with design automation. Companies that need to do only basic analysis will make limited use of CAD software, while companies doing more advanced engineering work will be heavy users of more advanced CAD tools, such as AutoCAD Civil.

→ **Software examples:**

- Microsoft Office suite (Excel, Word, etc.)
- Google Earth and other mapping tools (QGIS)
- AutoCAD

Option 2: Standard software with vitamins: for those wanting a basic step towards automation through plugins

Adding plugins that are tailored to solar projects allows companies to introduce a level of automation to their desktop applications.

Many use PVsyst, or free alternatives. PVsyst is the totem of photovoltaic energy yield estimation. Commonly found in many solar engineering teams. It's very customizable but, as a trade-off, it lacks automation. It's a fantastic tool for energy yielding — it has been used for almost 30 years — . However, getting results with it requires extensive experience and engineering hours.

Some companies also use AutoCAD plugins to speed up the time it takes to design the layout, such as PVcase or PVCAD.

These solutions require less manual work, but because they are still within the AutoCAD ecosystem, the documentation production capabilities or the computer hardware requirements for simulation utility-scale PV plants are limited.

Whether companies use specialized plugins for performance and financial analysis will depend on where they sit in the project pipeline. Companies that work on the later stages of a project, such as detailed engineering work, may not need to do any performance analysis as the project is already financed at that stage.

→ **Software examples:**

- PVsyst
- AutoCAD plugins (PVcase, Helios 3D, PVCAD)

Option 3: Specialized end-to-end software: for those looking for a tailored, in-depth option

For a technology solution tailored specifically to those working on solar projects, companies can use specialized PV project planning tools, like pvDesign or Helioscope, to supplement their traditional tech stack tools. The cost of establishing these stacks can be higher, but they also have greater throughput. Some GIS tools for solar also fit in this category, such as Anderson Optimization and Terabase.

These modeling solutions tend to be cloud-based, making it easier for teams to collaborate and share information with customers.

They offer a higher degree of automation than the more basic systems. Companies can develop engineering designs and off-taker proposals from a single app, integrating information from a range of sources — from meteorological or topography to equipment library — .

Specialized solar software applications include a range of features specifically targeted at PV project design at utility-scale.

They offer energy projections, module and inverter configuration, terrain shading modeling, transmission and interconnection data, financial analysis, and simulation settings.

→ **Software examples:**

- pvDesign, PlantPredict, Terabase, HST for utility-scale PV
- Helioscope, PVSol for commercial, industrial and small utility-scale projects
- GIS prospecting solutions such as Anderson Optimization for utility-scale projects
- Aurora for rooftop solar installations

Option 4: Fully customized in-house software

Some companies develop their own internal tools to produce detailed solar project designs up to their corporate specifications and standards.

Large companies are more likely to allocate resources to devise tailored software stacks that meet their specific requirements for project development.

The total cost of ownership is higher as developing and maintaining software requires a huge amount of investment.

Oruga is a customizable software package developed by Spanish energy engineering and construction firm Sener. Oruga comprises a series of modules, from implementation and cost to performance and battery storage. It has a graphic user interface (GUI) and the ability to integrate with a building integration management (BIM) environment. Oruga features advanced optimization and 3D backtracking algorithms that calculate the optimal angles for PV panel installation to minimize shading.

→ Software examples:

- Oruga from Sener
- Canadian Solar System Simulator

4. Solar software helps engineering and design teams achieve their goals

Human errors and manual tasks related to engineering workflows are one of the most industry common soft costs drivers[2]. An end-to-end solar software can help engineering and design teams reduce them, through more accurate and faster time-to-design. It drives a decrease of their soft costs, lowering LCOE of their PV projects and making the business most competitive.

4.1 Increase return on investment

Tailored software solutions enhance the internal rate of return (IRR) and return on investment (ROI), providing investors with certainty that potential investments will become profitable.

Engineering teams play a key role in driving productivity and profitability of their companies just by switching to a tech stack suited to their roles and their unique needs. They can enhance their financial modeling and reduce the LCOE of PV projects by focusing on technical details that are usually overlooked when setting out financial projections.

Solar software considers aspects of PV installation design that translate into maximizing capacity and production.

It limits human error and cuts costs in financial models by optimizing the use of a company's internal human resources and reducing outsourcing.

4.2 Optimize engineering teams workflows

Solar software **increases teams' productivity and flexibility**, reducing the time they spend planning a single PV plant and allowing them to devote that time to value-added tasks.

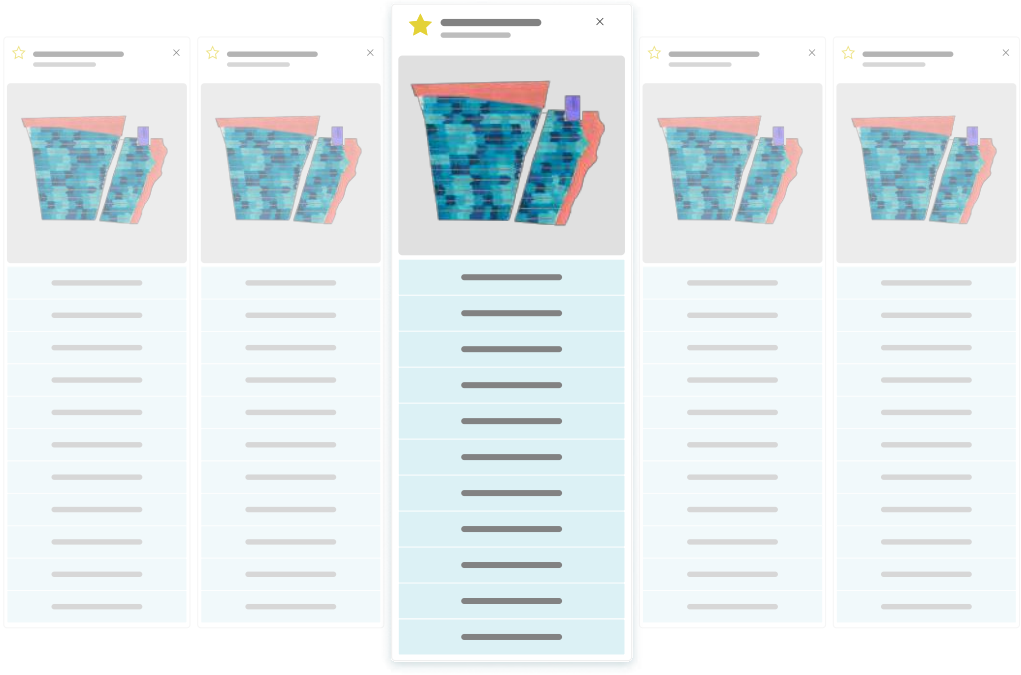
[2] *Renewable Power generation costs (IRENA, 2020) p. 26-28*

Design processes are simplified by PV software applications like pvDesign that unify tools in a single platform for every stage of the planning process. Teams can manage their work and collaborate on the same projects using the same tools, allowing teams to combine their specialized skills. This results in reducing workloads for engineers,speeding up the design and engineering process, which in turn increases the volume of projects they can take on at a competitive LCOE.

4.3 Grow project pipelines

Unified software tools allow teams to gather accurate engineering documentation quickly, simplifying the procurement and quotation process. By speeding up these processes, they can pursue more market opportunities over the same period.

By participating in more tenders and investment opportunities, teams can increase their company visibility, attracting more business. And if they can increase the number of project locations they study, and participate in more feasibility studies and bidding processes, they can successfully increase the number of projects in their pipeline.



4.4 Democratization of solar design flow

Solar software tends to simplify usability while still obtaining accurate results.

This democratizes the design process, giving non-technical teams the chance to participate and optimizing resources.

It helps teams – regardless of their technical experience – to reduce their outsourcing needs, as this simplification makes the process much more accessible without the need for external expertise.

In the end, using these types of tools offers companies greater opportunities to participate much more actively in the renewable energy sector, and, ultimately, help accelerate the energy transition.

4.5 Accelerate the energy transition

By increasing efficiencies and dramatically reducing time-to-layout, software applications can help increase the production of clean energy, at a lower production cost. As the paradigm for energy production shifts globally, software can help corporations to diversify their energy portfolios.

5. Key features of solar software

Some of the most important features of solar software applications include specialized PV engineering to optimize the site design, as well as enterprise features that make them easy to use and keep the company IT network secure.

5.1 PV engineering features

Users need a tool that enables them to automate as much of the site design and engineering as possible. It should then generate reports that they can use in later stages of the development process such as to permit applications and requests for proposals (RFPs). Below are some of the key features to look for when purchasing solar software.

Layout automation

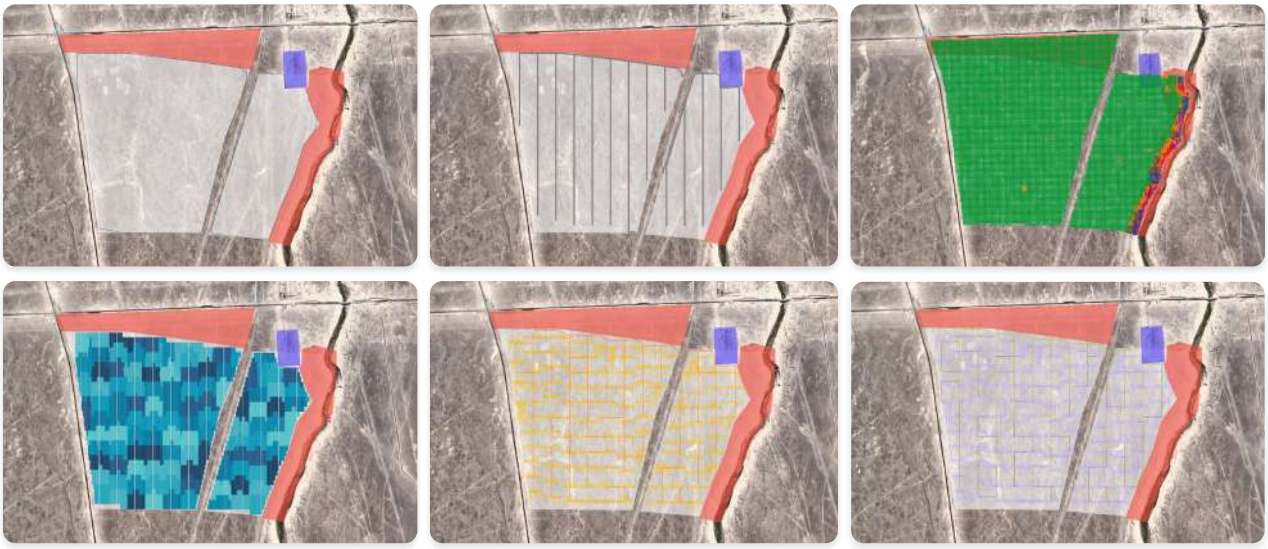
To design a solar energy system, users need a PV plant layout tool that incorporates all the components to **visualize the installation of modules and structures**. It should place structures in the correct location and take into account physical restrictions like bodies of water, trees, and slopes.

A handy feature you may need to expedite engineering will be having some dashboard where you can compare rated and peak power capacities and the maximum power that can be achieved within the defined limits of the design. This enables users to see how changing different parameters affects the layout.

The topographical analysis allows users to study the suitability of different parts of the site based on their preferred criteria. An advanced tool will modify the terrain to simulate the execution of earthworks.

The layout tool can generate georeferenced drawings of the different elements of the layout, including:

- General layout
- Topographical and terrain slope analysis
- Structures profiles
- LV and MV cables
- Modules
- Power stations and other plant buildings
- Roads
- Fences



While **structure profiles and interconnection facility layouts** are usually out of the scope of any solar software and commonly outsourced to third parties, some of them might include features covering these areas. Ask your salesperson about it when comparing utility-scale solar software.

Electrical equipment calculations

Users need a tool that **designs the layout of the electrical equipment, placing all the different power stations, combiner boxes and cables in the project**. Ideally, the tool will also size all the electrical elements such as cables, protection devices and transformers.

Based on the electrical equipment defined by the user, the software will design the blocks that best fit the configuration for each inverter, string box, or DC bus in the optimal position. It will then set out the cables and trenches based on the positions of the electrical equipment.

An algorithm will find the shortest path to minimize cable length, and size the cables based on the local standard.

Calculations include:

- The maximum and minimum number of modules per string
- The types of PV plant electrical configurations
- The sizing of protective devices such as fuses and breakers

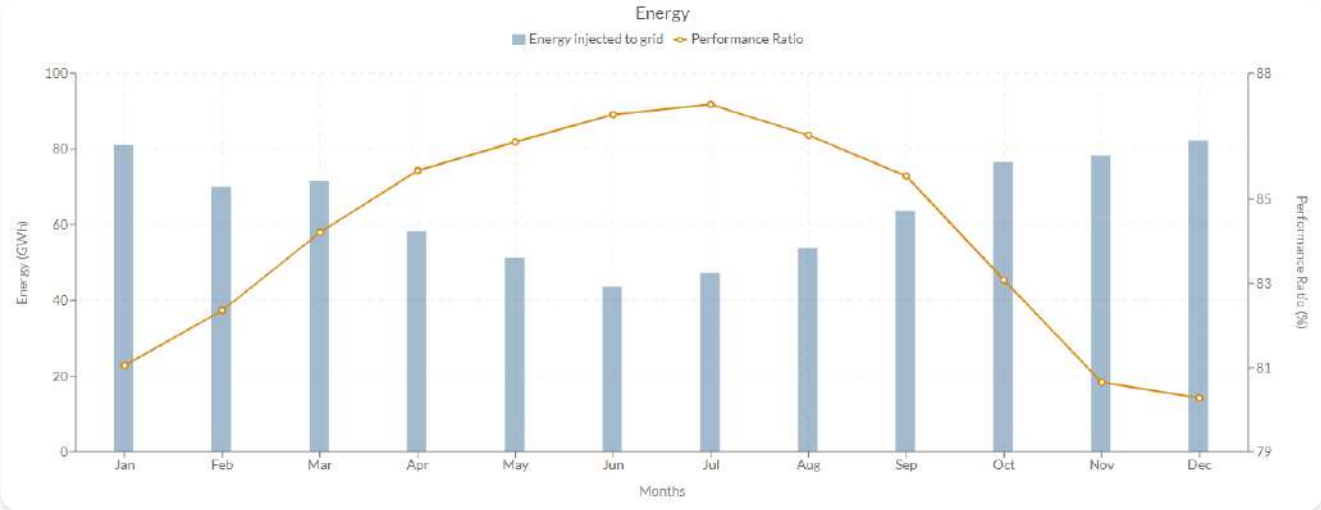
For more information on this topic, check out our Electrical Methodology for pvDesign.

Energy production

Users need a tool that allows them to simulate **how much energy the PV installation will produce**. The calculations can also give users a detailed sheet of results and take into account 3D modeling.

The energy yield calculation model should simulate fixed structures, trackers, monofacial and bifacial PV modules. Such tools study the following factors to calculate the annual energy yield:

- The position of the sun
- The sun-tracking algorithm used in single-axis trackers (backtracking)
- The effect of shadows on solar irradiation
- Photovoltaic conversion and energy produced by a single PV module
- Solar irradiation on the back of bifacial panels
- Module operating temperature based on meteorological conditions
- Electrical losses from each module
- Electrical losses from the modules to the electrical inverter (DC losses)
- Electrical inverter conversion performance and power output
- Electrical losses from the cables and transformers (AC losses)



The software will help engineers and solar designers decide how to balance the tilt of the panels to maximize their exposure to sunlight throughout the day, against how many modules can fit in the allocated space. With this, they can achieve the optimal combination of energy yield per module and electricity generation per square foot.

A solid energy yield estimate, alongside the asset' financial analysis are critical documents to get the PV plant financed.

Financial analysis

Some solar software solutions provide site design optimization tools but do not include financial reporting. This means engineering teams still need to use separate systems to compile their proposals. This takes more time than an end-to-end solution and has an impact on how many projects the team can work on, at any one time.

If looking for financial assessment capabilities in your next solar software you might find useful to have at least these key performance indicators of your PV projects:

- Capital expenditure (CAPEX)
- LCOE
- IRR
- ROI

These four metrics **help photovoltaic designers and engineering easily compare sites** and configurations, enabling them to choose the most optimum for their plant.

Customizable results

No matter how advanced the functionality of a software application, it needs to **offer tailored features so users can customize aspects of the design** to each project. Each project site has unique characteristics that must be taken into account for the most accurate planning. There are also likely to be **small details that need to be changed as projects evolve**.

Some common examples of this flexibility options are:

- Adjusting the position of layout components in the PV plant, such as internal roads, structures, or power stations
- Edit electrical system design and size, such as allowed cable sections
- Change internal parameters of the energy simulation, such as the heat constants or the soiling losses

Having reasonable expectations on what a tool can do for you is key to unlocking the value of solar software. End-to-end software with a high grade level of automation —powered by built-in algorithms— tends to be less flexible than CAD software. Ensuring output of the first is editable in the later is another top-notch feature to look after when purchasing these tools.

5.2 Enterprise software features

Aside from a suite of tools tailored to solar plant design, solar software solutions must incorporate standard functionality for enterprise-grade applications.

Cybersecurity

With the number of cyber attacks on corporate networks growing exponentially in the last few years, **it's essential that solar design software is secure**. Web applications should not introduce vulnerabilities into the IT network that hackers can exploit.

The software should provide login authentication to prevent access from unauthorized users. For example, pvDesign requires users to authenticate through AWS Cognito, using OAuth2 or federated authentication.

Cloud-based deployment

Cloud-based software applications offer enhanced security as they **can be patched and updated across network endpoints simultaneously**. Cloud providers have their own secure servers, providing added protection.

Cloud-based applications are also easy to set up for users needing access with remote installation and login, rather than desktop software applications that need to be installed on each device. What's more, subscription-based services offer regular automatic updates, without having to upgrade to the latest version of a desktop software application.

Hosting software on the cloud enables teams to collaborate on projects regardless of their location – whether they are in other offices or in the field. It eliminates the possibility of multiple versions of documents circulating, with project files updating automatically as users make changes.

6. Utility-scale solar software comparison checklist

	RatedPower's pvDesign	Solution B	Solution C
Location input capabilities			
Topography analysis	Google Earth, Custom		
Meteo data sources	PVGIS 5, NASA SSE, Custom		
Horizon data	PVGIS 5		
Topography analysis	MODIS BSA, Bare ground, Bare soil, Grass, Dry grass, Sand White pebbles now		
Albedo	Google Earth, Custom		
Civil engineering capabilities			
Roads	Horizontal, Vertical, Perimeters		
Perimeter	Uniform, Border adaptation		
Power station	Outside, Inside		
Structure	Standard, Rotated, Offset, Turning angle axis		
Equipment library			
Equipment library	Updated monthly		
Grid connection capabilities			
Electrical sizing	IEC, IEEE SA		
Substation engineering	Switching and breaking station, Substation		
Electrical capabilities			
Layout	Regular block design, Adaptative design		
Electrical configuration	Flexible, Fixed		
Solar field	String box, DC Bus system, String box L2 field, String box L2 station		
Cable sizing	IEC, NEC, Australian Standards, Chinese GB		
Energy yield modelling			
Simulation years	Up to 50		
Losses analysis	PV module, PV plant		
Deviation comparing to PVsyst	+1.08% — +0.24%		

	RatedPower's pvDesign	Solution B	Solution C
Layout design capabilities			
PV project scale	> 1MW		
Earthworks	Included		
Structures	Included		
Financial analysis capabilities			
CAPEX analysis	OPEX, LCOE, IRR, NPV		
Deliverables and results			
Deliverables included	General Layout, Layout 3D, Terrain slopes, MV single line diagrams, LV single line diagrams, Topography analysis, Structure profiles, Interconnection facility SLD, Interconnection facility, Layout		
Output languages	English, Spanish, French, Portuguese, Italian, Chinese		
Units	Metric, Imperial		
Integrations / Interoperability			
.kml and .kmz import	☑	☐	☐
.dwg export	☑	☐	☐
Editable format for deliverables	☑	☐	☐
Infrastructure & security			
Two-factor authentication (2FA) settings	☑	☐	☐
SAML access with your corporate identity provider	☑	☐	☐
Service level agreement (99,9% uptime guarantee)	☑	☐	☐
Pricing and additional costs			
No additional costs for new features	☑	☐	☐
No consulting costs	☑	☐	☐
No hidden costs or third-party software dependencies	☑	☐	☐
Support, Customer Success and training			
Knowledge base access	☑	☐	☐
Technical support	☑	☐	☐
Customer Success packages	Available		

6.1 Why engineers and solar designers prefer solar software

There are clear advantages for solar industry professionals in using end-to-end specialized software for utility-scale solar plants instead of CAD software.

Solar engineers and product designers can quickly compile drawings and documentation for large-scale projects, automating complex calculations and reducing the risk of manual errors. They can factor every component in the system into their designs and **make use of advanced modeling capabilities to create the most accurate plans**.

Development teams can replace a suite of tools with a single application. Ultimately, that empowers them to increase their efficiency, and deliver more on-time projects.

> "One of the best things about using pvDesign is that we're using our time more efficiently. Before using pvDesign, we created our sizing layouts using drawing software. And, we wasted a lot of time on the preliminary stages of a project. Now, using pvDesign, we save a lot of time which we can invest into other tasks."
>
> abei ENERGY
>
> **Antonio Verdugo**
>
> Head of Technical Office Enginee

“The way it creates a simple and consistent design giving only some basic information, is really impressive. It gives you a great and really quick preview of how much power you can estimate in your layout.”

voltalia

Mikael Macial

Electrical project manager and CAD designer

“Before, we used to use a mix of different tools, including AutoCAD, spreadsheets and PVsyst. Since switching to pvDesign, and using software that combines all the functionalities we need, our team has become so much more efficient. Processes that used to take more than one day to complete, are now done in just a couple of hours, which is a real win!”

IBERDROLA RENOVABLES

Thomas Gerstch

Engineering Manager of PV

“Very practical. It helps us escalate our project analysis capabilities. The automatic layout, bill of quantities, terrain analysis and access to exported data in commonly used formats in the industry.”

casadosventos

Lucio Carlos Pimentel

Solar engineer

"Intuitive and efficient design tool for the Solar industry professionals. The output documents are very professional. The interface is straightforward, and the user can easily and rapidly get a detailed vision of the future PV plant, in a level of detail sufficient for most development activities."

Administrator

Mid-Market company

6. 2 Automate and optimize your utility-scale projects with solar software

Wherever your company sits in the solar energy systems supply chain, software tools are key to **designing efficient products and projects that will generate the greatest return on investment**.

The type of software you choose will depend on the size of your company and the needs of your team. If you have the budget for an end-to-end software solution with all the benefits of a cloud-based service, consider pvDesign.

pvDesign is a cloud-based solar software application that helps engineers and designers to automate, test, and optimize each stage of the planning process. From the initial study through to design, engineering, analysis, and construction, you can use tailored functionality to examine every detail of a project.

Start accelerating your PV plant design and engineering today

Speed up the design and engineering process of large-scale solar PV projects to boost teams' efficiency, increase accuracy, and reduce the construction costs of PV plants.

Take a product tour

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