LONG-TERM SOILING IN A MODERATE SUBTROPICAL CLIMATE

Tony Sample*, Juan Lopez-Garcia and Alberto Pozza

European Commission, Joint Research Centre, Institute for Energy and Transport, Renewables and Energy Efficiency Unit, Via E. Fermi 2749, TP-450, I-21027 Ispra (VA), Italy.

Introduction

This poster outlines the results of 28 silicon-based PV modules which were installed from 1981 to 1985 in a open rack configuration in the outdoor test facility of the ESTI laboratory. The system was composed of modules produced by a single manufacturer, but they were manufactured at different times and as such incorporate different materials [e.g. modules using plain glass (6) or surface textured glass (22)]. Each module was composed of two series-connected laminates mounted in a single frame. The modules were dismantled in 2014 and different characterizations were performed prior to cleaning the surface of the modules to assess the extent of long-term soiling. Different cleaning methods were investigated from manual cleaning to the use of high pressure water washing.

Module characteristics

Original ESTI code	Module Type	N° modules exposed	Superstrate	Encapsulant	Substrate	N° cells	Cell type	Cell layout
BBxx	A	6	Flat glass	Silicone	White silicone	68	Ø 10cm mono-Si	
SOxx	B	7	Textured glass	Silicone	White silicone	68	Ø 10cm mono-Si	
COxx	C	7	Textured glass	Silicone	White silicone	72	Ø 10cm mono-Si	
BOxx	D	8	Textured glass	Silicone	White silicone	72	Ø 10cm mono-Si	

Table I Main characteristics of the modules.

The array is composed of a set of 28 crystalline silicon wafer based photovoltaic modules which were subjected to long-term continuous outdoor exposure for more than 30 years without cleaning.

The climatic conditions of Ispra (located in northern Italy) at 220 m above sea level, where the weathering was executed, are considered to be a moderate subtropical climate (-10 ºC to +35 ºC, with less than 90% RH).

The modules main design details are listed in Table I; four types are represented. Fig. 1 shows the typical soiling distribution on the modules and the view of the complete array before removal from the rack.

Fig. 1 (above) Single Si module, detail of the soiling between laminates and view of the complete array (bottom).

Cleaning setup

IV curves of the modules were measured before cleaning (at the end of 2014), after a manual cleaning with standard detergent for glass using a cloth or a soft sponge, and after an additional cleaning using a high pressure water machine for 3 minutes at a distance of 30cm.

Electrical performance

IV characteristics were obtained using a PASAN IIIB solar simulator at 1000 W/m^2 and 25.0±0.1 ºC.

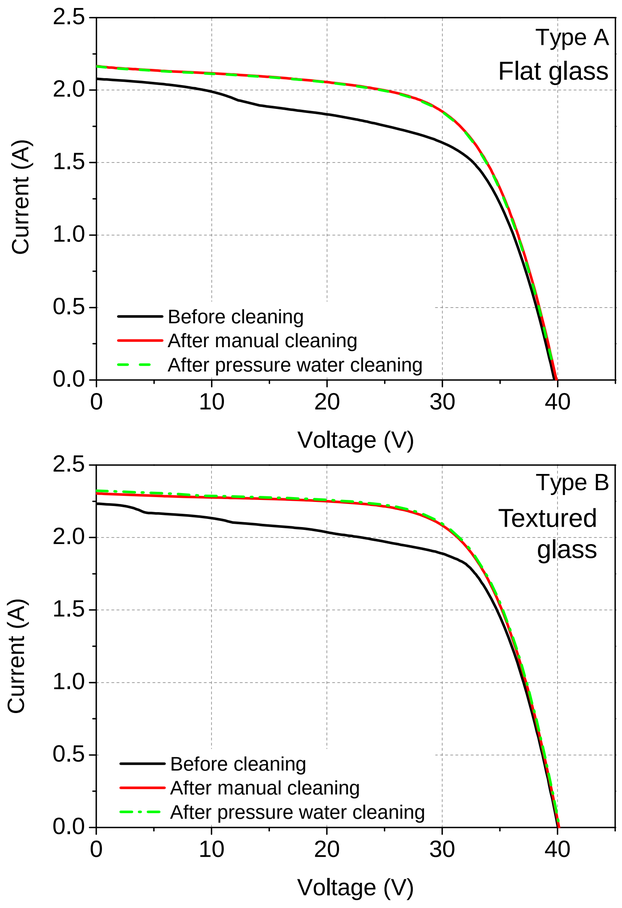

Fig. 2 IV curves of soiled modules of type A and B, cleaned manually, and with an additional pressure water procedure.

The effect of cleaning procedure on glass type

- Manual cleaning is effective on all the modules.
- Additional high pressure water spraying gives no additional improvement to plain glass modules.
- Textured glass modules show a further small improvement using a high pressure water spray, following manual cleaning.

Results by module type

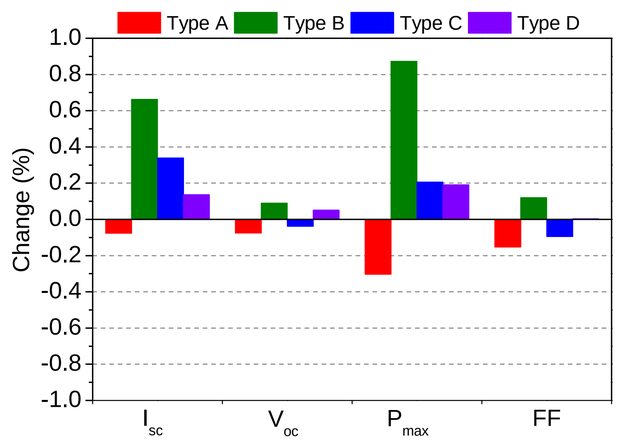

Fig. 3 Average change in % of representative modules of each type measured after additional cleaning with high pressure water, in comparison to manual cleaning.

A batch of 14 representative modules were cleaned manually and with a pressure washer. As shown in fig. 3 there are very small differences between manual cleaning and the additional cleaning with high pressure water. As such, the whole set of modules were measured after both cleaning processes.

- The slight increase in the P_{max} (~0.9%) of type B modules after the additional cleaning with high pressure water is mostly due to an increase of the I_{sc} (fig. 3).

The average increase in P_{max} after both cleaning procedures, compared to the soiled modules, is greatest for type A (11,5%). However, the variation in the extent of soiling for the textured glass modules is much higher (Fig. 4).

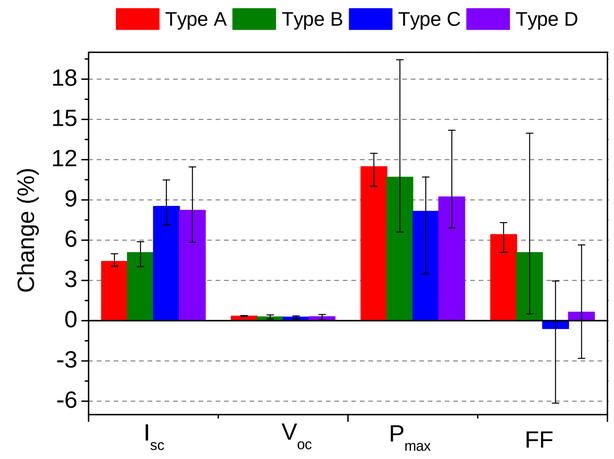

Fig. 4 Average change (%) of modules parameters following both manual cleaning and high pressure water, compared to the initial soiled modules (black bars indicate the max. and min. values)

Overall Results

	I_{sc}	V_{oc}	P_{max}	FF
Average Δ (%)	6,68	0,30	9,80	2,67
St dev (%)	2,17	0,09	3,03	4,05

Table II Average change in % of modules parameters of the whole array.

The average change values of the whole set are listed in table II. P_{max} increases 9,8 % and the I_{sc} 6,7 %. However, only a small average change between the different cleaning procedures is observed (within the measurement uncertainty band).

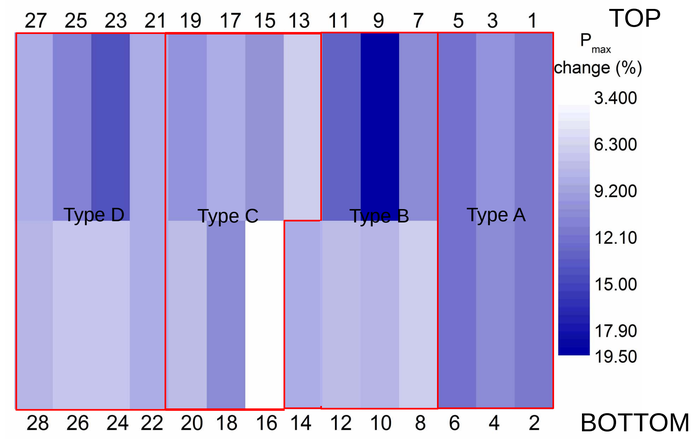

Fig. 5 Average change (%) distribution of the whole array in the same position than in the field (viewed from the front).

Conclusions

- ✓ More uniform soiling behaviour was observed for the flat glass modules, those with textured glass exhibited a greater variation in soiling.
- ✓ Manual cleaning was effective at improving the output of all the module types.
- ✓ Additional high pressure water spraying on plain glass modules showed no further improvement, but showed small improvements on the textured glass modules.
- ✓ Overall improvements in P_{max} after cleaning ranged from 3.5% to 19.4%, with an average value of 9.8%

www.jrc.ec.europa.eu

Joint Research Centre

*Tel: +39 0332789062, Fax: +39 0332789268, e-mail: tony.sample@jrc.ec.europa.eu