ON THE CALCULATION OF THE STC POWER OF PV GENERATORS BY USING TYPICAL MONITORING SYSTEM DATA

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ABSTRACT

- The sizing of photovoltaic (PV) plants has been increasing from the very first systems in the 80's, going from around 100kWp up to several hundreds of MWp at present. Those plants are composed of several PV generators each connected to a PV inverter.
- The properly characterization of the power at Standard Test Conditions (P_{STC}) of those PV generators is becoming increasingly important in order to evaluate the performance and efficiency of the whole PV system.
- **In this poster, an automatically P_{STC} calculation procedure is proposed in order to properly characterize PV generators by using the data provided by a typical monitoring system.**
- This procedure has been validated through 8 PV generators of a large PV power plant (Amareleja, 45MWp).

OBJECTIVES

- The automatic and accurate calculation of the P_{STC} of a PV generator with no need of including additional measuring equipment to a typical monitoring system. **Input data used:**
  - In-plane Irradiance(G_m).
  - Module temperature (T_m)
  - DC Power provided by the PV inverters (P_{DCgen}).

P_{STC} CALCULATION PROCEDURE: Linear regression of the $P_{DCgen25}$ vs G_m

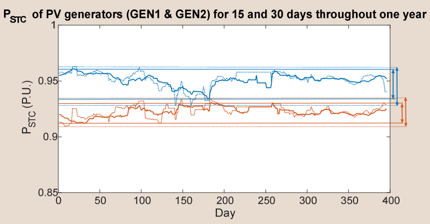
$$P_{DC_{gen25}}[G_m, 25°C] = \frac{P_{DC}}{[1+\gamma(T_m-25)]} * \left[a + b * \frac{G_m}{1000} + c \cdot \ln\left(\frac{G_m}{1000}\right)\right]$$

Requirements of the data

- **Enough accuracy of the PV generator DC power measurement**:
  - Accuracy of the DC power measurements provided by two PV inverters at the Amareleja PV plant (±1.5%):

PV Gen	ERROR				Type of day
	AVG		σ^2		
	[kW]	[%]	[kW]	[%]	
GEN1	-0,23	-0.18	0,39	0.31	Sunny
GEN2	-0,19	-0.15	0,28	0.22	Sun and clouds

- **Data recording frequency needs:**
  - After a carefully analysis:
    - Recording data every **10 minutes** provides similar results than recording data every minute
    - Recording data every hour causes precision loss.
- **Criteria for the data filtering:**
  - Elimination of data when some measurement problem may have occurred .
    - $P_{AC_{gen}}(t) < 0;\ G_m(t) < 3;\ P_{DC_{gen25}}[G_m, 25°C](t) < 10$
  - Only data corresponding to high irradiance values are considered
    - $G_m(t) < 800W/m^2\ y\ G_m(t) > 1050W/m^2$
  - Elimination of data when irradiance varies
    - $\frac{|G_m(t)-G_m(t-1)|}{G_m(t)} 100 > 5;\ \frac{|G_m(t)-G_m(t+1)|}{G_m(t)} 100 > 5$
  - Data are not considered when the PV inverter is limiting AC Power
    - $P_{AC_{gen}}(t) > 0.95 * P_{Lim,gen}(t)$
  - Only data from clear days are considered
    - $G_m(t) < G_{clear_{day_{efec}}}(t) \cdot 0.95$
  - Data is not considered if the difference with the previous regression is higher than 5%
    - $a_{dow\_gen} = (P_{STC\_gen_{yesterday}} * (1-0.05)/1000)$
    - $a_{up\_gen} = (P_{STC\_gen_{yesterday}} * (1+0.05)/1000)$
    - $\frac{P_{DC_{gen25}}}{G_m} > a_{up\_gen}$ ó $\frac{P_{DC_{gen25}}}{G_m} < a_{dow\_gen}$
- **Number of days needed:**
  - 30Days



Procedure Validation

Experimental set up

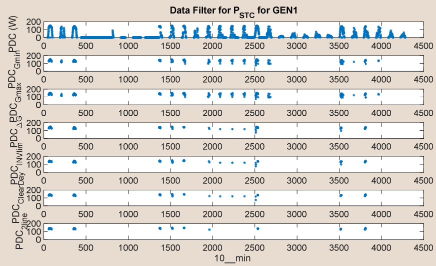
8 PV Generators

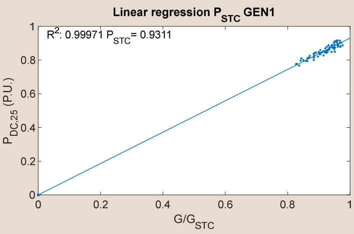
Each one:
- 168 kWp
- 9 Trackers
- 1 Reference module
- 1 PV inverter

Tracker with Reference module

PV inverter

One day calculation

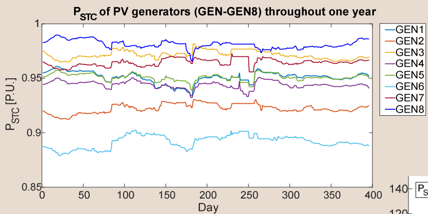




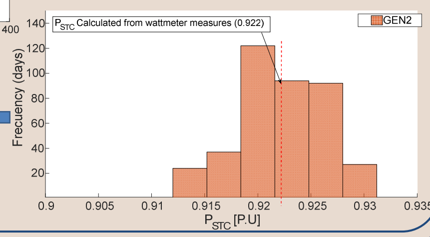
Validation

Statistical results of 8 PV generators P_{SCT} calculations throughout one year

GEN	P_{STC}		GEN	P_{STC}	
	AVG (P.U.)	σ^2 (P.U.)		AVG (P.U)	σ^2 (P.U.)
GEN1	0,970	0,0052	GEN5	0,955	0,0055
GEN2	0,924	0,0081	GEN6	0,893	0,0095
GEN3	0,976	0,0061	GEN7	0,966	0,0049
GEN4	0,951	0,0065	GEN8	0,954	0,0049



UNCERTAINTY ⟶ ±1%



ACCURACY ⟶ ±0,2%

CONCLUSIONS

- The PV inverter measurements could be used to obtain an accuracy P_{STC} measurement of a PV generator
- A procedure based on linear regression has been developed in order to automatically calculate the P_{STC} of a PV generator by using the DC power measurements provided by the PV inverters, the in-plane irradiance and the module temperature registered by reference modules
- The number of days required to obtain an accurate linear regression depends on the climate conditions. At the Amareleja PV plant, 30 days are more than enough
- In this PV plant, the **uncertainty** in the PV generators P_{STC} calculation is around **±1%** and the **accuracy** is roughly **±0.2%**

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