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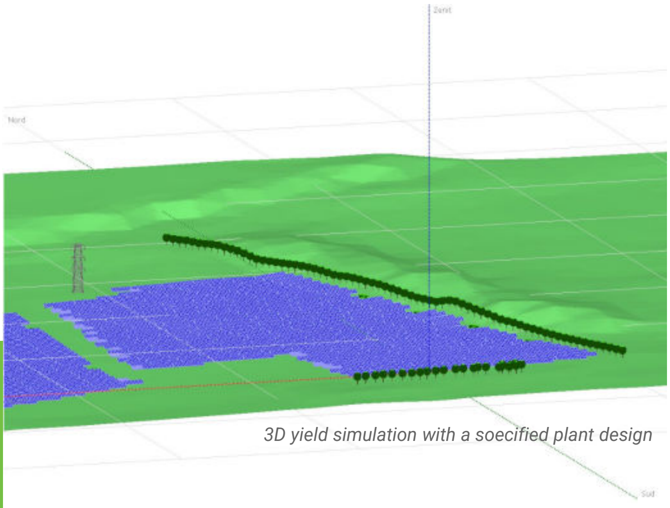
What makes a good yield report

When planning a PV park or a PV plant, the yield report plays a significant role: it serves to determine the subsequent plant performance and provides the various stakeholders with valuable information about their (potential) project:

- **Project developers and EPCs** use it to accurately determine the basic revenue potential of a site or area and whether it is profitable for them to implement a project and possibly sell it later on.
- It provides **banks or investors** with a well-founded basis for making decisions about possible financing of the project.
- It serves the **subsequent operator** as a basis for investment and performance orientation and enables a concrete target/actual comparison of the performance of his plant.
- In a **sales process**, yield reports are often submitted and used by both parties as a basis for the sales negotiations.
- Increasingly, service providers such as **EPCs or plant operators** are issuing performance guarantees in their contracts based on the results of the yield report. While better performance is rewarded with a bonus, there are severe penalties for non-performance.



3D yield simulation with a soecified plant design

Yield report at a glance:

- Objectively created for the most realistic result possible,
- Surveyed comprehensively and in detail for best possible accuracy,
- Expertly analysed and evaluated for maximum resilience,
- Conclusively justified for best possible transparency and comprehensibility of all using parties.

A good yield report shows one thing above all: a realistic result

It should be noted that a yield report always includes certain uncertainties: It is therefore even more important to draw an as well-founded yield picture of the individual plant as possible by using long-term data from various sources and taking into account various relevant factors and justified assumptions. Only then a yield report can provide a reliable and neutral basis for the stakeholders involved in the project.

If the forecasts are too conservative, it is possible that no investor or financier will be found for the project. If, on the other hand, the calculations are too optimistic, there is a risk that the project will not meet expectations in the end and that the investment costs will not be recovered. This would not help either party.

Therefore, possible standard uncertainties are always included in a yield report. For example, they take into account deviating meteorological conditions or uncertainties in the technical interpretation of the data and the simulation software. The P50 value, on the one hand, indicates the yield that the plant can generate with a probability of 50%. Another value, P90, on the other hand, indicates the yield that will be exceeded with a probability of 90%.

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Which parameters contribute to a yield forecast that is as realistic as possible?

Above all, the meteorological conditions (especially the irradiation and temperature) at the location, the given topography and possible shading objects, as well as the technical design of the plant including the components used have an influence on the later production of a photovoltaic plant. Here, it is important to precisely determine all possible site factors and technical conditions and to take them into account when preparing a yield report. In the first step, this is often done by recording all conditions on site as part of a site analysis. Nowadays, the use of drone technology has proven its worth here. It is capable to draw an exact aerial picture of the site, including elevations and inclines, and can thus depict the topography and possible shading objects with centimeter precision.

Definition of terms – yield simulation or yield report?

While a yield simulation is about results that are output from a simulation tool such as PVSyst, a yield report completes these results with explanations of certain data and derivations as well as a critical appraisal. For example, it explains the circumstances and assumptions why certain settings were chosen in the simulation program. The results are also evaluated and interpreted in detail.

Irradiation at the site

Determining the future irradiation at the site is the basis for the report and the subsequent evaluation. For this purpose, historical data of horizontal global irradiation (measured in kwh/m²) of the last 10 to 20 years is usually used. They are collected and made available by various providers. The irradiation is measured, among other things, by stationary systems in the environment or by satellites for the respective location. Since the various measurement methods can lead to irradiation differences of several percentage points, data from different sources are used to estimate the yield as reliably as possible. They are carefully evaluated and then a weighted average is formed, usually from the 3 sources considered most realistic for the site.

Use of different sources for realistic generation of irradiation forecasts

Topography / Shading

Also relevant for the later yield is the shape of the designated PV area. In the rarest cases, this is a flat area without shading objects. However, even a challenging, uneven terrain with surrounding slopes can be developed with an efficient PV system if the planning precisely determines possible disturbing factors and takes them into account in the later design. This does not only include the shading resulting from slopes or trees, but also the immediate surroundings of the area should be examined more closely: for example, high-voltage pylons or rotor blades of nearby wind turbines can cause relevant shading. Nearby factories can cause shading not only with their chimneys, but also with their smoke emissions under certain weather conditions. There is also the threat of pollution in the form of exhaust fumes, pollen drift, and small particles of processed materials along highways and railroad tracks, near farms or industry. In areas with a lot of snow, possible snow days are also relevant as a shading risk.

Shading by a nearby wind turbine

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Plant design

In addition to the site conditions, the selected plant design also plays an overriding role.

Mechanical design

The positioning of the modules determines how much irradiation hits the PV generator.

- At what **tilt** are the modules installed? This has a significant influence on the irradiation reaching the module surface and also determines the internal shading. The flatter the modules are set up, the less irradiation can be absorbed by the modules, but the less shadow is cast on the modules behind them. Are bifacial modules used, which can absorb sunlight on both the front and the back?
- Which **alignment** was chosen for the modules? This is also referred to as the azimuth angle. An angle of 0° describes the optimal south alignment. With plus values (+) an alignment to the west is described, with minus values (-) to the east. The maximum yields are delivered by a system aligned exactly to the south, but depending on the area, it can also be more advantageous to choose a deviating layout in order to possibly install more power.
- The **row spacing (pitch)** is also relevant for the yield: The closer the module rows are placed, the higher the installed power and the absolute energy yield. However, the closer the rows are spaced, the more shading occurs and the specific yield decreases. Therefore, during the planning phase, it must be carefully considered at which row spacing the available space can be used most efficiently in terms of absolute and specific yield.

Moving solar modules that follow the sun

In southern Europe in particular, module trackers are increasingly being used in PV parks. The modules installed on this kind of mounting system follow the sun and thus always receive the optimum irradiation.

In northern Europe, this model can only be used to a limited extent. Longer sunrise and sunset times result in longer shading of the modules in the off-peak hours and an associated reduction in yield. Since the trackers are also more expensive to procure and install, and the systems require more maintenance, the additional yield generated by the moving modules does not generally compensate for the higher costs.

The further infrastructure for the PV system must also be planned in a way that objects such as transformer stations, fences or camera masts, as well as access roads, internal roads or compensation measures within the solar area, only impair the irradiation and yield as little as possible. All these factors must be carefully considered in the yield simulation.

Electrical design

The electrical design describes the connection of the electrical components on the direct current (DC) and alternating current (AC) side. Thus, the yield calculation has to consider how many modules are connected in a row to form a string and how many strings are connected in parallel to a generator junction box or directly to the inverter.

In addition, it is crucial how much module power is connected per inverter. This so-called DC-AC ratio determines the load the inverter operates with and whether there is a limitation of the DC power by the inverter at higher irradiation (this is also referred to as clipping) and thus yield is lost. On the other hand, a high utilization of the inverter also leads to higher yields in times with lower irradiation.

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Component characteristics

The components of the different manufacturers also have different characteristics that affect the yield generation of the plant. Depending on the operating condition and external meteorological influences, performance, losses and efficiency change. Therefore, it is important to determine in the yield simulation how the components selected for the system will react under different conditions. These include

- Behavior of the modules at low and high irradiation
- Reflection behavior of the module (IAM = Incidence Angle Modifier)
- Change in module or inverter power at different ambient temperatures and correspondingly changing module or device temperature
- Natural power losses also affect the yield of a photovoltaic system. All crystalline modules, for example, are affected by light-induced degradation (LID). This effect causes the output of new modules to be immediately reduced by 0.5 - 2 percent by the first contact with sunlight.

The individual properties of all components used are taken into account in the yield simulation.

Module manufacturers provide information about the exact characteristics of their components in form of data files for simulation tools (.pan files). They are uploaded into the simulation tool, stored and used in the yield simulation process. However, the expert should always critically question this information and check it for plausibility. Independent test reports or tests from independent laboratories, which can often also be obtained from the manufacturers, are helpful here. Over time, the manufacturer's files provide the expert with a broad database of the characteristics of many components and, if necessary, he can also compare them with one another.

Corresponding files are also provided for the various inverters (.ond files). Among other things, they address the efficiency under various conditions and the behavior in the event of temperature deviations.

For transformers, the data sheets show, among other things, resistance losses (so-called copper losses) and losses due to remagnetisation and eddy currents (so-called iron losses).

The cabling of the plant also plays a role in the yield. Certain materials as well as long cable lengths and cross-sections lead to voltage losses on both the DC and AC side and thus also reduce the yield, which must be calculated accordingly and included in the simulation.

Specifications of the grid operator

When designing a photovoltaic system, the provision of reactive power must also be taken into account. In AC circuits, it is unavoidable and arises due to physical effects. The desired shift factor ($\cos(\varphi)$) or the factor required by the grid operator plays a decisive role here: it determines the amount of apparent power and thus the additional inverter power required. It can be used to neutralize an existing phase shift in the grid and to influence the voltage in AC grids. The yield assessment considers the active power of the plant in certain operating states and also calculates the provision of reactive power.

In addition, the expert opinion also makes assumptions about the yield deviations that would result from failures of the system itself, a grid failure or a grid disconnection by the grid operator. This is done, because the loss of yield of a system cannot always be compensated by an insurance solution or compensation payments.

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Self-consumption of the PV system

Every PV system also has a certain amount of self-consumption. This is caused by integrated consumers, such as lighting, ventilating, communication and monitoring components, but also by the inverters and transformers. This consumption is usually covered during the day by the production of the PV system, but the usable energy is reduced accordingly. The self-consumption can be determined either from empirical values or by a detailed analysis of the consumers and their operating times.

A good yield report also questions the given plant design

Usually, the yield report is based on an existing plant design with predefined parameters. If the simulation and the subsequent evaluation by the expert suggest that a modified design could still improve the yields, this should be discussed and, if possible, implemented together with the plant designer and project developer or investor.

Under certain circumstances, the yield report can make a change of the given plant design reasonable.

You have questions? Please contact us!

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