Performance maintenance of large PV installations

14. Nationale Photovoltaik-Tagung, 22. - 23. Februar 2016, Bern

Manuel Lanz, Prof. Urs Muntwyler

Partners:
Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra
Bundesamt für Energie (BFE)
SCCER – FURIES
Shaping the FUtuRe SwIss Electrical InfraStructure

PV LAB

Monitoring of large PV installations can be very labour intensive. A thermal imaging drone system can significantly increase the monitoring efficiency.
A new system and unmanned aerial drone vehicle, developed and built at the Photovoltaic Laboratory (PV LAB) of Bern University of Applied Sciences BFH, provides evidence for efficiency advantages in the search for soiling effects on large PV installations.

Unmanned aerial vehicle UAV

The PV LAB drone system carries both (i) an infrared camera that records a thermal imaging video and (ii) a digital camera for comparison shots. Using this combination, PV module surfaces can quickly be monitored and defects easily determined and located. Fig. 1 shows the UAV ready to take-off.

Fig. 1: PV LAB IR-multicopter drone; the take-off weight is about 7.5 kg.

Quality control of PV installations

Screening of PV installations in the monitoring network operated by the PV LAB at BFH shows that the UAV is able to detect power losses of about 5 Wp.
Fig. 2 displays a IR video capture and a close-up thermal image of a defective Siemens M55 module.

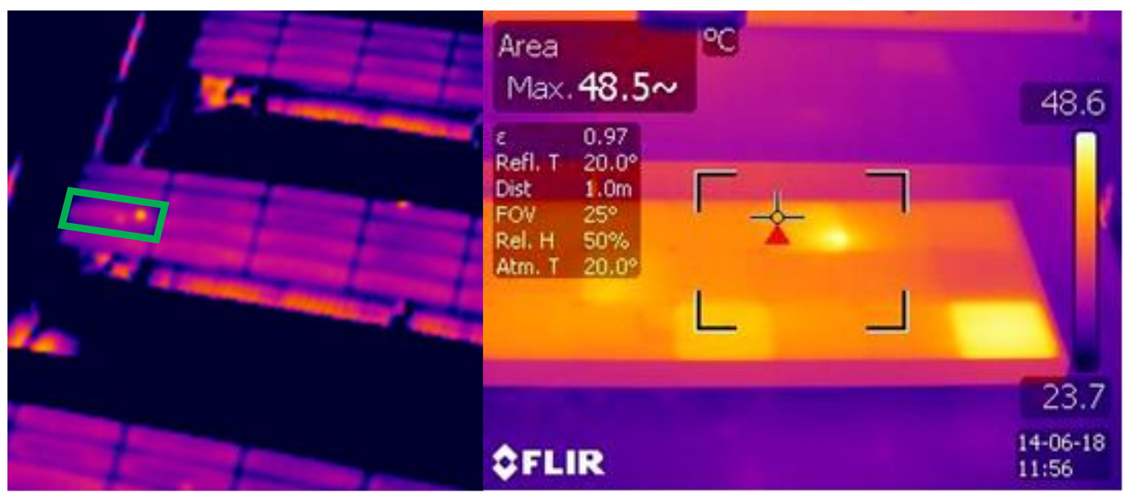

Fig 2: IR video capture, magnified (left) and close-up of marked module (right).

Fig. 3 illustrates the power loss (of about 20%) of the module in Fig. 2.

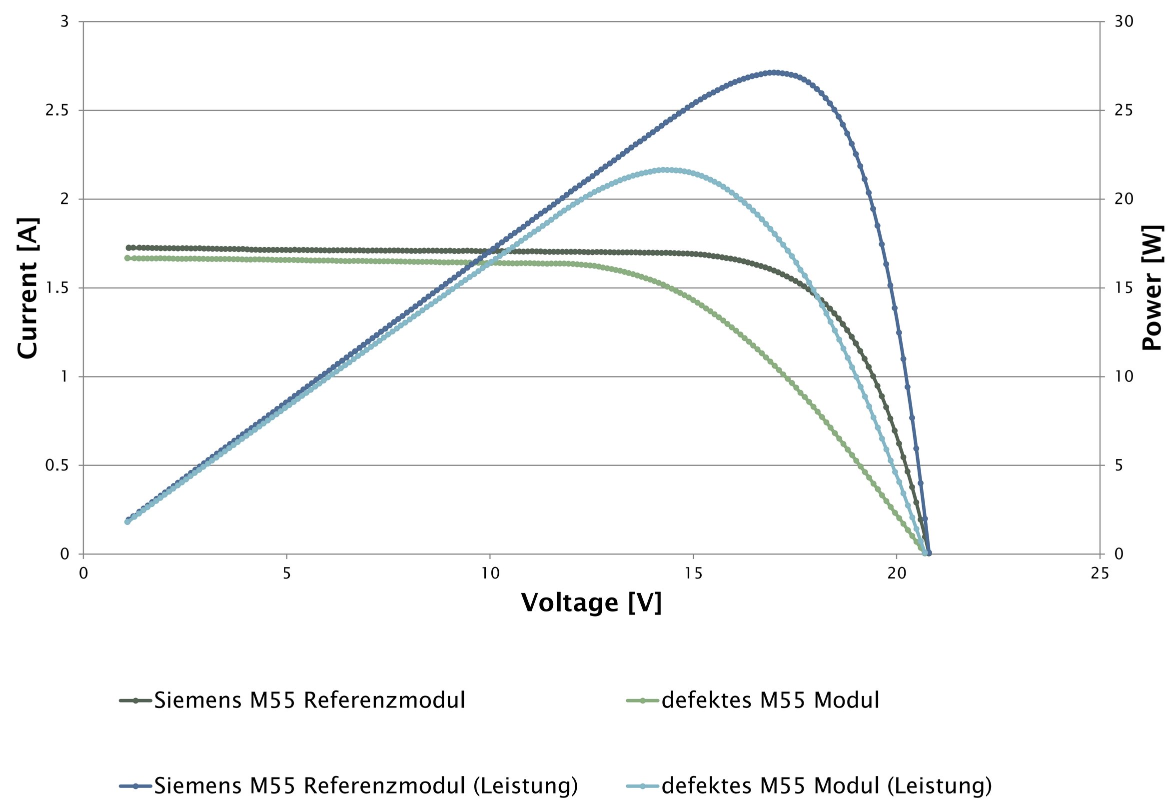

Fig. 3: Characteristics of the defective module (marked Siemens M55 module, Fig. 2)

Soiling effects on PV installations

As evidenced by PV LAB studies (e.g., examination of the PV plant on the "Stade de Suisse"), regular cleaning of PV modules increases the electric energy production. As an example, the Siemens M55 PV module surface, a 50 kWp installation on the roof of the PV LAB building at BFH in Burgdorf, is cleaned every four years. This results in a yield increase of 5-8% (Fig. 4).

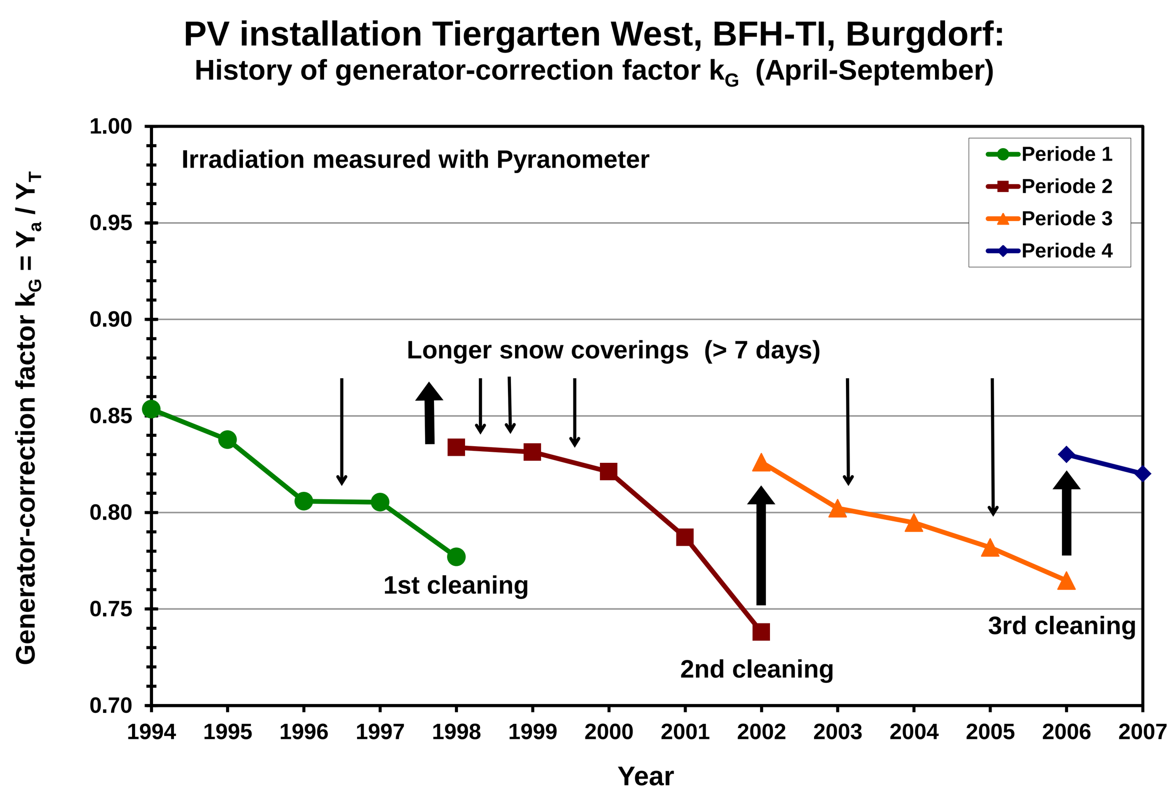

Fig. 4: Energy yield increase (1994-2007) of the PV installation at BFH Burgdorf due to cleaning.

The values in Fig. 4 are determined with the "generator correction factor" k_G, which is formed by dividing the "array yield" Y_A with the "temperature-corrected radiation yield" Y_T (Formula 1) and thus represents the ratio of the actual yield to the theoretical yield.

$$k_G = \frac{Y_A}{Y_T} = \frac{Array - yield}{temp. - corrected\ radiation\ yield}$$

Formula 1: Calculation of formula k_G

Another example is the "Stade de Suisse", a PV installation with a total capacity of 1347 kWp. Cleaning effects were determined in summer 2015. The soiling effects were examined before and after cleaning the installation with the PV LAB thermal imaging drone. Again, the extra energy yield gained from cleaning the PV modules was determined by the difference in K_G-values (Table 1).

Subsystems	Increase in %	Notes/year
BI1	4.0 → ~4	2nd cleaning 10/15
BI2	6.4 → ~6	2nd cleaning 10/15
CI1	5.7 → ~6	2nd cleaning 10/15
CI2	4.3 → ~4	2nd cleaning 10/15
CI3	4.3 → ~4	2nd cleaning 10/15
DI1	5.6 → ~6	2nd cleaning 10/15
DI2	6.4 → ~6	2nd cleaning 10/15
E1 (AA1)	6.4 → ~6	1st cleaning 07/15
E2 (AA2)	8.5 → ~9	1st cleaning 07/15
F1 (DA1)	7.8 → ~8	1st cleaning 07/15
F2 (DA2)	7.5 → ~8	1st cleaning 07/15
Total	**6.2 → ~6**	

Table 1: Increase of energy yield at "Stade de Suisse" after cleaning the PV modules.

The degradation of the "Stade the Suisse" PV installation is displayed in Fig. 5. Cleaning the PV modules in 2015 (i.e., after 5 years of operation) increased the energy yield up to 4-5% (module inclination of 7 degrees). Cleaning the PV modules after 8 years of operation (also in 2015), increased the energy yield up to 6-9% (module inclination of 20.5).

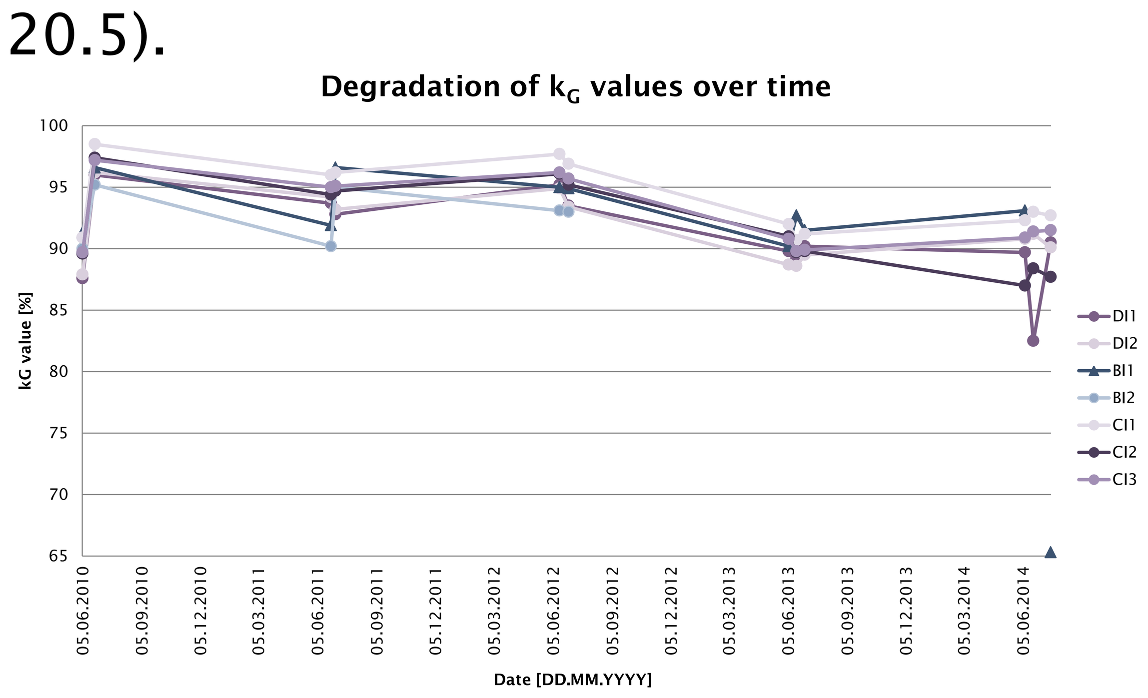

Fig. 5: Degradation of k_G values (2010-14) of the "Stade de Suisse" PV installation.

In conclusion, regular inspection with thermal imaging drones offers a real efficiency advantage when monitoring the improved energy yield production from PV due to cleaning.

This PV LAB research is sponsored by:
GVB
Wir versichern Ihr Gebäude.

Berner Fachhochschule
Haute école spécialisée bernoise
Bern University of Applied Sciences

▸ Engineering and Information Technology
▸ Photovoltaic Laboratory

Daniel Gfeller
Jlcoweg 1 | 3400 Burgdorf | Switzerland
www.pvtest.ch | iem.bfh.ch/photovoltaik | daniel.gfeller@bfh.ch