



🔹 🔹 mono–Si

1.88 1.90

1.86

APE (eV)

нт

# **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<sub>Isc</sub>) with APE on different timescales:
  - Mean daily values for the whole measurement period
  - · Instantanous measurements on clear sky days
- · For daily values:
  - $PR_{Isc} = (\sum m I_{sc} * \Delta T) / (H * 0.001 * r I_{SC})$
- Where  $ml_{sc}$  is the measured and temperature corrected  $l_{sc}, \Delta T$  is the measurement interval between concurrent measurements,  ${\it H}$  is the daily insolation and  $rl_{sc}$  is the rated  $l_{sc}$
- · Measured APE values were weighted by irradiance
- For instantaneous measurements:
  - PR<sub>Isc</sub> = mI<sub>sc</sub>/(G \* 0.001 \* rI<sub>SC</sub>)
  - G is in-plane 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<sub>Isc</sub> 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<sub>Isc</sub> with daily mean APE does not result in clear trends (Figure 6) and seasonal variation of daily PR<sub>Isc</sub> 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<sub>Isc</sub> 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 postnoon trends on clear sky days



mon

нп

1.84 1.86 1.88 1.90

APE (eV)

0.7

1.78 1.80 1.82 1.84

0.7

1.76 1.78