**Textos para el jueguecito**

# 1- Modules

### Textos

**1.**

The panels are the main elements of a photovoltaic plant. Their mission is to turn the solar irradiation into electricity. Although there are several technologies, the most extended one is the crystalline (mono or multi-crystalline). The crystalline solar cells are made up of sillicium, which is a very abundant element in our planet.

You may have heard of the thin film technology too. In fact, this term does not refer to one only technology, but several different technologies, each one made up of different elements. Nowadays, the more sucessful option among the thin film technologies, from a comercial standpoint, is the one made up of tellurium and cadmium (CdTe).

As always happens, each technology has pros and cons. At this point, let’s just say that the crystalline technology represents around 90% of the PV market, so, in general, I will be making reference to crystalline modules from here on.

2.

Although the dimensions may vary and there are different configurations of cells and shapes, as a reference, a typical crystaline module may have a size of about 1,7 x 0,9 m and a power of between 250 and 280 watt "peak" (Wp). This "peak" power is set for certain “standard conditions” (STC), so it is not the “real” production of the module, but an accepted standard, used to compare apples with apples.

The realtime yield of the modules will mainly depend on the solar radiation, the ambient temperature, the heat evacuation and the module relative position with respect to the sun, so it changes along the day. To evaluate the production of a PV plant, it is necesary to simulate those conditions, but also, the electric losses, shadows, soil, inverters performance, reflectivity, etc. Not so obvious, but hey! that’s what we are here for!.

3.

The output of the modules is characterized by a type of graphs known as I-V curves. These curves vary depending on the existing irradiation and temperature, and they represent the operating current produced by the modules at the different voltages. This is are I-V curve for different irradiations and temperatures:

*Espacio para poner la imagen*

Was it too technical? Press enter for some real life references:

4.

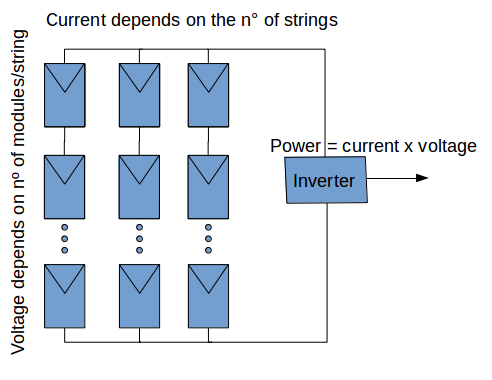
Real life references.

→ Aproximately 3 kWp of modules may suffice to produce a significant part of the annual energy consumption of an average family in the South of Europe. With 260 Wp panels, 12 panels are needed, occupying hardly 17 m². A roof with a proper orientation may produce a significant part of a family’s needs. This may cost around 3800-4500 €.

This doesn’t mean that, as such, we can break up with the Utility. solar panels only produce during the day and mainly in the midday hours and only in sunny days. Similarly, our energy consumption is not constant either. Unless we use batteries to store our energy, we will need the Utility to balance our needs. Consider the previous figures just as a general reference of the PV potential. In any case, this may suffice to understand why self-consumption and distributed generation are having more and more importance in many countries.

5.

Configuration. The modules are usually arranged in parallel strings. The number of panels in each string will determine the total voltage of the string. The string voltage is the sum of the voltage of each module. On the other hand, the total current may be calculated as the addition of the current output of each string. The total power of a field of panels is the product of the current and the voltage. Not so difficult, isn’t it?



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6.

PV plants are fully scalable. From a few panels on the roof of the houses up to huge Utility scale projects of over 100 MW, one can adapt the configuration to every need. No other energy technology is so flexible. A 100 MW project requieres more than 350,000 modules and produces energy for approximately 33,000 families, consistently with previous figures.

7.

Let’s get practical again. These are some of the main aspects that should be considered during the modules installation:

- Fasteners: be sure that the panels are properly fastened, to stand the environmental conditions in the long run. Fasteners should include plastic elements to avoid metal contact and galvanic degradation.

- Cables: pay attention to the wiring. Cables have to be properly fastened and protected from environment. If the cables are not properly held and hang up carelessly, they may be damaged by the environment or even eaten by rodents, and more importantly, they may represent a safety issue for the operators and the own facility. It is also important to properly label the cables for maintenance purposes.

- Connection: it is a good practice to start connecting the modules from the inverters backward, rather than the opposite, to avoid accumulated voltage at the moment of interconnection and the risk of electric shock to the technicians.

8.

Some typical deffects that may appear in relations to the modules are PID degradation, TCO degradation (in thin film tehcnologies), galvanic degradations, microcracks, snail trails, deformations, yellowing, etc.

Speciallly in Utility scale facilities, it is recomendable to test statisticaly significant samples of modules, to ensure a proper check of these deffects. The PID degradation is one of the may concerns for owners and developers, sin it may significantly impact the modules performance. It may be specially relevant in hot, humit environments. Most current first class manufacturers assure that their modules ar PID effect free, but these conclusions need to be further and independently tested. There is not an universally accepted test standard to evaluate the PID degradation yet, but some laboratories are providing their own tests in this regards.

All in all, these are specific tests that are recommendable, to evaluate the previous aspects in Utility scale projects:

- Flash tests to determine the modules performance.

- Electro-luminiscence, that helps to identify micro-craks.

- Specific tests for PID evaluation.

8.

Wanna know more? → feel free to contact me via Linkedin or Twitter

# **2- Inverters**

1.

The inverters have several functions. Not only, they are in charge of transforming the energy received from the panels and adapt it to the grid conditions, but they are also the brain of the installation. They track the power produced by the modules and force them to work in the maximum power point, to optimize the instalation yield.

Besides, the inverters include several electric protection systems to detect and react after breackdowns and shortcircuits. In spite of that, it is recommendable to add, additional external protections to spare the inverters own systems.

Finally, the inverters log operational data of the plant and produce a set of alarms to inform about the operation of the plants.

2. Characteristics

There are many different types of inverters, with nominal powers that go from a few Ws of nominal power (microinverters) up to over 2 MWs. The selection of the best option for a specific project depends on many factors: specific price conditions, logistics, maintenance, performance, environment, etc. In general, central inverters of over 1 MW are preferred for big Utility scale plants, and micro-inveters or kW type inverters for on roof or smaller plants.

3. Good practices

Inverters are one of the weakest parts of a PV plant. They have to be carefully preserved to ensure a proper and long lasting operation of the plant. Since they are made up of electronic elements, they are very sensitive to the environment. Very high temperatures may harm them, such as dust or marine or chemical environments. When designing a PV plant it is worth spending some good time for the selection of the best model of inverter. Other essential desitions, have to do with their location, shelter, refrigeration, etc. Protect the inverters from direct radiation.

# **3- Civil works** (poner escondidos en alguna parte) Que salga un bocadillo (what’s this?) al pasar por algún lado, y ahí si se pulsar enter sale la info!!

### Textos

1.

Opppss! We almost missed this! We are not an exception. In many real facilities, the importance of the civil works tend to be understimated. However, they are essential. A poor design of the foundation of the structures or trackers may ruin a PV plant, and cause significant damages. Not to pay the due attention to these aspects is the best way to endanger the whole investment. Let’s take into account that a PV plant should have a lifetime of at least 20 years.

2.

Civil works can be planned only after a thorough assessment of the terrain conditions and the environment. The following surveys are mandatory or highly recomendable for a proper engineering:

- Geotehnical study: it evaluates the type of terrain and its characteristics: strengh, acidness, humidity, pollutants, water table, etc. This is essential to set the dimentions of the foundations and ensure its duration for the lifetime of the project. A careless evaluation of the terrain charateristics may entail a mistaken design for the foundations. Although these errors may be unnoticed for years, in the medium or long run, they may eventually be catastrophic.

- Hydraulic survey: It estimates the maximum water that may accumulate in the plant and the required flow to evacuate it.

- Wind surveys: although it is not so common, in windy areas, and specially when trackers are being considered for the project, it is recommendable to evaluate the wind characteristics. Not only the average wind speed but the gusts need to be considered.

- In seismic areas, specific seismic surveys

3.

After carrying out all the previous studies, it is possible to do the proper engineering. These are the main aspectos that should be considered.

- Foundations: the structures need cope with different types of loads, mainly: modules and self weight, wind and seismic loads. The foundations need to ensure that the main loads in the structure are properly transmited to the terrain and that it has the capacity to endure them.

- Drainage system: in my career, I’ve seen some catastrophic situations in PV plants. In most of these cases, they had to do with an improper drainage design. Water has an inmense power, don’t forget to plan how to deal with it.

- Roads and accesses: a good enginnering here will absolutely worth it. It will be essential during construction and operation stages.

# **4- Structure/trackers**

1-

Nowadays, the most usual structural options in PV plants are one-axis trackers and fixed structures. Sometimes understimated, it is important to thoroughly evaluate the structural integrity of the solutions and its elements. It is important to take into account that they have to last for the lifetime of the projects. Not only their static integrity, but eventuality their deformations are important. In the event of displacements of the elements, important loads may be transfered to the modules, which may end up damaged.

Before designing a final stuctural design, it is essential to carry out specific geotechnic, hydraulic and seismic surveys.

Even further, it is important to test the final solution with specific destructive on-site tests, to check axial and latteral resistance of the foundations.

# 5- Control Center

1.

The control center compiles the operative information of the plant. It usually deals with three sources of information:

- the operational data delivered by the inverters or, in some cases, other specific sensors in the strings.

- the meteo station data: mainly irradiation, temperature and wind speed

- Communications from the security system: security cameras, IR alarms.

An effective communication system is important to do the follow-up of the plant remotely. In remote areas, satellital communication is sometimes adopted, but 3G or 4G covarage tend to be enough, at least for the management of the alarms and operational data.

2.

Asset Management:

Some years ago, while the PV plants where supported by specific subsidies that ensured their profitability, a thorough management of the operations was not considered essential by some owners. The margins left some room to be careless. Not anymore. Energy sector is more and more competitive and black numbers require strict maintenance and optimization measures. It is essential to monitorize the operational data, check the alarms and ensure a proper maintenance logistic.

3.

For a proper operation, it is important to take into account the following:

- An effective just-in-time monitoring of the operational alarms of the inverters.

- Updated and available storage of the spare parts to solve eventual breakdowns.

- Recurrent evaluation and comparative assessment of the performance, if possible, at a string level

- Planned inspection to visualy check the condition of the structures and modules, and the operation of the sensors.

- Other recomendable tools to do more accurate approaches at some point, are the IR cameras and the IV curve testers.

# 6- Meteo Station

1-

For a proper optimization of the PV plant operation, it is essential to have good meteorological measurement. How else would it be possible to determine the plant performance, taking into account that it depends on the meteo factors? However, surprisingly enough, meteo measurements are not always given the due importance. A meteo station should consist at least of the following elements:

- pyranometers for the measurement of the irradiation of at least first class, or more recomendable, secondary standard type. Other devices, such as calibrated cells, may not be accurate enough for proper performance evaluation.

- Termometers for ambient temperatures record.

- wind anemometers of first class type.

- wind vanes, at least in facilities with trackers.

- Thermocouples, for the measurement of the modules temperatures.

A proper maintenance of the meteo station, including a frequent clean up of the pyranometers, should be considered within the maintenance plan.

# 7- Evacuation infrastructures

1- The inverters transfor the direct current into alternating one, but big Utility scale plants are often far away from the consumption centers. The energy needs to be transported to these areas. With this aim and in order to connect with the utility infrastructures, it is often necessary to go high voltage.

Big Utility scale plants usually have their own electric subestation. The main element of the substations are the transformers. Their function is to increase the voltage. The higher is the voltage the lesser are the electric losses in the energy transport. That’s reason why, high voltage infrastructures are used. Depending on the location and type of interconnection, the PV plant will need to have specific high voltage infrastructures. It is usually the Utilities, that set the specific conditions for the interconnection, aligned with national specific regulations.