NORDIC IRRADIANCE CONDITIONS AND THE EFFECTS ON SOLAR MODULE EFFICIENCY

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Introduction

The high latitudes of the Nordic countries significantly affect both the intensity and the spectral distribution of the solar irradiation. Furthermore, it is well known that variations in the light intensity and solar spectrum give rise to technology dependent changes in the solar cell efficiency. This work aims to study the insolation conditions in the eastern and southern part of Norway and the resulting quantitative effects on two different solar cell technologies, p-Si and CIS.

Spectral irradiance distribution

In this work measurements of spectral irradiance has been performed using a spectroradiometer at two locations, Kjeller and Grimstad.

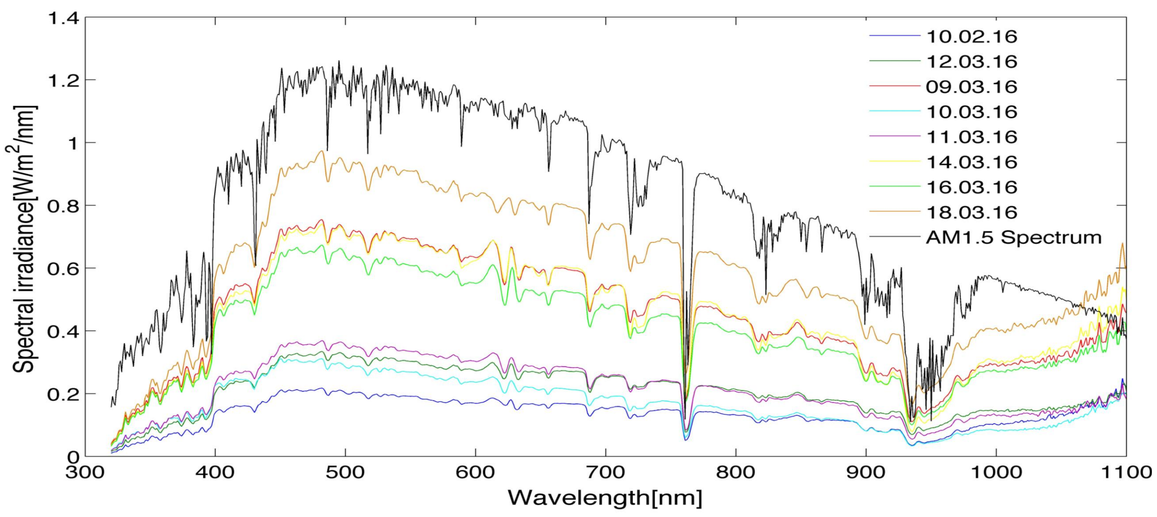

Figure 1: Measured solar spectra at Kjeller and in Grimstad vs the AM 1.5 solar spectrum. The solar spectra presented are the ones with the highest spectral irradiance from each sequence.

Figure 2: The daily variation in spectral factor (SF) for every measurement sequence. The spectral factor indicates the performance of the considered solar module under the actual spectrum relative to the performance under the standard 1.5 AM spectrum. The presented SF values are average values of calculated spectral factors based on each measurement conducted during each hour.

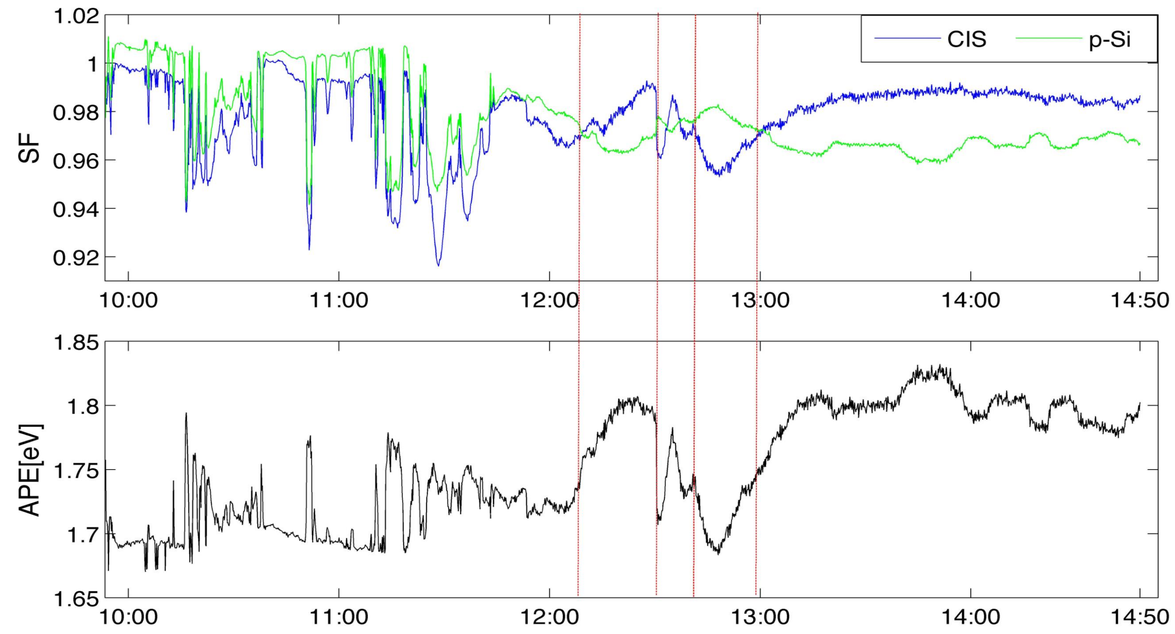

Figure 3: The combined figures show the correlation between average photon energy **(**APE, **bottom)** and spectral factor **(SF, top)** of both modules, and how it varies during the day. The calculated values are based on 1769 measurements performed on the 18.03.16 at Kjeller. The red lines indicate some of the regions when the spectral factor of the two different modules deviates.

Irradiance levels

Global horizontal irradiance data obtained from the measurement station at Ås (NMBU) in the period 2011-2015 was used to study the relative energy contribution at different intensity levels.

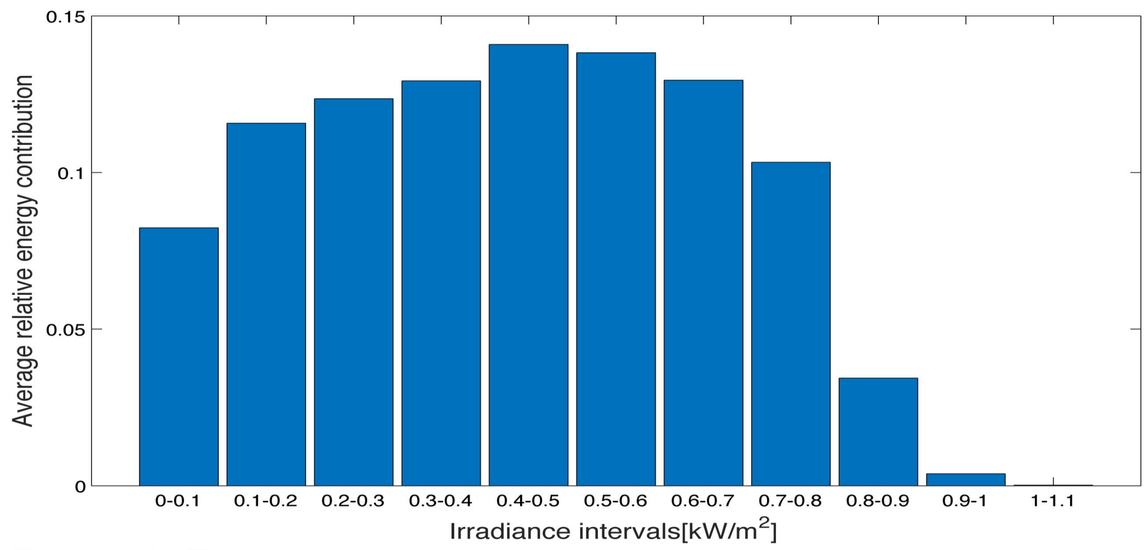

Figure 4: The average relative energy contribution with respect to irradiance levels. The highest relative energy contribution is achieved at light intensities ranging between 400-500 W/m^2, contributing with 14 % of the average energy received during a year on a horizontal surface.

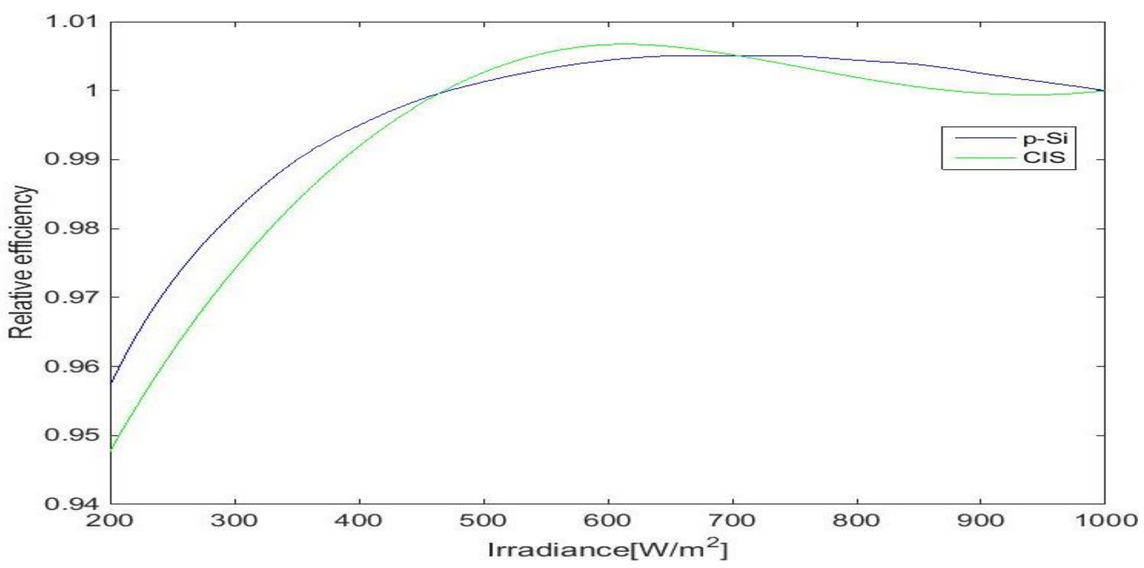

Figure 5: Relative efficiency with respect to irradiance levels, for both the CIS- and p-Si module. The average efficiencies of the CIS- and p-Si modules at light intensities 400-500 W/m^2 are 13.37 % and 15.88 %, respectively. The p-Si module is produced by IBC SOLAR and has a STC efficiency of 15.9 %. The CIS module is produced by Solar Frontier and has a STC efficiency of 13.4 %.

Conclusion

- The relative energy contribution is homogeneously distributed at low and medium intensities, but is drastically decreased after 800 W/m^2.
- Compared to the CIS module, the p-Si module maintains a higher efficiency at light intensities that contribute with the largest portion of the yearly irradiation.
- The overall low average photon energy, calculated for each measurement conducted between February and March, indicates red rich spectra.
- The p-Si module performs better in red rich spectra compared to the CIS module which appears to perform better in blue rich spectra.