

INFLUENCE OF INITIAL POWER STABILIZATION OVER PV MODULES MAXIMUM POWER

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ABSTRACT: Measurements that suppliers offer in flash lists, unfortunately do not always fit the actual power measured in independent laboratories like CIEMAT. In fact, independent measurements usually appear lower than those printed in the label and sometimes a value beyond the allowed tolerance pointed by the manufacturer in the same label. In addition, a valuable power reduction has been reported when Standard IEC - EN 50380 is applied (according to this, PV module must be exposed to sunlight more than 20kWh/m² previously to performing the measurement), crystalline PV modules usually decrease its power around 1%, but descends greater than 4 % have also been reported. These power losses are only detected after the mentioned power stabilization.

Keywords: PV Module, Light-soaking, Power conditioning

1. INTRODUCTION

Spanish photovoltaic market has been involved in a huge expansion on last few years. Only in 2008, installed PV power grew from 250 MW to more than 2,500 MW. One of the consequences of PV modules massive installation has been the operation of new companies, dealers and manufacturers. The final customer really needs to know, the earlier the better, the power that PV modules will provide when the plant will be under operation. In order to fulfil this requirement, PV modules suppliers offer flash lists where customer could see the actual power that the module will provide, but often do not take into account several effects that may affect the power that a PV panel will actually provide.

That is the reason why many owners could not know the actual power of the PV module until it has been installed in the plant, and do not take into account these losses. Often, PV module manufacturers are against any kind of power stabilization previously to measurements. On the other hand, PV modules made of some technologies like CdTe and CIS, increase the measured maximum power supplied after the modules have been exposed to sunlight for a few hours. In such cases, many manufacturers do have a great interest in testing PV modules after stabilization.

In this way, actual peak power of PV modules is related to peak power of the whole plant. The answer to the following question: *will modules installed on a plant suffer a significant power decrease in their first days of operation?*, is essential in order to know what is the real reason for a lower-than-expected energy supplied by the PV plant.

Under this context, present paper shows some different cases of stabilization for different PV module types and manufacturers. The power losses after the stabilization have been quantified in terms of percentage over initial power. Also, some tips are given in order to minimize errors associated with power calculations that should be taken into account by those who want to know the actual peak power offered by a PV module.

2. ANALYSIS PROCEDURE AND MEANS USED

2.1. The solar simulator

The method consist on performing the I-V electrical characteristic curve by means of a class AAA, single pulse flash solar simulator, to a selection of photovoltaic modules which still have not been exposed to sunlight in a photovoltaic plant. Resulting measurements are extrapolated to Standard Conditions of Measurement (STC) consisting on:

- *Solar irradiance: 1000 W/m²*
- *Solar cell temperature: 25 °C*
- *Spectral distribution of irradiance: AM1.5G (IEC 60904-3)*
- *Normal incidence over the cell.*

Inside the simulator, conditions are very close to Standard ones, with little deviation (25 ± 2 °C and 1000 ± 5 W/m²). By extrapolating the obtained measurements, using module temperature (**a**, **b**) and Irradiance correction factors, they will be determined in STC (see IEC 60891 Standard). Special care is taken by ensuring that PV modules have not received direct solar light before this first round of measurements.

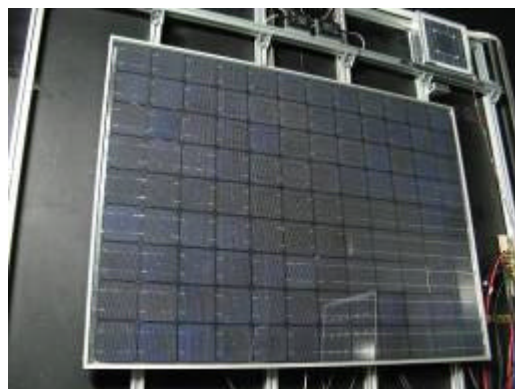


Figure 1: Position of the PV module under analysis inside the solar simulator.



Figure 2: A view of the 4 xenon lamps and the collimators of the light of the simulator.

In order to determine if the simulator and every single element involved in the measurement is operating correctly, two patterns are used. From both of them a measure is taken. These measures should not have a difference greater than 0.5% from the known value. Each pattern is made in a different technology, i.e. one of them is made with monocrystalline silicon cells and the other one with polycrystalline cells.

2.2. The method

Once the initial results are obtained, a sample is selected from the whole set in order to be exposed to natural sunlight. Selected modules will remain under exposition for a variable period of time, according to the current season, in order to receive from 20 kWh/m² to 40 kWh/m² cumulative solar radiation, (see IEC-EN 50380 Standard). From the initial set of non exposed modules, another PV module is chosen in order to maintain a future reference.



Figure 3: some of the external elements of the solar simulator: computer, electronic load and temperature indicators.

Once exposed PV modules have received cumulative radiation enough, a new measurement is taken. As previous time, it is performed in Standard Conditions inside the solar simulator. In order to check if they are valid, the electrical characteristic curve of non-exposed module used as reference is taken as well, verifying if it remains constant, so avoiding in this way uncontrolled changes in measuring conditions. If averaged value over exposed modules presents a loose of power higher than 2 %, it is considered as significant.

Lower values of power losses are not so considered, due to total uncertainty associated with measurement processes. Nevertheless, when set under test is large enough, power losses from 1% to 2% should be considered as a valuable tendency.

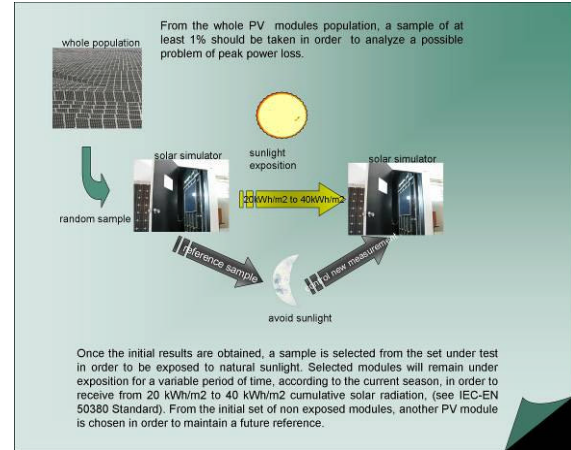


Figure 4: A scheme of the method.

A total amount of 179 PV modules from 42 different manufacturers were tested, being 63 the total number of different models. In this work, all of the analyzed modules were constructed from crystalline (both monocrystalline and polycrystalline). Nominal power of analyzed modules varies from 125 Wp to 240 Wp. A comparative analysis is carried out, taking considering the following aspects:

- *Kind of technology: monocrystalline versus polycrystalline silicon.*
- *Different manufacturers.*
- *Different nominal peak power.*

When a significant power loose after a sunlight exposition higher than 20 kWh/m² is detected, it can be said that PV module presents the referenced problem of power loose during initial power stabilization. In any case, even if power losses are not reported, photovoltaic modules may still present stabilization effects, since it is not always known the previous module history, and it can not be sure that modules were not previously exposed to sunlight for time enough to reach their definitive power stabilization. In order to avoid this problem, it is recommended to perform these kind of measurements over samples as numerous as possible.

3. RESULTS AND DISCUSSION

It can be obtained some conclusions from the analysis of results. For instance, it can be determined if there is a type of technology presenting different response to initial power stabilization, and also if valuable differences between different PV module manufacturers and different nominal peak power are registered.

3.1. Monocrystalline vs. polycrystalline silicon

It clearly be noted a tendency in measurement results, indicating a bigger initial loose of power in monocrystalline silicon PV modules than referred to polycrystalline silicon ones (see Figure 5). The averaged

difference between the two kinds of technology is about 1%. Obviously, it does not mean this technology would present a worse quality level, but only the final stabilized power should be always measured after the mentioned initial exposition to sunlight. On the other hand, an initial loose of power must be considered. This initial loose will be higher in monocrystalline silicon PV modules, and also would vary from one manufacturer to another.

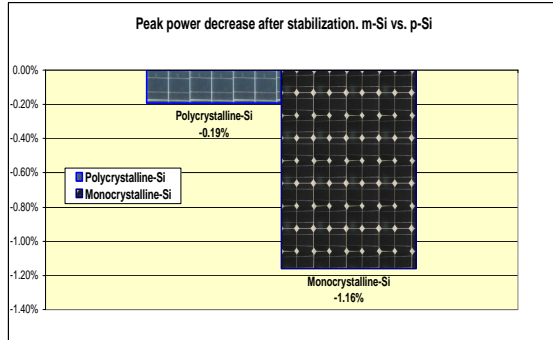


Figure 5: Different technologies comparison.

3.2. Different manufacturers

When results are analyzed from different manufacturers, differences between m-Si and p-Si are found, as represented in Figure 5. In this way, most of tested m-Si PV modules, constructed from different manufacturers, show an initial decrease of power higher than 1% after sunlight exposition. In Figure 6 it can be seen the tendency of the mean loss of power when different m-Si PV modules from different manufacturers are analyzed. Practically every set of modules present an initial peak power loss.

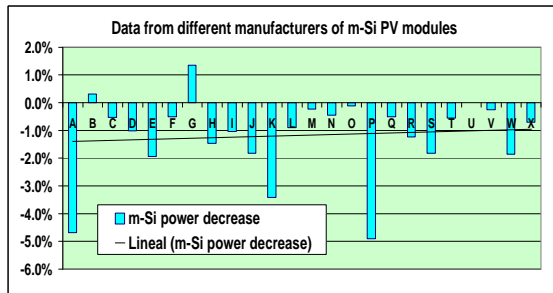


Figure 6: Manufacturer comparison in m-Si PV modules.

On the other hand, p-Si modules do not always present a significant power descent, since obtained values are below 1% (around 0.5%). Looking at data from p-Si comparing to m-Si PV modules, it may be assured that beyond a value, there is a tendency in m-Si modules indicating they suffer a smooth decrease in measured peak power.

It must be pointed that the general error when a single test is performed could be to 2%, but we are comparing measurements made with the same solar simulator and in the same conditions. In this case the error could be better than 1%.

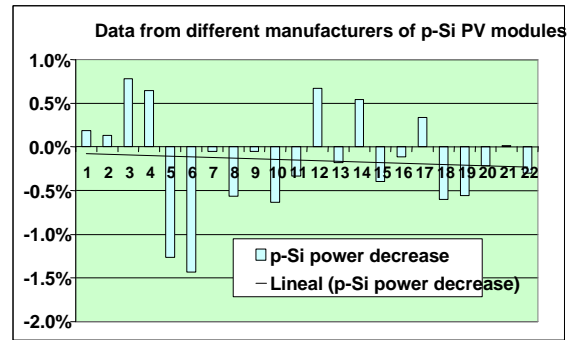


Figure 7: manufacturer comparison in p-Si PV modules.

Also, a valuable difference from one manufacturer to another is reported. These differences can vary from no changes detected during peak power measurements after power stabilization, to extreme cases where measured power can be reduced up to 4.5% from initial power. Clearly, it would present a descending in PV generated energy when the plant becomes operative. Therefore, the only way to detect it is performing a previous power stabilization over a sample selected from the whole number of modules to be installed, and to claim to the manufacturer if high power loose is detected.

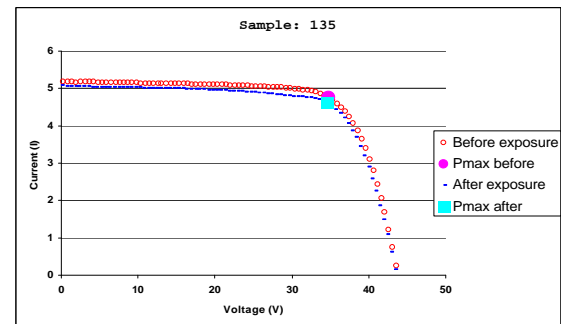


Figure 8: Example of high peak power loss.

3.3. Different nominal peak power

When it is analyzed the initial loose of power in panels with different peak power values, it is not reported any significant difference between them. This means there is not a defined relationship between the number of cells and the initial power loose during stabilization. It is then a problem related with the technology of the cells forming the PV module.

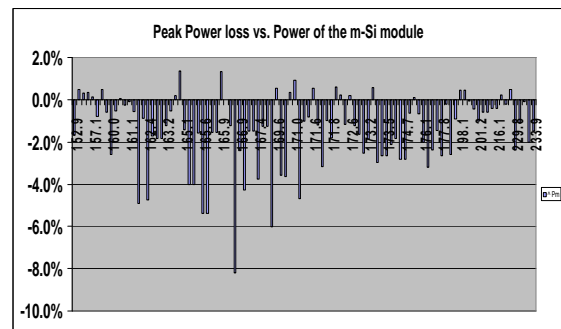


Figure 9: Power loss vs. peak power comparison in m-Si PV modules.

3.4. The problem of flash lists

When an independent PV laboratory performs measurements over a sample of PV modules to be installed in a PV plant, there are commonly differences between laboratory results and power values indicated by manufacturers in the list of PV modules known as “*flash list*”, or list of electrical characteristics of supplied PV modules. Usually, measured power is lower than indicated power in the list. If related difference is lower than power tolerance, manufacturer may argue it is allowed: unfortunately, measured power appearing in the flash list, was taken previously to a sunlight exposure, so final power could be much lower than indicated. According to Alonso, mean value for difference is -1.6%, but it could vary from +4 % to -12 % [4].

4. CONCLUSIONS

Generally, PV modules made of monocrystalline silicon cells and also those made of polycrystalline cells, suffer an initial small peak power loss which is known as power stabilization. According to the results of this paper the mentioned peak power loss is a little higher in monocrystalline PV modules. Besides this, a big difference from one manufacturer to another should be found. In some cases the initial peak power loss is higher than 4%.

In order to know a reliable value for the peak power of the modules and also of the whole plant, a previous analysis over a sample of the modules that will be used in the plant is recommended. The modules in the sample should be randomly chosen. The analysis must take into account that the modules should not be exposed to the sunlight prior to the analysis. Finally, the analysis should include a power stabilization test, where the customer could know the mean of the peak power loss after the first exposition to sunlight where they receive from 20 kWh/m² to 40 kWh/m² cumulative solar radiation.

5. REFERENCES

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