# PV performance study
# From SIRTA research platform

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## OBJECTIVES

- To study the performance of PV modules based on the basic PV principles (mainly focus on monocrystalline silicon solar panel in this study)
- To apply quality controls on the measurements to minimize the effects of error sources in measurements (such as temperature fluctuations, distributions of cloud, shadow effects, high solar incidence angle and misalignment of devices)
- To model the PV modules with electrical model for results validation

## In situ devices

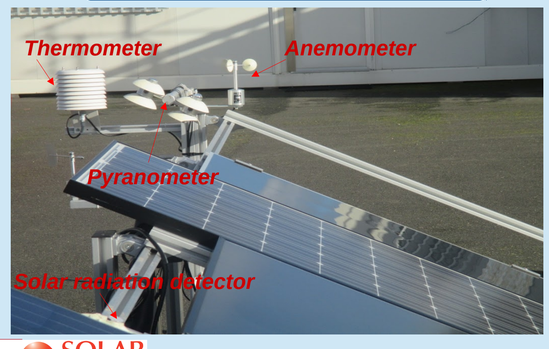
### In situ installed solar panels


Tandem micro-amorphous
Pmax = 128 W
η = 9,5% SHARP
*Thin film technology*

Monocrystalline
Pmax = 250 W
η = 15%
FranceWatts
*The most common technology*

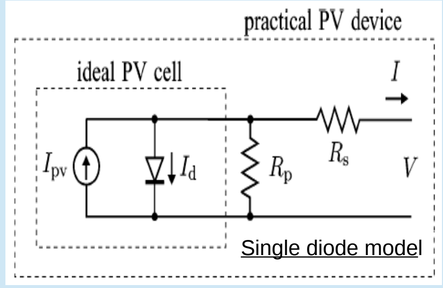
CIS
Pmax = 150 W
η = 12,2%
SOLAR FRONTIER
*Thin film technology*

### Measurements devices




**SIRTA : PV platform**
- **Joint Collaborations with LMD, LIMSI, LPICM and GeePs**
- **This platform was installed since December 2013**
- **All of the panels are oriented south with inclination angle of 27.7° for maximizing in-plane solar irradiance**

## Electrical model




Single diode model

**Equations** *(Villalva, M.G.; Gazoli, JR.; Filho, E.R. 2009)*

$$Illumination\ current\ (I_{pv}) = [I_{sc,STC}(1+\alpha\times\Delta T)]\frac{Irradiance}{Irradiance_{STC}}$$

$$Diode\ Saturation\ Current(I_o) = \frac{I_{sc,STC}(1+\alpha\times\Delta T)}{exp\left[\frac{V_{oc,STC}(1+\beta\times\Delta T)}{nV_t}\right]-1}$$

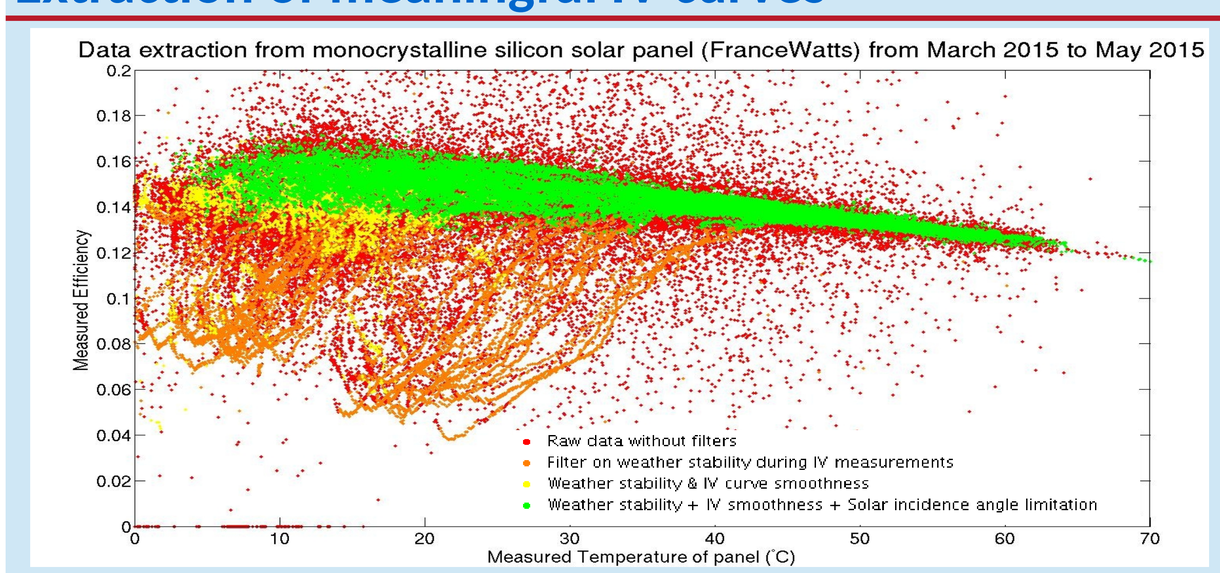
$$Output\ Current(I) = I_{pv} - I_o\left[exp\left(\frac{V+R_sI}{nV_t}\right)-1\right] - \frac{V+R_sI}{R_p}$$

*Reference : Villalva, M.G.; Gazoli, J.R.; Filho, E.R., "Comprehensive Approach to Modeling and Simulation of Photovoltaic Arrays"*

**Single diode model is implemented using Matlab for modelling with the known input values from datasheet provided by manufacturer**

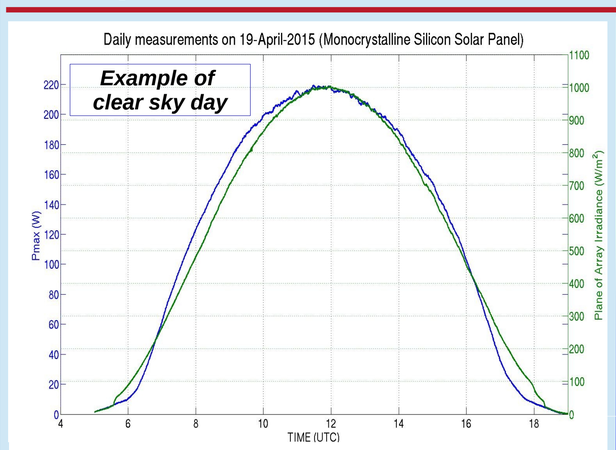
| *Parameters* | *Meanings* | *Values* |
|---|---|---|
| $I_{sc,STC}$ | Short circuit current at STC conditions | 8.64 (A) |
| $V_{oc,STC}$ | Open circuit voltage at STC conditions | 37.67 (V) |
| $V_T$ | Thermal voltage at room temperature | 0.026 (V) |
| α | Temperature coefficient of Isc | 0.02 (%/°C) |
| β | Temperature coefficient of Voc | -0.36 (%/°C) |
| n | Diode ideality factor | 1.2 |
| $R_s$ | Series resistance | 0.36 (ohm) |
| $R_p$ | Parallel resistance | 358.77 (ohm) |

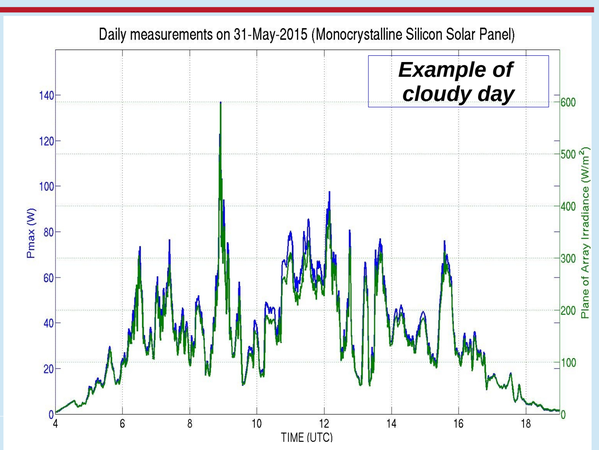
## Extraction of meaningful IV curves

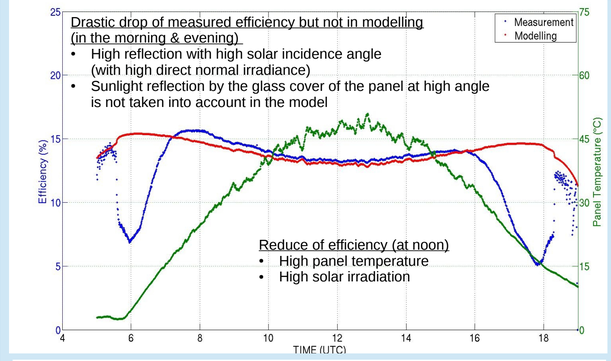


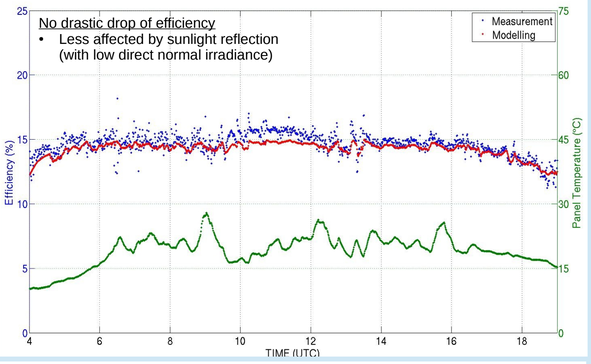

**Quality controls are applied to ease the analysis of PV performance with minimized effects of weather instability, shading of PV panel and high reflection angle.**

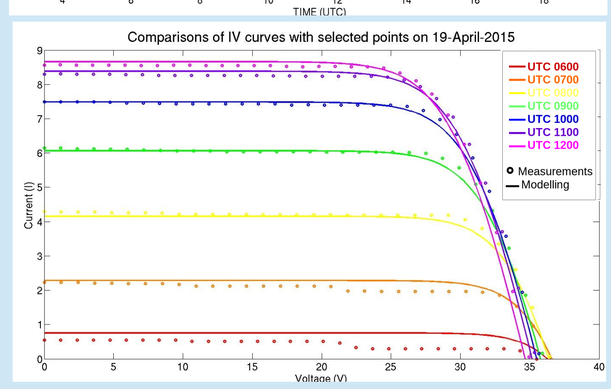
## Daily PV measurements with IV curves

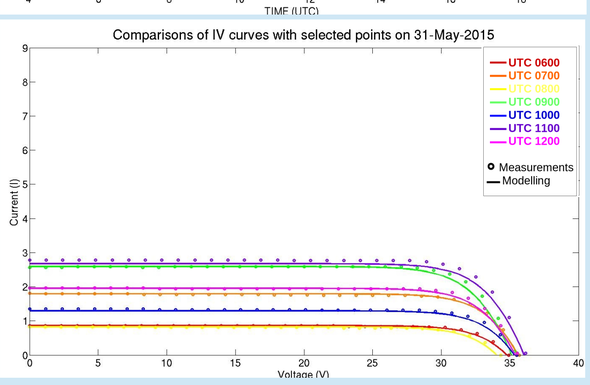


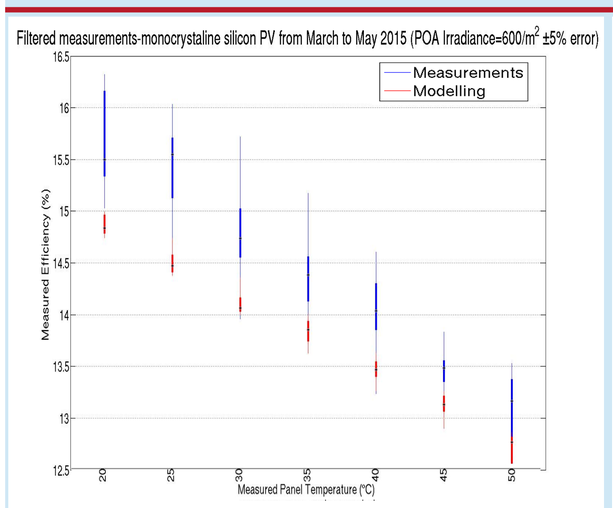



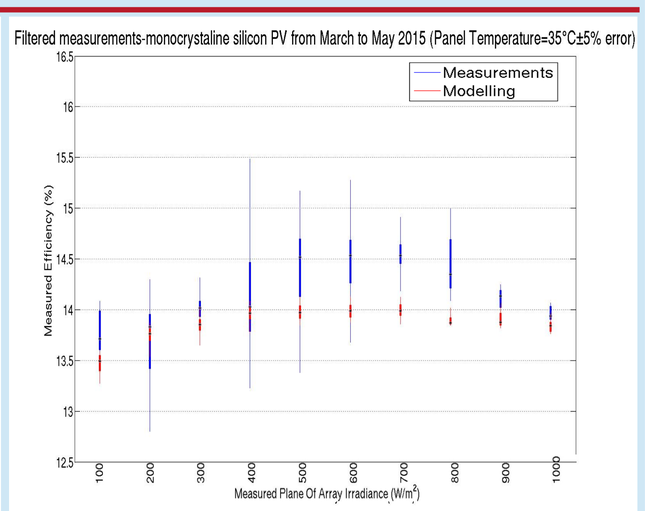




## Impacts of temperature and irradiance

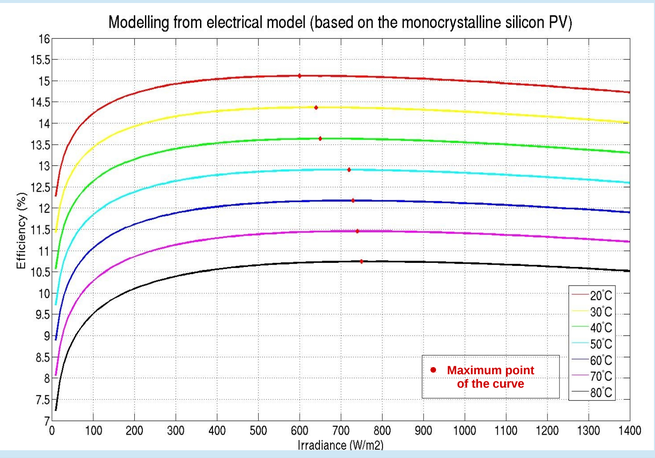



- **Efficiency drops with increasing panel temperature due to the drop of open circuit voltage**

- **Efficiency rises with increasing solar irradiance due to the rise of short circuit current**
- **Efficiency starts reducing with much higher solar irradiance due to the dissipation losses in series resistance**

## Conclusion




- **Performance of monocrystalline silicon PV is evaluated with the help of data filters to minimize the error sources in the measurements**
- **Electrical model is implemented for modelling and it shows the impacts of temperature and irradiance matching with the measurements**
- **Other types of PV panels will be studied for their performances and suitable electrical models will be developed**

## References:

1. Villalva, M.G.; Gazoli, J.R.; Filho, E.R., "Comprehensive Approach to Modeling and Simulation of Photovoltaic Arrays," Power Electronics, IEEE Transactions on , vol.24, no.5, pp.1198,1208, May 2009