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SUPSI

# Advanced metrology for the characterization of solar modules

Challenges beyond the Standard Test Condition (IEC 60904-1) and the international Energy Rating standards (IEC 61853)

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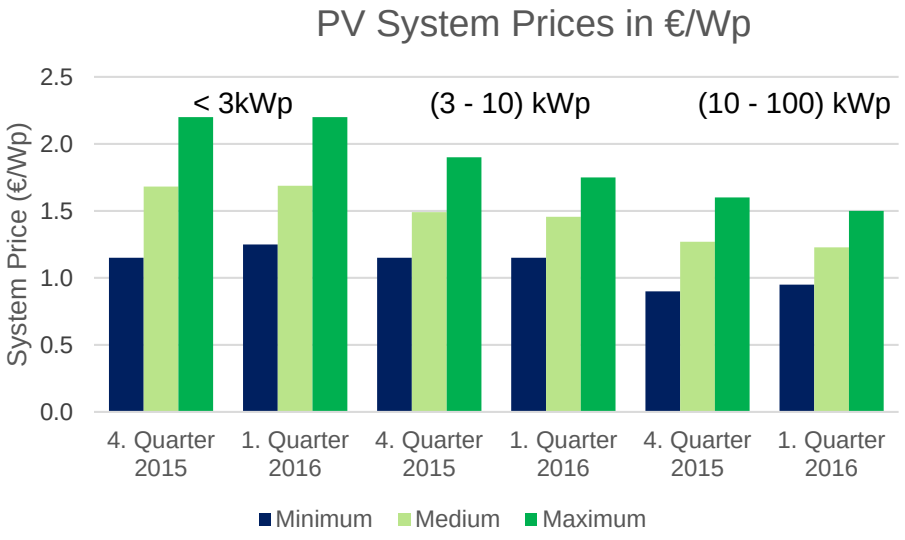
9 ottobre 2017

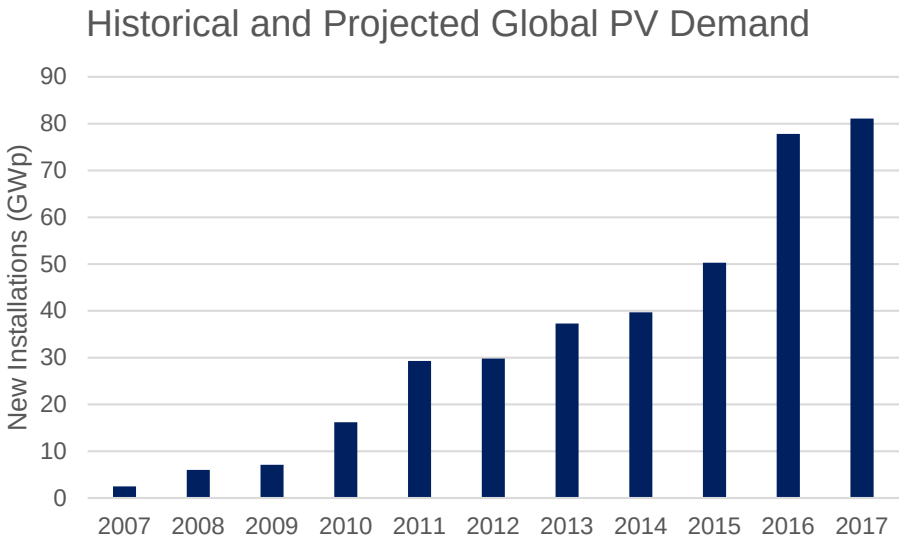
# Agenda

- Introduction
- Relevant projects
- Main challenges in characterization
- Conclusions

# Introduction




Source: www.solarwirtschaft.de/preisindex




Source: GTM Research, Q2 2017

Financial uncertainty = Global annual installation × Price × Uncertainty • 2015:

Financial uncertainty = 50,0 GW/year × 1.27 €/W × 1 % = 635 M€/year

# Introduction

- PV modules are optimised, selected and sold on the basis of power produced under Standard Test Conditions (STC).

- This metric does not reflect real-world conditions:
  - ambient temperature
  - irradiance
  - angle-of-incidence
  - spectrum
  - wind-speed

# Introduction

- A new set of standards, IEC 61853, provides a framework for energy rating of PV, including measurement, modelling and reference meteorological data.

- Remaining challenges arising from emerging technologies and market trends:
  - Bifacial modules: claim to increase energy yields by 10 to 20 % - lack of standard tests and rating methods
  - PV modules on buildings: differences in operating conditions compared to ground-mounted PV - not reflected in the current standards
  - Module characterisation: LED simulators for fast characterisation

# Relevant Projects

**ENHANCE – nExt geNeration pHotovoltaic performANCE**

**(SI/501325-01, Aug 2015 – Dec 2018)**

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

- To promote both SUPSI's national and international role as an accredited testing laboratory – ISO 17025

- To support Swiss leading research institutes and PV module manufacturers

# Relevant Projects

**PV Enerate: “Advanced PV Energy Rating – Higher Precision and New Technologies” (16ENG02, May 2017 – Apr 2020).**

EMPIR EURAMET
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

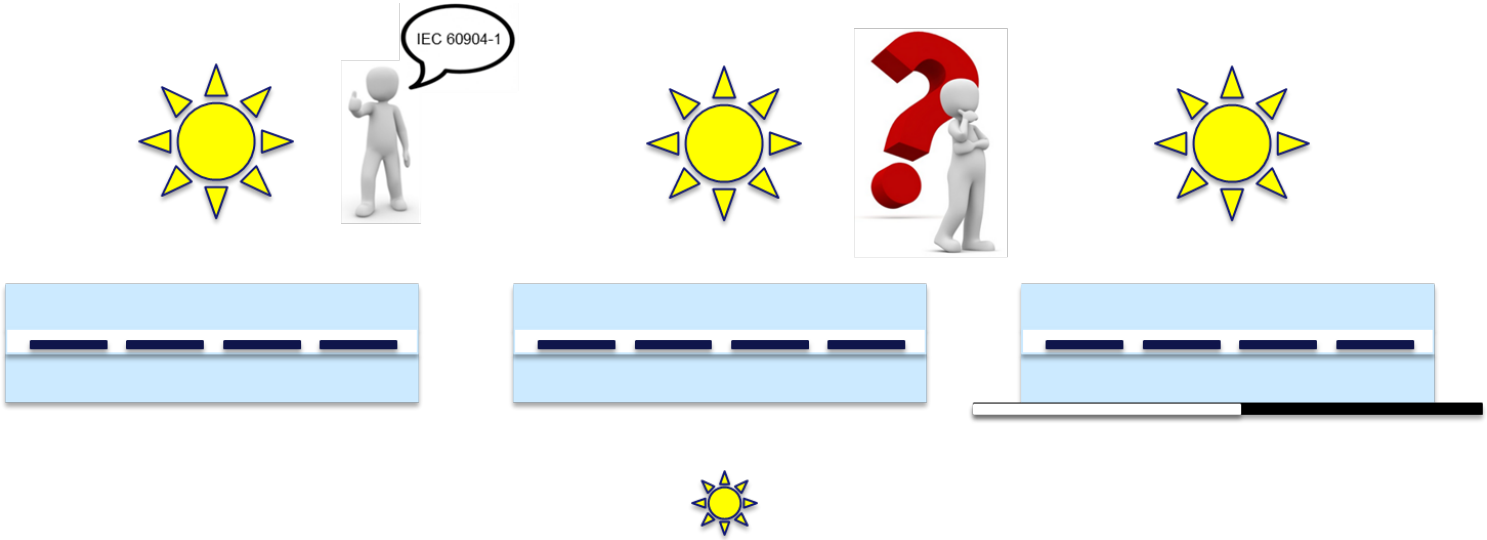
- Improvement of measurement equipment and methodologies

- PV energy rating standards.

# Challenges - Bifaciality

**Measurements of Bifacial PV modules currently discussed in the IEC TC82 WG2 project number IEC TS 60904-1-2 ED1**

- Which is the required front illumination intensity?
- Background?
- Both-sided illumination?



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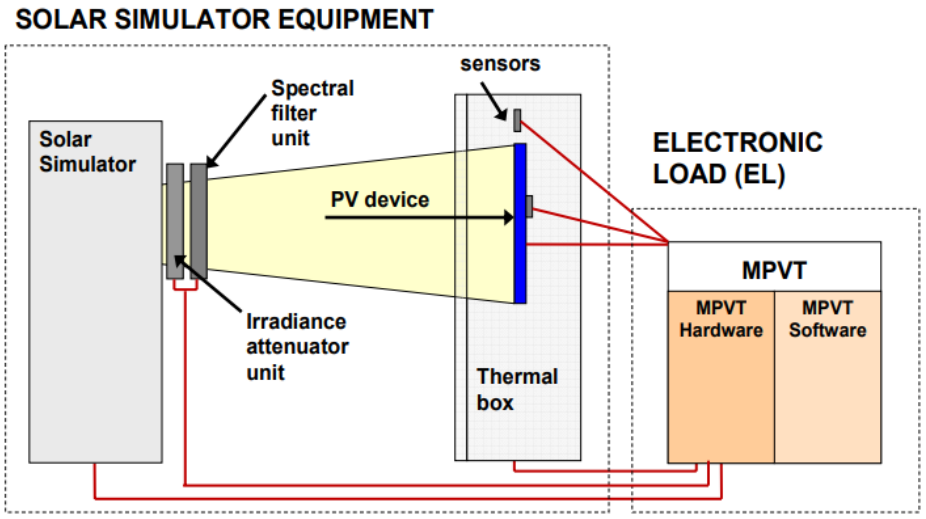
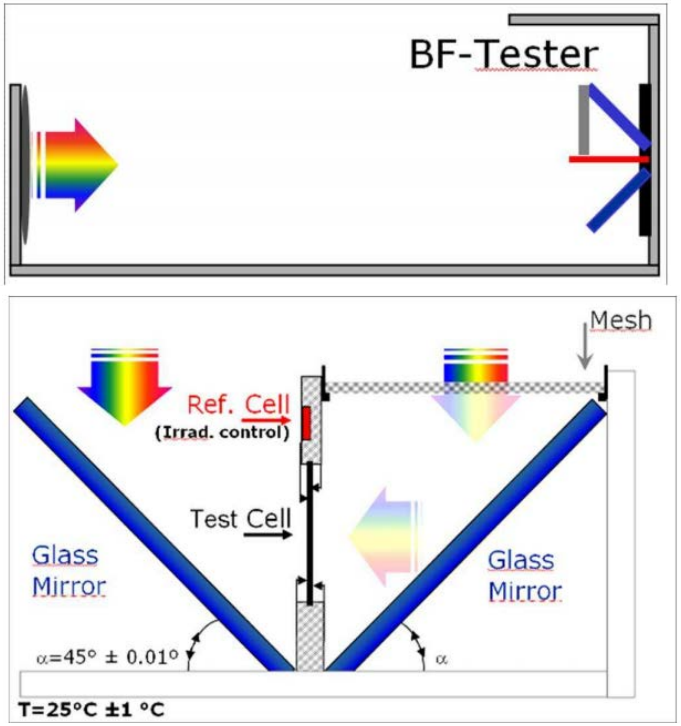


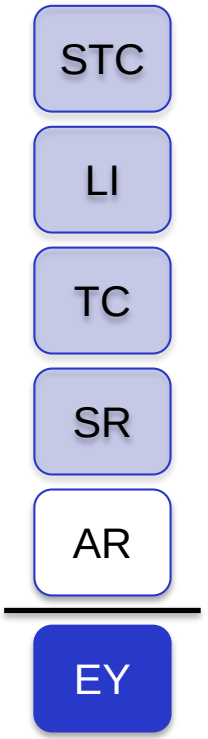




M. Ezquer, I. Petrina, J.M. Cuadra, A.R. Lagunas, design of a special set-up for the IV characterization of bifacial photovoltaic solar cells, EUPVSEC, 2008

# Challenges - Angular Response

**Main contributors for accurate estimation of the energy yield, EY:**

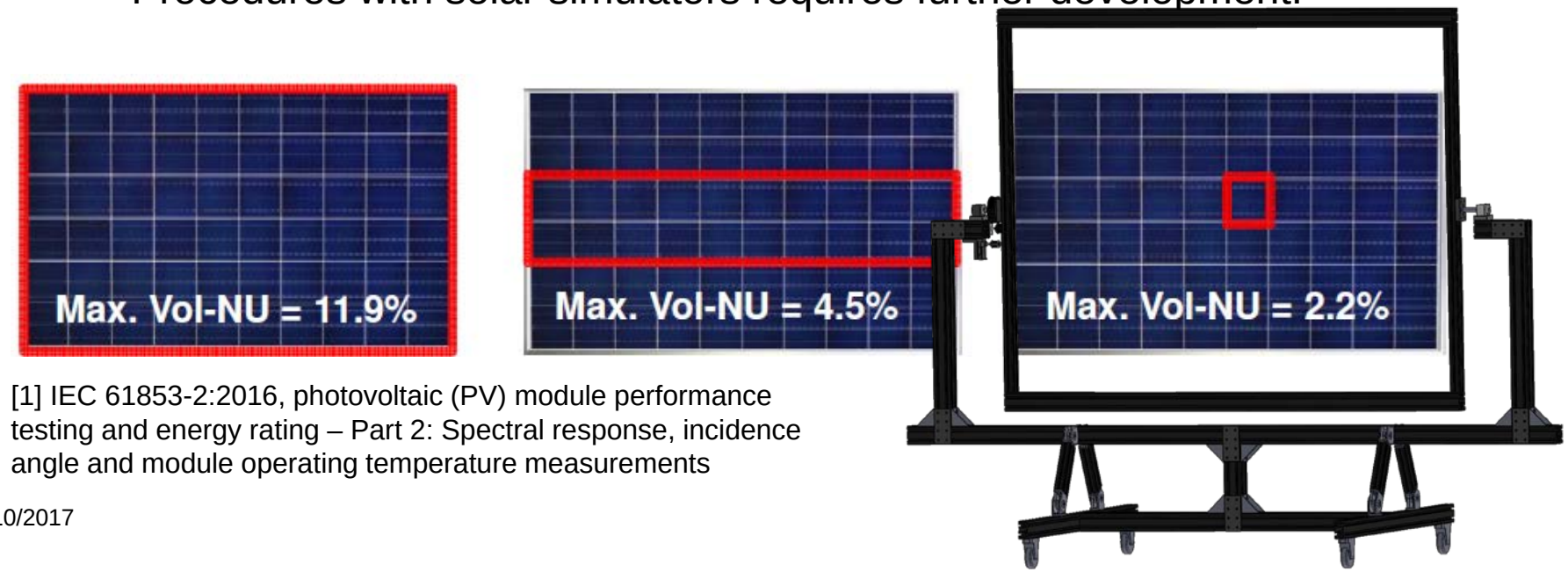
- Performance at standard test condition, STC
- Low irradiance, LI
- Temperature coefficients, TC
- Spectral response, SR
- Angular response, AR



# Challenges - Angular Response

**IEC 61853-2 [1] defines measurement procedures for AR**

- Non-uniform irradiation of the PV module considerably increases if the PV module is rotated: volume non-uniformity, Vol-NU?
- BIPV?
- Procedures with solar simulators requires further development.




[1] IEC 61853-2:2016, photovoltaic (PV) module performance testing and energy rating – Part 2: Spectral response, incidence angle and module operating temperature measurements

# Conclusions

- The measurement uncertainty of the nominal PV power has a relevant financial impact through a complete solar project structure

- Traceable and accurate measurement methods for emerging solar modules and trends are required, including:
  - Bifaciality
  - Angular dependency of modules

- Energy rating methods for bifacial solar modules and BIPV are demanded