

# Photovoltaic plant at Jungfrauoch

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**Keywords:** photovoltaics; PV system; PV module

## 1. Project description

In 1993, the highest grid connected PV plant in the World was built at Jungfrauoch (3454 meters above sea level) [1]. Since then, the 24 modules Siemens M75 (48Wp) with a total rated power of 1152 Wp reliably produced solar electricity. The PV module degradation has found to be 0.11% per year in former publications [2], which is roughly ten times less than predicted based on typical degradation warranties at the time. Despite many strong storms, not a single PV module glass has broken in three decades. However, some modules are showing the first degradation effects, which will be examined in more detail in the coming year.

## 2. Activities 2023

The long-term measurements on the PV system on the Jungfrauoch were continued in 2023 with the new database. In a preliminary inspection, the modules were examined for optical damage and tested using various measuring methods. More detailed measurements are planned for 2024.

### 2.1 Data Evaluation

A new database based on InfluxDB, Telegraf and Grafana was introduced in 2022 and used in 2023 for the first full year. The systems works reliably and offers several new opportunities for data evaluation.

Figure 1 shows the course of irradiation and dc power in 2023. Figure 2 shows the correlation between irradiation and power. This shows that the system still delivers high performance at high levels of irradiation. The average performance ratio is measured with PR = 87.5% (no filters applied).

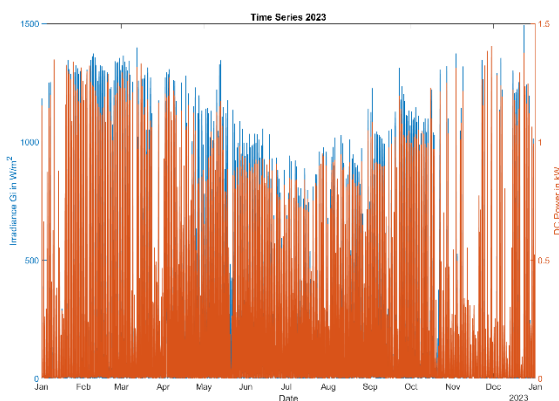


Figure 1: Data Monitoring in the new Influx database.

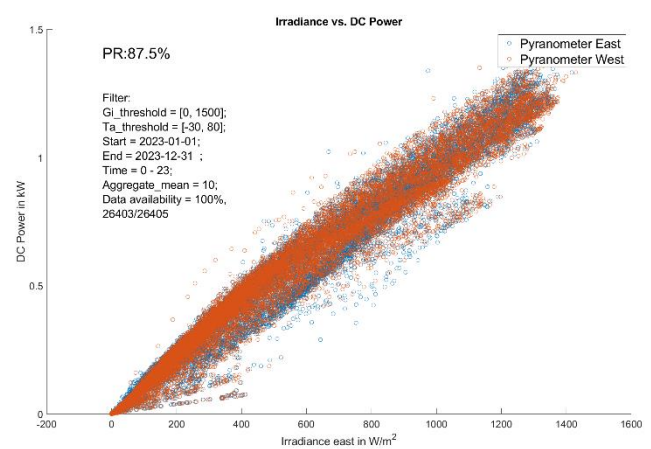


Figure 2: The correlation between  $G_i$  and PMPP shows the high availability of the 30-year system.

As shown in [2], [3] and [4], very low degradation rates have so far been measured at the PV system on the Jungfrauoch. For this reason, both the PV modules and the measuring equipment should be checked for further damage and their accuracy in the near future.

### 2.2 Visual System Inspection

The 30-year-old PV system was systematically examined for visual damage. Moisture ingress is suspected to have been found on the lower edge of some PV modules (Figure 3). These are quantified in Figure 4. The numbers indicate how many cells per module are affected by the optical impairment.

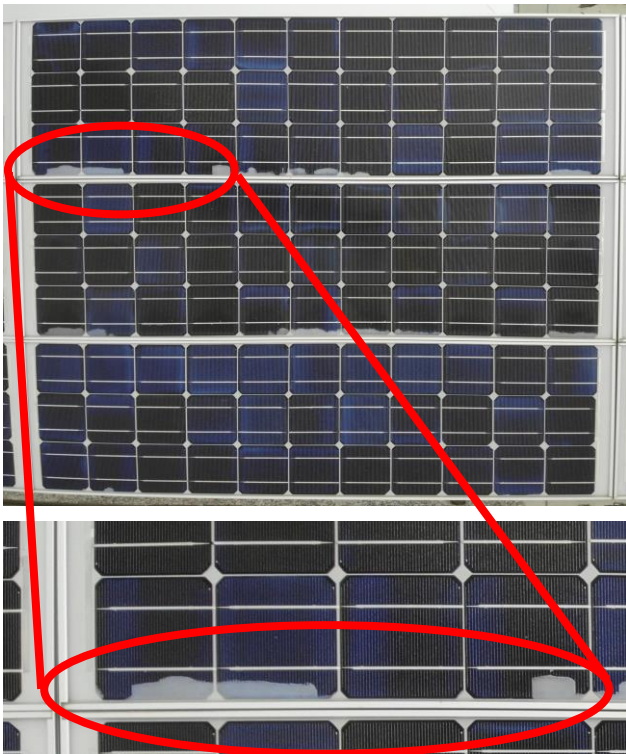


Figure 3: Visual inspection.

column	A	B	C	D	E	F	G	H
row								
Upper	0	1	0	0	0	7	1	0
Middle	0	8	2	0	1	8	9	0
Lower	0	1	0	1	0	1	1	2

Figure 4: Number of cells per module affected by optical impairment.

The optical impairments were recorded in daylight and verified at night using UV luminescence. However, the UV luminescence images could only be carried out as an example and not systematically (Figure 5).

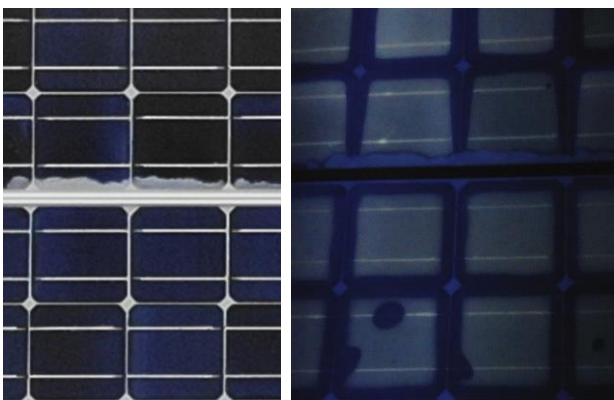


Figure 5: UV luminescence (right) reveals defects that are not visible to the naked eye (left).

## 2. Outlook 2024

The following work packages are planned for 2024:

- Checking the system for hotspots using infrared images
- Examination and comparison of the module states in comparison with other systems from the PVDETECT project
- To be confirmed: aging test of PV connectors under alpine conditions.



Figure 4. PV system at Jungfrauoch in Summer 2023

## References

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