32nd European Photovoltaic Solar Energy Conference and Exhibition - Munich, Germany, 20-24 June 2016
TOPIC 5: Operation, Performance, Reliability and Sustainability of Photovoltaics - 5.2 Operation of PV Systems

EVALUATION OF SOILING DURING A 2-MONTHS DROUGHT AND CONTRUCTION WORKS NEAR A PV TEST FACILITY IN NORTH-EAST OF ITALY

G. Belluardo[1*], P. Ingenhoven[1], D. Moser[1]
[1]Institute for Renewable Energy, EURAC Research, Viale Druso 1, 39100 Bolzano (BZ), Italy
[*]Phone: +39 0471 055626; Fax: +39 0471 055699; E-mail: giorgio.belluardo@eurac.edu

SUMMARY

The accumulation of dust on PV modules surface results in a loss of performance. PV plants installed in areas prone to pollution, or to the presence of sand or sea salt in the atmosphere are more affected by soiling. The process is also favored by the scarcity of rainfalls. The South Tyrol region (North-East of Italy) is not particularly affected by this process. However, in the last two months of 2015 a dry period with no rainfalls was registered in the area. This coincided with construction works on the extension of the runways at Airport Bolzano Dolomiti, where a multi-technology PV test facility composed of 24 different types of PV modules and mounting systems is installed.
This paper calculates the performance losses of the different PV technologies installed and carry out comparisons.

PURPOSE OF THE WORK AND APPROACH

This study aims at detecting and quantifying the loss of performance, expressed as daily percentage, occurred on different PV arrays between the end of October 2015 and the beginning of January 2016, when no rainfall was registered and construction works were carried out in their proximity, with a consequent presence of dust in the air. DC-current values were measured by the inverters with 15-minutes frequency. These were corrected for temperature and filtered in order to exclude shading events. The performance loss rate due to material degradation is also taken into account. Daily values of Performance Ratio (PR) are calculated and linearly regressed during the dry period in order to assess the loss of performance.

SCIENTIFIC INNOVATION AND RELEVANCE

The relevance of this study is the assessment and comparison of performance loss due to soiling occurring on modules characterized by different material, glass (e.g. smooth versus textured), design (e.g. without or with frame that could cause accumulation of dust in some parts) and mounting system (e.g. fixed tilt vs. solar tracking systems).

PRELIMINARY RESULTS AND CONCLUSIONS

Preliminary results show that the quantification of performance loss due to soiling is detectable and quantifiable from operation data. Daily losses for one monocrystalline-silicon and one Cadmium Telluride PV array are respectively -0.02% and -0.08%, which correspond to -1.15% and -4.88% on the 64-days long dry period. The final paper will determine soiling losses of more technologies, and a comparison will be carried out in order to detect differences between design solutions, glass types and mounting systems.

EXPLANATORY PAGES

From 25th August to 30th November 2015 construction works were carried out at the Airport Bolzano Dolomiti (South Tyrol, North-East of Italy) that released dust in the air. The PV test facility installed in August 2010 [1] and monitored by EURAC is just few meters away and was subjected to the deposition of dust. During the period between 30th October 2015 and 3rd January 2016 no rainfall was registered in the area, thus the effect of soiling on PV modules increased. The purpose of the work is to quantify the performance losses on several PV systems occurred during the 2-months drought. These systems differ from material technology, glass type, design and mounting system.

DC-power and DC-current are registered on a 15-minutes basis by commercial inverters. Irradiance on the plane-of-array and back-of-module temperature is registered by a weather station every minute and averaged on a 15-minutes basis. The weather sensors were regularly cleaned during the entire period in order to keep them free from dust accumulation. Daily cumulated precipitation is retrieved from the Meteorological Service of the Autonomous Province of Bolzano, and measured by the station of Bolzano hospital, a few kilometers far away from the PV installation.

The metric used for the study is the Performance Ratio calculated on DC-current on a daily base:

$$PR_{Impp} = \frac{\sum I_{dc}(i)}{\sum G(i)} \frac{G_{STC}}{I_{STC}} \tag{1}$$

where I_{dc} is the DC-current of the PV system at time i, G is the irradiance measured in the plane of the modules at time i, while G_{STC} and I_{STC} are the irradiance and the PV system current under standard test conditions (STC) , respectively. PR_{Impp} differs from the Performance Ratio PR defined by IEC Standards [2] for the use of current in place of power. This choice is motivated by the fact that DC-current is less affected by temperature than DC-power, and therefore the seasonality of PR_{Impp} is lower than simply using PR. However, a temperature correction is performed on PR_{Impp} in order to eliminate any temperature effect that might mix-up with the effect of soiling:

$$PR_{Impp\_corrected} = PR_{Impp} \frac{1}{1+\alpha(T_{cell}-T_{STC})} \tag{2}$$

where α is the temperature coefficient in maximum power point current (%/°C), given by the manufacturer, T_{cell} is the cell temperature, considered in a first approximation equal to the back-of-module temperature, and T_{STC} is the module temperature at STC. In the study, we will always use the term PR_{Impp} in the meaning of temperature-corrected PR metric.

A linear regression of daily values of PR_{Impp} is then performed in order to calculate the daily losses ascribable to soiling. The latter is then decreased in order to take the gradual performance loss of modules, calculated in a previous work [3], into account.

Before applying Equation 1 and 2, 15-minutes based values of DC-current are filtered in order to consider only values between 11AM and 1PM and G > 500W/m^2. This way possible shading from close obstacles, more pronounced around winter solstice, is filtered out and days with heavy cloud couverture are excluded.

Figure 1 shows pictures of two of the twenty-four PV arrays of the PV test facility considered in this abstract taken during the dry period: one monocrystalline-Silicon based (mc-Si) and one Cadmium Telluride based (CdTe).
The daily values of PR_{Impp} for the two considered PV arrays is shown in Figure 2, together with the cumulated daily precipitations. Data series starts on the 1st of July and ends on 31st January. Values related to the period before, during and after the dry period are plotted in green, red and blue, respectively. A linear regression of the dry period values is also reported that shows a decreasing trend more accentuated than the

preceding period. Daily losses result in -0.02% for mc-Si and -0.08% for CdTe. During the 64-days drought, this corresponds to -1.15% losses for mc-Si and -4.88% losses for CdTe.

In the final paper results concerning more technologies will be presented. Comparisons will be carried out on the basis of the different design type (e.g. modules without or with frame that could cause accumulation of dust in some parts), glass type (e.g. smooth versus textured front glass), and mounting system (e.g. modules installed on a fixed rack vs. modules on solar tracking systems).

Figure 1: Two of the twenty-four technologies considered in this abstract, visibly affected by soiling.

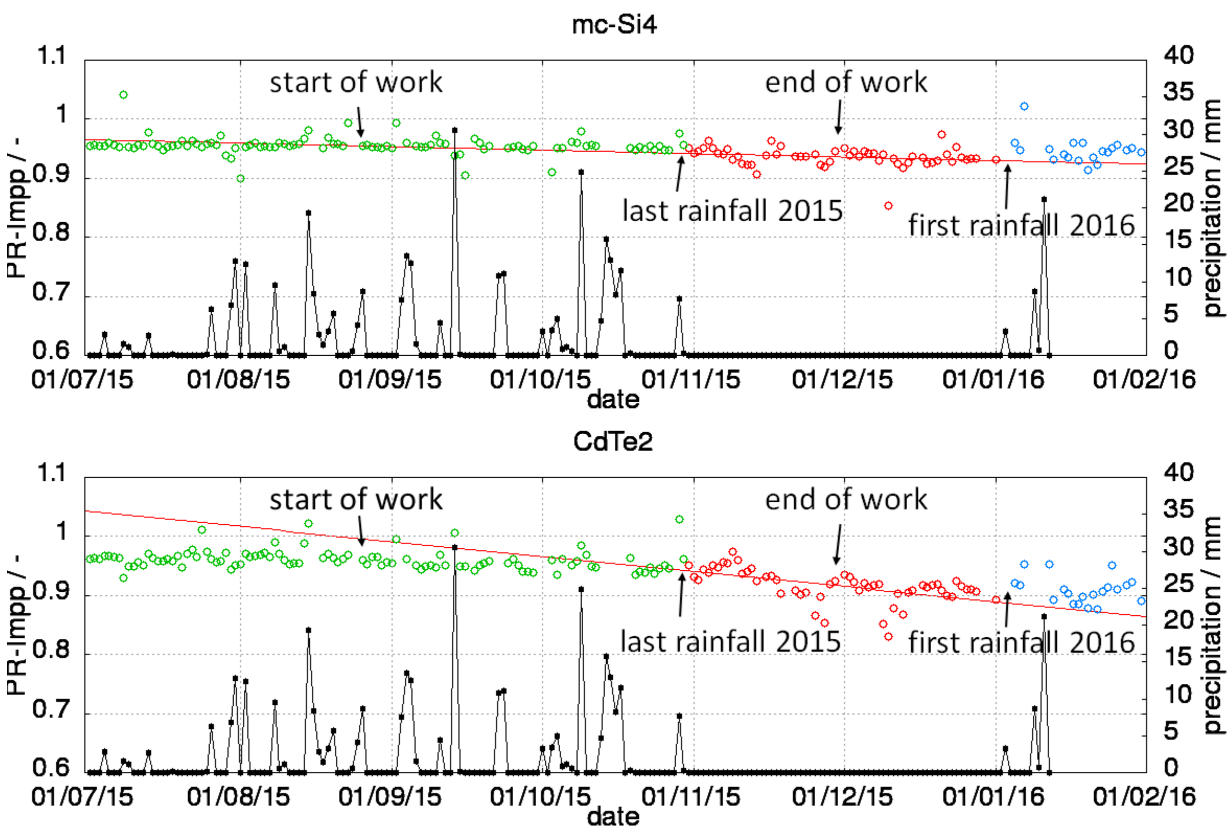

Figure 2: Daily values of PR_{Impp} and cumulated daily precipitation from 1st July 2015 to 31st January 2016. Construction work period and dry period are indicated. Green, red and blue points correspond to the period before, during and after the dry period, respectively. Regression line is displayed only for the dry period.

Keywords: soiling, dust, PV performance.

REFERENCES

[1] Belluardo, G., Ingenhoven, P., Moser, D., 2013. Medium-term degradation of different photovoltaic technologies under outdoor conditions in alpine area. Proc. 28th EU PVSEC, 4318 - 4321.

[2] IEC61724:1998, 1998. Photovoltaic System Performance Monitoring Guidelines for Measurement, Data Exchange, and Analysis.

[3] Belluardo, G., Ingenhoven, P., Sparber, W., Wagner, J., Weihs, P., Moser, D., 2015. Novel method for the improvement in the evaluation of outdoor performance loss rate in different PV technologies and comparison with two other methods. Sol. Energy 117, 139-152.