



Photovoltaic modules EDF EN quality control

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Abstract: The present document summarizes the procedure set-up by EDF EN to control the quality of the modules to be installed in EDF EN PV power plants (*crystalline and thin film technologies*) for a total volume larger than 500MW net capacity installed before 2012. Indoor and outdoor measurements have been initiated for initial power evaluation, long-term degradation and reliability. This allows to:

- Minimizing the risk of failure during operation, assuring the investors and lenders about the robustness of the installed field,

- Evolving a business plan which can reflect more the reality of the field behavior

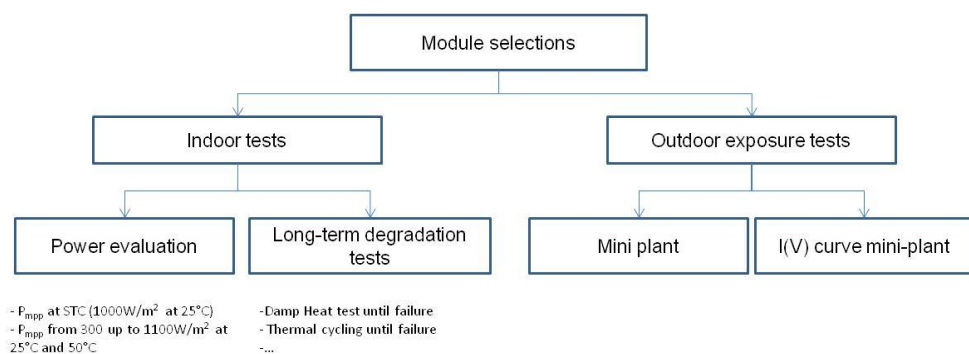
A statistical method is defined by Fraunhofer Institute (ISE) or Certisolis¹ laboratories to select a small amount of module representative of all purchased modules. The quality control procedure is defined according to some selected tests from IEC standards.

1- Introduction

The objective of this note is to give an overview about the quality control procedure and results for photovoltaic modules as defined and applied by EDF EN. Two test categories were followed:

- The first tests are from IEC standards (*IEC 61646 and IEC 61215*). This procedure permits to evaluate modules quality in terms of power estimation.
- The second set of tests is set-up to evaluate module robustness by performing complementary test to the IEC standards.

Both tests can be used to evaluate module quality for existing or new module manufacturers in EDF EN sourcing.



2- Power Estimation

a. Module sampling

A fraction of modules is taken randomly, by using a statistical method, from all modules flash lists for a corresponding lot or from a production batch. The module fraction and sampling is selected according to the maximum power at STC, to the production date and the acquired experience of the manufacturer. Finally, the distribution of the selected modules is checked visually with respect to the serial numbers or the date of production. Selection is made by ISE or Certisolis by defined statistical methods.

b. Electrical characteristics : Incoming indoor tests

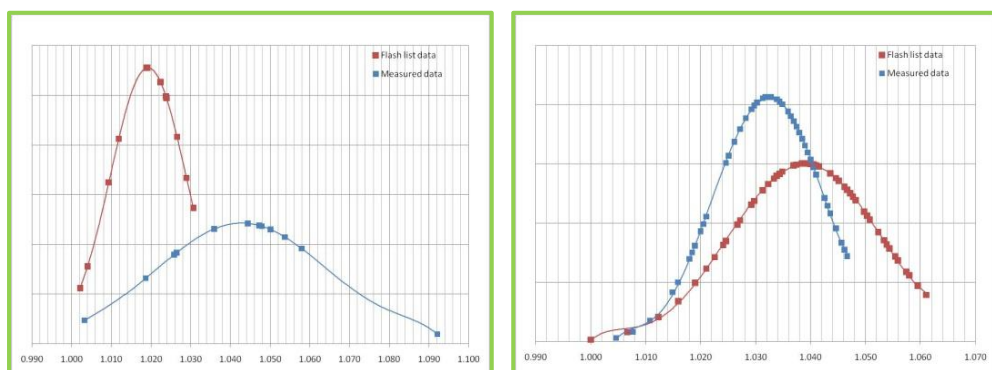
The indoor test for incoming modules is undertaken to verify module power before outdoor exposure or installation in the field. In fact, to determine the current-voltage characteristics I(V) of the module in accordance with IEC standard at the following conditions: *STC conditions: $1000 W/m^2$, at module temperature of $25^\circ C$ and at different irradiance from 200 up to $1100 W/m^2$, at module temperature of $25^\circ C$ and $50^\circ C$ to verify low irradiance behavior of the modules.*

The pre-conditioning procedure corresponds to the one given by the manufacturer in the case of thin film technology modules.

The main results compared to the flash list data given by manufacturer are:

- The maximum power (P_{mpp}): should be in the tolerance range of module manufacturer
- The Fill Factor (FF %): need to have the same value as manufacturer one.

MPPT power comparison of CdTe (by using the preconditioning procedure developed by the manufacturer) and crystalline modules is presented below:



Comparison of Indoor power measurements between Flash list (Red) and measured one (Blue) by using pre-conditioning procedure from CdTe manufacturer

3- Long term behaviors

a. Long-term degradation : Indoor test

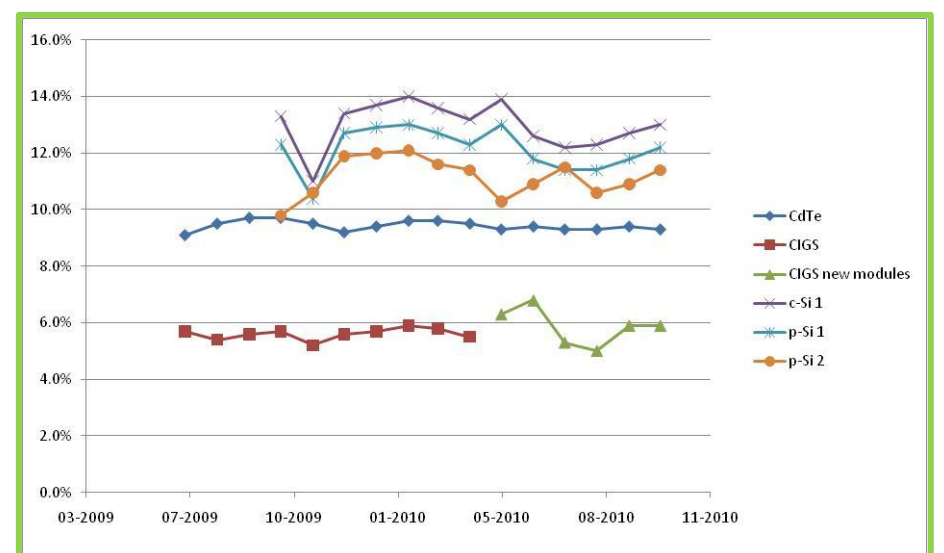
Additional tests with modules selected randomly, such like damp heat and thermal cycling, are also undertaken to determine and understand failure modes for crystalline silicon and thin film modules. These tests are performed longer than IEC standards. The results of some manufacturer were surprising. The performance full down quickly after IEC limits. More details are presented in the paper "Damp Heat Testing Longer than IEC Standards" presented by Mike Van Iseghem et al. EDF R&D.

b. Outdoor exposure test

To make a preliminary assessment of the ability of the module to withstand exposure to outdoor conditions and to reveal any synergistic degradation effects which may not be detected by laboratory tests. A significant amount of modules is taken from a random position from all flash lists for a corresponding lot or from a production batch. The modules are mounted in a small plant as recommended by the manufacturer. An irradiation measuring device is installed with the same orientation of the modules.

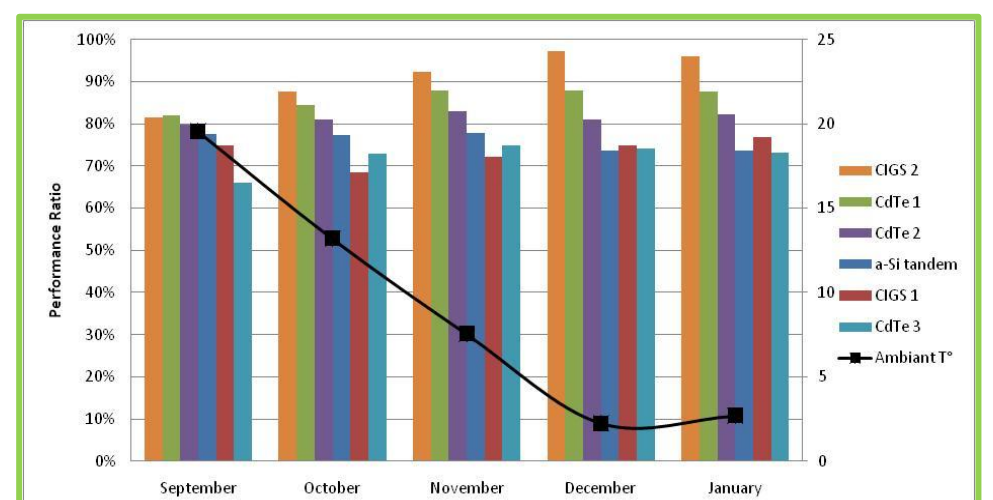
Two kind of installation are made:

- 3 modules per technology (CdTe, CIGS, a-Si and c-Si) are connected to a resistive load sized, such that at STC the modules will operate near the maximum power point via Papendorf software solution system. The I(V) curve is recorded every minute. The information is collected since more than one year.



Comparison of outdoor measured efficiency for CdTe, CIGS and crystalline modules

- 1 up to 100 kW_p equivalent modules are connected to different inverters by mean of PADCON system permitting to measure more precisely DC and AC current and voltage. The information is recorded since August 2010.



Comparison of outdoor measured performance ratio for CdTe, CIGS and a-Si tandem modules

4- Conclusion and perspectives

Flash test and long term degradation experiment undertaken by EDF EN help understanding the long term behavior of crystalline and thin film modules with collaboration with the manufacturer. All the information is shared with each manufacturer in order to improve their quality and assure good performance stability for our core business.