QUALITY CONTROL DURING THE SUPPLY OF PV MODULES: FUNDAMENTAL KEY TO GUARANTEE THE PROFITABILITY OF PV INSTALLATIONS

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ABSTRACT: The aim of this paper is stating the reasons why is necessary to carry out a quality control during the PV modules supply in the fabrication of a PV installation to obtain its maximum of energy production. Moreover, this work marks the guidelines to follow and the basic quality control to carry out to make sure that the installed PV modules have a minimum of quality to guarantee the profitability of the installation during its operative life. Finally, commonly detected defects during tests carried out in the Enertis Laboratory for PV characterization are showed.
Keywords: PV Modules, Quality Control, Testing and Characterisation.

1 INTRODUCTION

The world photovoltaic market has experimented an elevated increase in the last years thanks to, between other, politic compromise adopted by different goverments and reflected in the promotional frameworks of large range in many countries, in special Germany, Spain and USA.

Data indicate that at final of 2006, the total installed capacity of photovoltaic energy worldwide exceeded 6500 MWp compared to 1400 MWp at final of 2001 [1], so the annual increase rate of PV installations is higher than 35% from 1998. At final of 2007, the total PV power installed exceeded 9100 MWp as Fig. 1 shows [2].

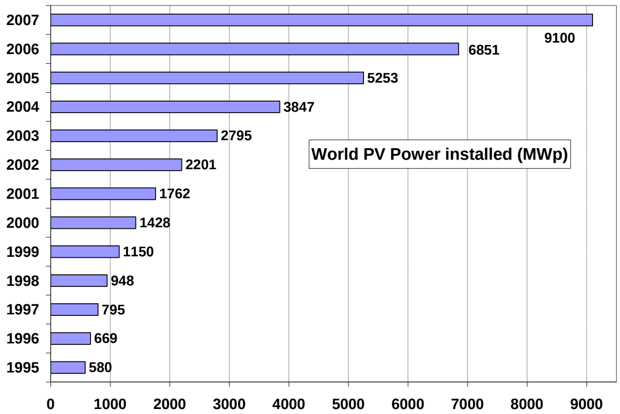

Figure 1: Evolución de la potencia fotovoltaica total instalada en los últimos años.

A clear example of this situation is the photovoltaic market in Spain, where the installed power reached 643 MWp at final of 2007, so 450% higher than 2006, and 1000 MWp are foreseen for 2008. Moreover, the industrial investment in photovoltaic sector during 2007 exceed 536 million euro, 500% higher than 2006. With this, the spanish productive capacity has reached 350 MW in 2007, 18% of world capacity [3].

Due to this situation of world PV market, the bussiness of PV components is in a continuous process of growth. A great many different manufacturers and products are appearing in the market and producing confusion as a consequence of shady specifications, different prices and doubtful qualities. This circumstance is reflected in a reduction of the market share of the main 10 companies of PV industry in the last years, with a decrease from 85% in 2004 to 75% in 2007. This effect is specially pronounced in case of PV modules and it is necessary to carry out an appropriate quality control that includes an inspection of manufacturing process and inspections in the receipt of the modules according to IEC-61215:2005.

Also, the shortage of silicon and the "boom" of PV market have caused a decrease of the quality of silicon due to the appearance of many new manufacturers of silicon ingots and wafers. Many of these companies, coming from other industrial sectors, do not keep the necessary quality levels of the polysilicon and their fabrication processes [4].

2 IMPORTANCE OF QUALITY CONTROL OF PHOTOVOLTAIC MODULES

The module is the most important component of the PV system due to two main reasons. The first reason is technologic because is the component which converts the incident irradiance in electric power, and the second one is economic because the cost of modules is commonly upon 50% of the total cost of PV installation. These two reasons between others make necessary to carry out a suitable quality control of modules during the supply.

2.1 Necessity of quality control

The photovoltaic modules have a very long useful lifetime so it is essential to check that they will work correctly during minimum 25 years. To pay attention only in the origin of module's manufacturer and its certificates as quality control it is not enough. This behavior is not correct because certifications are obtained for a concrete model of module with certain components and a specific design. It would occur, for instance, that the production of monocrystalline modules from a manufacturer has the IEC-61215:2005 certification but the production of polycrystalline has not it. Also, the market conditions of components produce that the manufacturers have to change punctually their design or include different components from the origin ones that passed the certification.

Respect to the origin of module's manufacturer, it is not an important aspect because, for instance, many European companies have not enough capacity and they need to buy OEM brand modules in China.

Other important aspect is that there are different production lines into a factory, each one with many technologic equipment which need optimized parameters. A wrong adjustment in a certain part of the line can produce output modules without quality enough. Thus, a company can produce modules with different quality in a certain period of time.

2.2 Avoiding the use of manufacturer guarantees

The manufacturer guarantee of the modules covers its electric production during 25 years at least. If a batch of modules is not in agreement with this requirement from a determined moment, the production of the PV plant will have a heavy drop. Moreover, the cover of this guarantee is only for the module and it does not cover the dismounting of defectives modules, the shipping cost of new modules from the manufacturer and the replacing of these new modules in the PV plant. In addition to theses costs, the profit reductions will increase the economic losses. To avoid these future problems, the quality control of a PV installation can not be simply limited to check punctually its production or during a short period of time, but it is necessary to implement an integral quality control of the modules during the process of construction. Thus, the acquisition of modules with indications of degradation in short and medium term will be minimized.

2.3 Inclusion of quality control in the supply contract

In the case of detecting performance problems with modules or characteristics different from contracted ones, the inclusion of this quality control and its acceptance and rejection plan of batches to the supply contract permits to resolve the problem before mounting and to avoid the use of manufacturer guarantee. Thus, the economic risks assumed by the different entities involved in the PV plant installation will be minimized.

2.4 Cost of quality control

An important aspect is the cost of this quality control of PV modules, specially for the builder. Enertis Solar has executed quality control of modules and many PV installations and its experience says that, depending of its depth, the quality control must be between 0.5-1% of the total investment in photovoltaic modules. This cost is very low it is compared with the profit losses, between 5-10%, caused for wrong performance of modules [5].

Obviusly, the cost of the quality control depends of number of samples for testing. Enertis Solar advice to do always the sampling for tests according to ISO 2859.1:1999 with the aim to select the number of samples appropiated to a predefined cost.

3 EFFECTS OF MODULE DEGRADATION ON PERFORMANCE OF PV SYSTEMS

Degradation is considered as the termination of the ability of a module to perform its primary function which is to provide safe, useful electric power. Normally, degradation of modules is not caused by one isolated factor, but that is dependent on multiple factors, some of which interact causing degradation that is difficult to simulate in the laboratory.

According to manufacturers guarantee the module degradation is around 1% per year. The lack of quality control could produce existence of installations with faulty modules in strings. For example, studies carried out by the National Renewable Energy Laboratory (NREL) show module performance losses of 1-2% per year in systems tested over ten-year period [6] and the LEEE-ISAAC laboratory has measured losses ranging from -0.7 and -8.2% respect nominal power after first 15 month of exposure [7].

It is very important to show that a few modules with power degradation in a PV installation can reduce its performance drastically. Sandia National Laboratories have detected degradation in performance of entire arrays of 50% from the initial rating after 12 year of exposure [8]. This drastic reduction of performance was attributed to specific problems such as complete failure of individual modules in strings.

4 EFFECTIVE QUALITY CONTROL OF PV MODULES

The certification IEC 61215:2005 of PV modules includes 17 tests which determine the thermal and electric characteristics. Also, the tests show that module is able to be exposed large period of time in outdoor conditions without failures.

In the quality control of a PV module supply it is not possible to do all test in each module due two reasons: several of them are destructive tests, and the realization of all non-destructive tests is too expensive. Also, it would be necessary a long time for the quality control.

Enertis Solar has developed a Quality Assurance Program for PV installations which includes a PV module quality control with three tests of certification and an additional non-destructive test. This quality control is showed in Fig. 2.

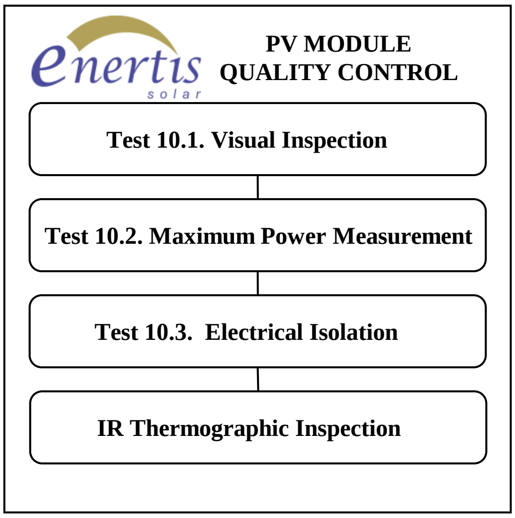

Figure 2: Tests included in the quality control proposed.

For the manufacturer acceptance and agreement of the quality control and its inclusion in the supply contract, the tests have been executed in laboratories with suitable equipment and carry out by technical staff according to IEC 61215:2005.

5 DEFECTS DETECTED DURING QUALITY CONTROLS OF PV MODULES

In this section, the tests are briefly commented and defects commonly detected in PV modules are showed. The tests have been executed in the Enertis Solar Laboratory for PV module characterization.

5.1 Test 10.1. Visual Inspection

This test is carried out with a minimum illumination of 1000 lux and contains 30 inspection points grouped in 4 fundamental parts of module: front, back, frame and junction box.

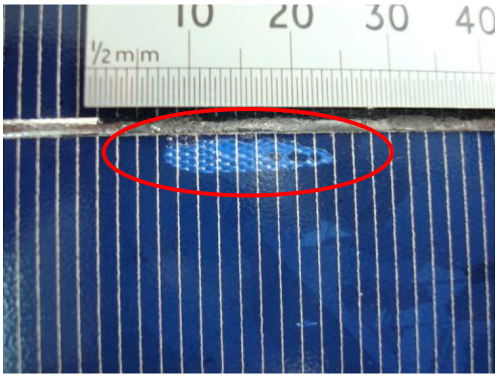

Figure 3: Bubble on a cell.

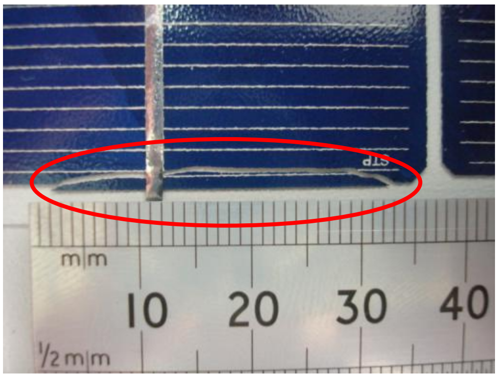

Figure 4: Cracked cell.

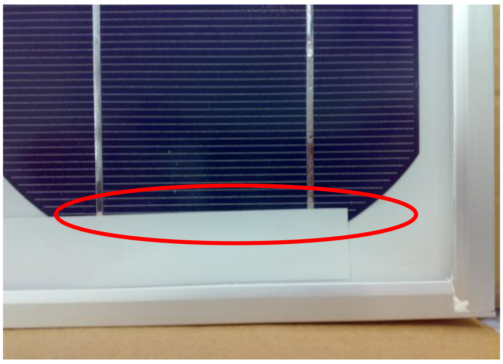

Figure 5: Partially shaded cell.

Typical defects detected are: bubbles (Fig.3), metallic inclusions, chips or cracks in cells (Fig.4), misaligned cell connection string, partially shaded cells (Fig.5), short-circuited junction box (Fig.6), non uniform sealant in frame (Fig.7), etc.

5.2 Test 10.2. Maximum Power Measurement

This test is carried out with a solar simulator Class AAA according to IEC-60904-9 which determines the electrical parameters in STC conditions (Irradiance 1000 W/m^2, 25 ºC and spectrum AM1.5G).

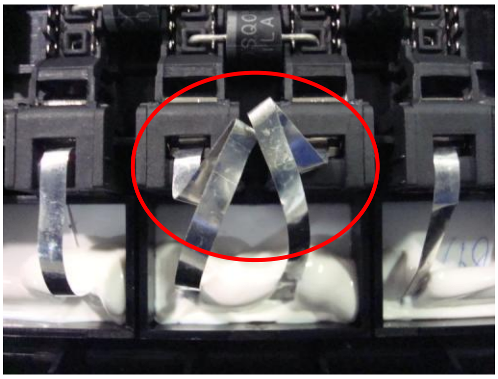

Figure 6: Short-circuited junction box.

Figure 6: Non uniform sealant in the back sheet. It can produce inclusion of moisture and dielectric problems.

It is recommendable to measure the maximum power before exposure because in case of detecting values lower than specifications, it is possible to make use of the fabrication guarantee and reject the supply. In this case, the low power is only due to failure performance and it is not related to the initial power degradation that occurs normally in the first hours of exposure. However, if the modules have been exposed, the performance of modules is regulated by the power guarantee (commonly 90% in the first 10 years and 80% in 25 years).

Fig. 7 shows an example of measurements of maximum power corresponding to a sample of modules from a PV installation. The values are represented respect of power range from specifications. Maximum power is normally lower than specification and manufacturer Flash-Report, but inside of range Pn ±3% before exposure.

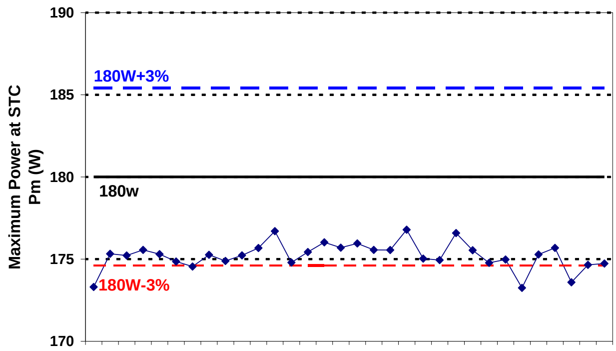

Figure 7: Example of maximum power measurements of 32 monocrystalline 180 ±3% Wp modules.

The experience of Enertis Solar indicate that most of manufacturers are really closer to low limit of tolerance range than upper limit, Pn-3% or Pn-5% depending of photovoltaic module specifications.

5.3 Test 10.3. Electrical Isolation

The aim of this test is to analyze if the PV module is correctly electrical isolated between its current conductor parts and the frame. In this test the absence of dielectric breakdown is checked and the isolation resistance is determined.

The failed tests during the quality controls are mainly related with defective laminated processes and faulty frame assemblies.

5.4 IR Thermographic Inspection

This inspection permits to detect defects which are not visible with a naked eye: cracked or broken cells (Fig.8,12), hot-spot in cells (Fig.9) or their connections and soldering (Fig.8,11), non active cells or region which do not contribute to photogeneration and failures in bypass diodes wiring.

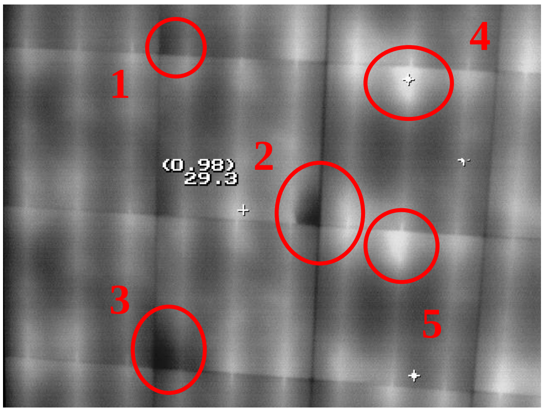

Figure 8: PV module with three broken cells (1, 2, 3) and two hot spots in cell interconnections (4, 5).

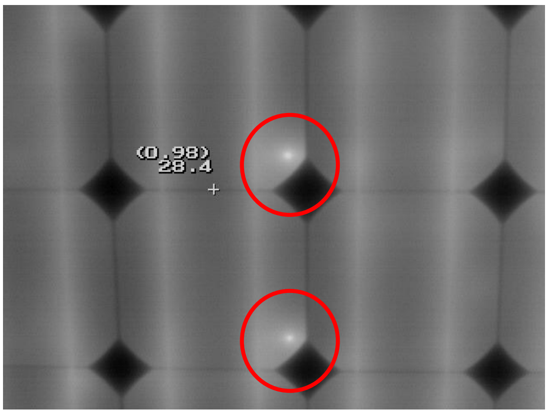

Figure 9: Hot spots in cells due to fabrication process.

6 CONCLUSIONS

The cost of a PV installation is elevated so it is indispensable to carry out a quality control, specially in case of photovoltaic modules because they are the most important components of the system and their cost is upon 50% of total cost of installation. It is important remark that with a low cost it is possible to avoid millonaires losses.

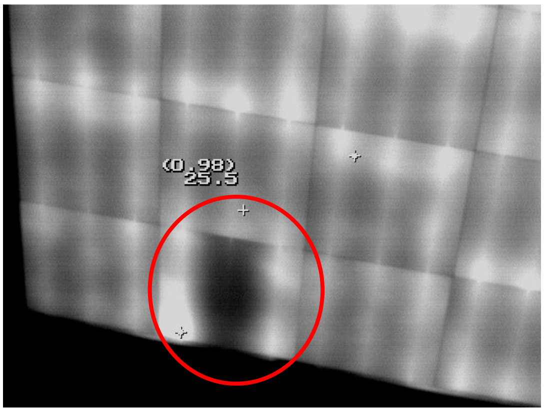

Figure 11: Hot spot cause because internal busbar is not correctly soldered and the current is forced to be extracted only through other two busbar increasing resistance.

Also, the actual photovoltaic market has produced the aparition of high number of modules manufacturer with uncertain quality. For this, this paper explain the main reasons because an effective quality control it is required, focusing in avoiding the manufacteres guarantee to reduce costs. Advices for the inclusion of quality control in the supply contract and its appropiated cost are also given.

Moreover, this articule proposes a basic quality control, which includes four tests, and marks the guidelines to carry out it. Finally, defects commonly detected in the application of this model of quality control to many PV installation are shown.

7 ACKNOWLEDGEMENTS

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8 REFERENCES

[1] *EPIA/*GREENPEACE, Solar Generation IV, 2007
[2] EPIA, Global Market Outlook for Photovoltaics until 2012, February 2008.
[3] ASIF. Infome anual 2008.
[4] Photon, March 2007, pp. 40-43.
[5] ASIF, Infome anual 2006.
[6] M.G. Thomas et al. Proceedings NREL Photovoltaic Performance and Reliability Workshop, NREL/CP-411-7414, 1994 pp. 279-285.
[7] D. Chianese et al, Proceedings of 22nd EPVSEC, 2007.
[8] M.A. Quintana et al., Proceedings of 28th IEEE PSC, 2000.