

Evaluation of the Effect of Outdoor Solar Spectrum Variations on the Performance of Different PV Technologies

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Introduction

PV performance and spectral irradiance measurements have been performed at the Utrecht Photovoltaic Outdoor Test facility (UPOT). This facility is located at the Utrecht University Campus in the centre of the Netherlands, and features 23 modules of 6 different PV technologies.

Figures 1 and 2 show irradiance and spectral (Average Photon Energy, APE) characterisation for this location for the measurement period March 2013 - September 2014. The variation in device performance is shown in Figure 3.

The research aimed to evaluate the effect of outdoor solar spectral variation on the performance of 6 PV technologies

Methods

• Comparing the Performance Ratio of the short-circuit current (PR_{Isc}) with APE on different timescales:

- Mean daily values for the whole measurement period
- Instantaneous measurements on clear sky days

• For daily values:

- $PR_{Isc} = (\sum m_{Isc} \cdot \Delta T) / (H_{POA} \cdot 0.001 \text{ m}^2/\text{W} \cdot r_{Isc})$
- Where m_{Isc} is the measured and temperature corrected I_{sc} , ΔT is the measurement interval between concurrent measurements, H_{POA} is the daily plane-of-array insolation and r_{Isc} is the rated I_{sc}
- Measured APE values were weighted by irradiance

• For instantaneous measurements:

- $PR_{Isc} = m_{Isc} / (G_{POA} \cdot 0.001 \text{ m}^2/\text{W} \cdot r_{Isc})$
- G_{POA} is plane-of-array irradiance.
- 7 clear sky days selected manually

• Measurement period: 2013/03 - 2014/09

Results

a-Si modules are affected by variations in APE:

- Daily PR_{Isc} values for a-Si show a similar seasonal variation as daily mean APE values (Figure 4); daily PR_{Isc} increases with increasing APE (Figure 5)
- Instantaneous measurements on clear sky days also show the PR_{Isc} of a-Si modules to increase with increasing APE (Figure 7 and 8).

Results for other PV technologies are less consistent:

- Correlation of daily PR_{Isc} with daily mean APE does not result in clear trends (Figure 6) and seasonal variation of daily PR_{Isc} does not coincide with APE variations (Figure 4).
- Instantaneous measurements on clear sky days do however show a limited correlation for CdTe devices (Figure 7 and 8).

PR_{Isc} is likely affected by other parameters than just APE:

- Measurements from different clear sky days can show large discrepancies
- Large differences were observed between pre- and post-noon trends on clear sky days

