Impact of Soiling on Transparency of Different Glass Types: A Comparative Study

22nd Swiss Photovoltaics Conference, 21 - 22 March 2024, Lausanne

Donat Hess, Christof Bucher, Matthias Burri, Sina Spring, Laboratory for Photovoltaic Systems, Bern University of Applied Sciences, Switzerland

To improve the optical properties of photovoltaic (PV) modules, many manufacturers use new glass surface structures that reduce glare. However, these modifications can increase susceptibility to soiling. This research presents a new method for assessing soiling by positioning glasses without solar cells on a reference PV module. The preliminary results are presented together with the soiling data after two months at a selected site.

Introduction

In recent years, a steadily growing number of pollution studies on PV systems has been published. The results differ considerably, which can be attributed to location-specific factors.

This study presents a measurement method that can be used to examine the influence of tilt angle and glass surface on contamination [1].

Objective

The results of the study are intended to help understand the soiling tendencies of BIPV glasses. Two goals are set in the study:

1. A measurement procedure is to be developed, set up and tested, with which the soiling of different types of glass can be tested under various conditions.
2. The first results shall quantify how much the tilt angle and the glass surface of a PV module influences the soiling.

Table 1: Glass types used to demonstrate the soiling measurement method

Glass type	Description
Standard Solar Glass (SSG)	Used as reference.
Float Glass (FG)	"Window glass", flat
Satinated Glass (SatG)	Chemically etched
Sandblasted Glass (SB)	Sandblasted using 1) glass pearls and 2) Korund Biloxit
Coated Glass (CG)	Not yet part of the study

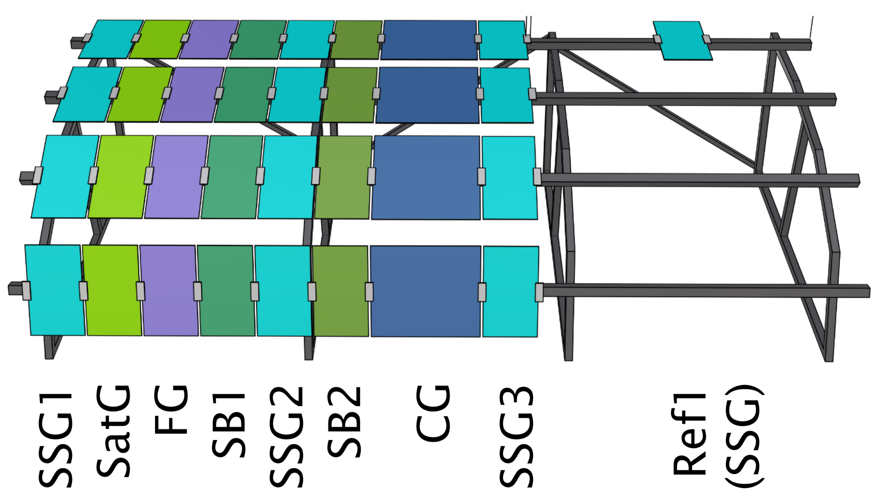

Figure 1: Test bench for the soiling study

Figure 2: First prototype of the soiling test bench

Measurement Concept

In order to achieve accurate transmission measurements despite the inaccurate outdoor measurement method [2], relative measurements are made. The transmission of a cleaned reference glass is compared with the transmission of a glass sample. The deviation in the measured value corresponds to the transmission loss. A mini PV module at maximum power point (MPP) operation is used as the sensor for irradiance measurements.

Measurement Procedure

To determine the transmission of a given glass sample S1 relative to the transmission of a reference glass Ref1, the following initial measurements are carried out:

- the power $P_{Ref1}(t-1)$ of the mini-module covered with the reference glass Ref1 is measured.
- The power $P_{S1}(t)$ of the mini-module covered with sample S1 is measured.
- The power $P_{Ref1}(t+1)$ of the mini-module covered with the reference glass Ref1 is measured again.

t is the time step or the number of measurements.

Subsequently, the weighted mean value of the reference measurement is determined in order to compensate for any changes in irradiation during the measurements:

$$P_{Ref1}(t) = \left(\frac{1}{\Delta t_1} P_{Ref1}(t-1) + \frac{1}{\Delta t_2} P_{Ref1}(t+1)\right) \cdot \frac{1}{\frac{1}{\Delta t_1}+\frac{1}{\Delta t_2}}$$

Transmission is then calculated as:

$$T_{S1}(t) = P_{S1}(t) / P_{Ref1}(t)$$

And soiling as:

$$S_{S1} = 1 - T_{S1,soiled}/T_{S1,initial}$$

Measurement Uncertainty

A key task in this study is the quantification of measurement accuracy. Since the measurements are taken outdoors, the results depend heavily on the weather conditions. The measurement accuracy is estimated as follows:

1. Measurements are taken as described above.
2. Only around 30 reference measurements are taken into account. These are all made with the same reference glass Ref1.
3. For each measurement, the measurement value is divided by the average of the previous and subsequent measurements. If all measurements were identical, the value 1 would result for each measurement.
4. The calculated values from 3 are compared with a normal distribution in a QQ plot.
5. The measurement accuracy is estimated with 2 sigma of this distribution.

The measurement uncertainties found are:

- 2σ = 0.54 % for initial measurements
- 2σ = 1.73 % for soiling measurements

The measurement uncertainty cannot be explained by the soiling measurements, but only by the weather conditions present at the soiling measurements.

Results and Conclusion

The first measurements of glass transmission and the first soiling losses are shown in the following figures and tables. The exposure time of the glass samples on an agricultural site is approximately two months. The measurement accuracy enables the identification of pollution trends, but for several measurements there remains a greater uncertainty than the pollution effect.

Table 2: Transmission of the clean glasses (measured values. Measurement uncertainty 0.54%).

Glass type	Transmission
SSG (Reference)	1.00 ± 0.005
Sat3	0.98 ± 0.007
FG	0.95 ± 0.008
SB1	0.88 ± 0.014
SB2	0.85 ± 0.024

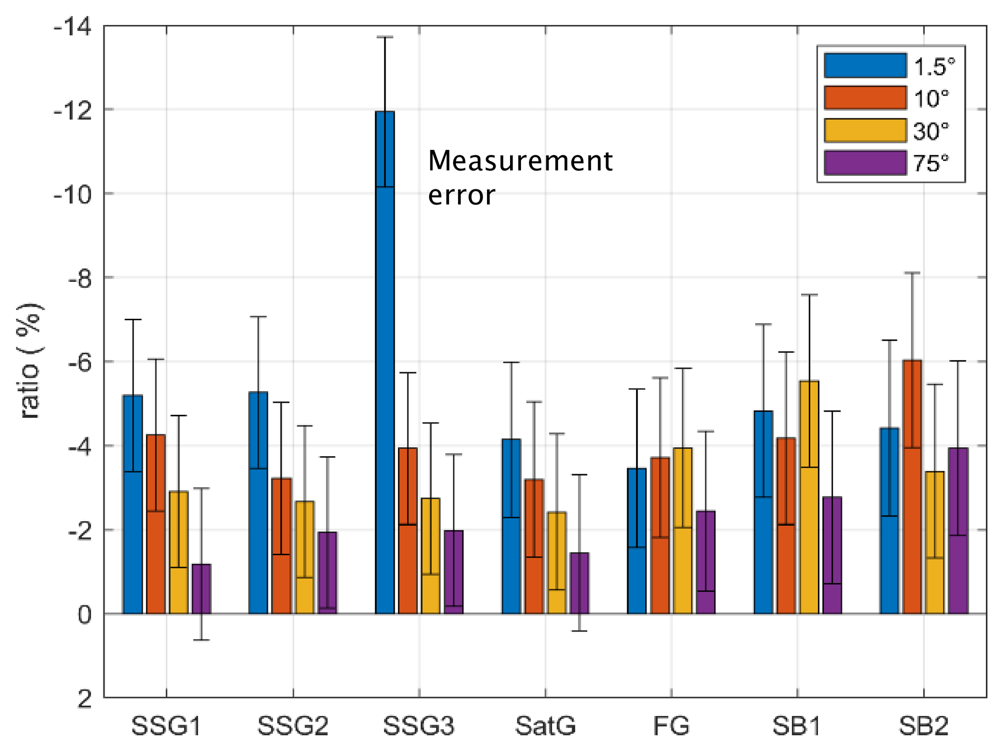

Figure 3: Transmission loss after the exposure time in Hindelbank. The 1.5° value of SSG3 is an outlier which cannot be explained physically (measurement error)

Table 3: Transmission loss after the exposure time in Hindelbank

Glass type	Mean transmission loss (%)
SSG	3.37 ± 0.55 (without SSG3, 1.5°)
SatG	2.80 ± 0.93
FG	3.39 ± 0.95
SB1	4.33 ±1.02
SB2	4.44 ± 1.04

Reference

[1] S. El Hassani et al., Impact of Soiling on Transparency of Different Glass Types: A Comparative Study, EUPVSEC, Lissabon, 2023
[2] Kipp & Zonen, Pyranometers v. Reference Cells for PV Installations, solar and direct solar radiation, https://www.kippzonen.de/, downloaded September 2023

Berner Fachhochschule
Haute école spécialisée bernoise
Bern University of Applied Sciences

- Departement Technik und Informatik (TI)
- Institut für Energie- und Mobilitätsforschung (IEM)

Labor für Photovoltaiksysteme | Jlcoweg 1 | 3400 Burgdorf | Schweiz
www.bfh.ch/pvlab | christof.bucher@bfh.ch