

1 Sensor platform with pyranometer and reference cell to validate performance ratio.  
2 Comparison of actual and expected performance ratio.

## PERFORMANCE MONITORING FOR PV POWER PLANTS

High performing PV power plants are key to your return on investment. We offer monitoring services, which include immediate reporting of deviations from the expected performance.

Faults and failures have to be detected reliably and immediately. Owners and operators of PV plants therefore rely on continuous monitoring of the photovoltaic system. According to IEC 61724, the value to be determined is the performance ratio (PR).

Fraunhofer ISE is known for secure, independent and customized performance monitoring for many years. Our customers appreciate our

- accurate and secure performance measurements
- high data availability
- analysis and report from renowned scientists of Fraunhofer ISE

Fraunhofer ISE implements technical solutions to provide reliable performance

values. We also support our customers in the definition of project- and site-specific technical pass- and fail-criteria in order to ensure feasible agreements between stakeholders.

With our approach, performance and meteorological data with maximum accuracy are provided. The measured weather data (irradiance, temperature) are used to calculate the expected performance in order to simulate the PR with a recognized procedure and validated methodology and parameters.

The method for performance evaluation and reporting was developed over the last years by Fraunhofer ISE and corresponds to the relevant state of science and technology. It has been applied successfully for utility scale PV plants worldwide and repeatedly proven the accurate performance evaluation.

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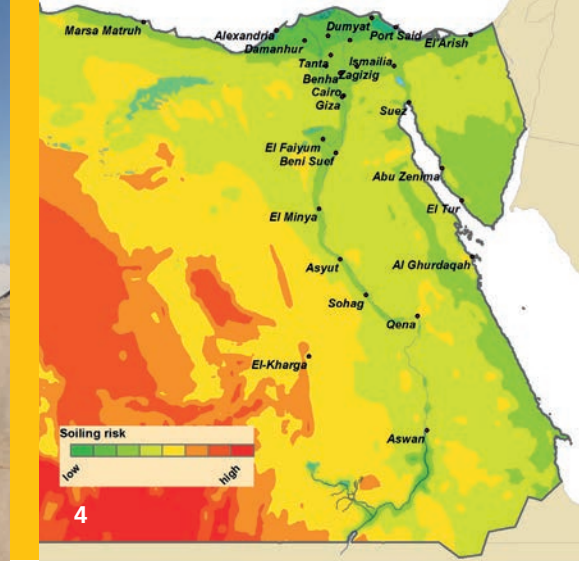
### Photovoltaic Power Plants

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### Data Acquisition System (DAS)

First and foremost, irradiation data needs to be of high quality and constantly available. For this reason reliable and proven sensors are used for the DAS:

- Global Horizontal Irradiation (GHI) measured with pyranometer
- Plane of Array Irradiance (POA): Measured with top-notch silicon reference cell, calibrated with world leading uncertainty of 1.3% in the accredited calibration laboratory Callab PV Modules at Fraunhofer ISE
- temperature: measurement of ambient and module temperature
- total AC energy output: measurement based on the existing energy meter, using standardized digital output
- status signals from utility, inducing downsizing of the maximal power output

### Performance Value and Evaluation

To calculate the performance ratio (PR), the actual irradiance and the system output are measured accurately during operation. The sensor platform of Fraunhofer ISE is equipped with measuring devices for irradiance and temperature data and delivers high quality measurement data for precise monitoring.

The actual meteorological conditions and irradiance is measured on-site with highest precision. Valid and secure performance values are calculated and compared to the expected performance ratio of the PV power plant considering the actual conditions (Fig. 5).

### On-site Soiling Monitoring

Soiling is a critical risk parameter and needs to be considered especially in arid locations. In many regions, regular occurrence of dust storms and high dust load in general lead to dust settlements on the modules surface. Dust particles absorb and reflect the solar irradiance, which leads to a loss in power generation. Different mitigation strategies can be implemented to reduce the risk of yield losses due to soiling.

To optimize the soiling mitigation strategy the actual soiling loss has to be measured. Fraunhofer ISE offers monitoring and analysis of soiling losses for PV power plants. The soiling monitoring is performed by measuring the current-voltage curves (IV curves) of naturally soiled reference PV modules and an automatically cleaned reference module. The soiling losses are obtained by comparison of two observed parameters: Short Circuit Current  $I_{sc}$  of PV modules and the Maximum Power Point MPP.

### Services and Reporting

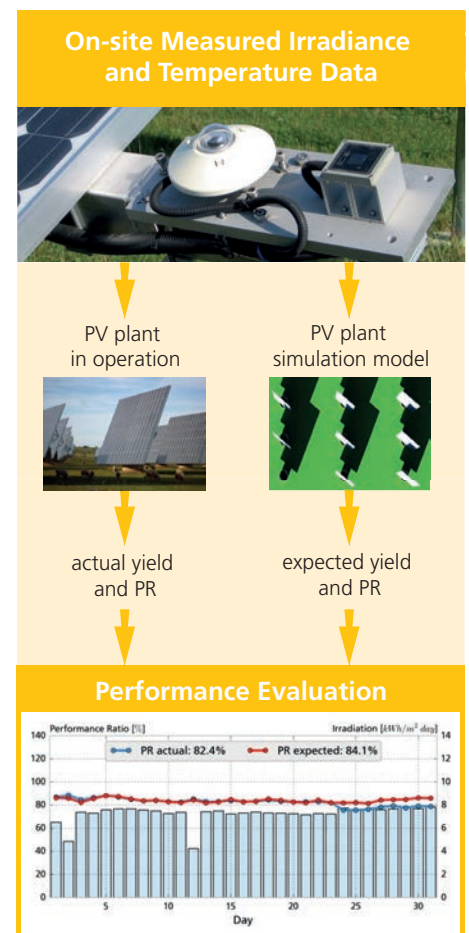
- daily reporting of the performance ratio on a customized website
- regular analysis, evaluation and performance control
- written reports and comparison of performance for defined time periods
- reporting to customer, if PR is less than expected
- root cause analysis for low PR
- energy loss calculation for low PR periods

3 Soiling leads to significant power losses.

4 Soiling risk in Egypt, map developed by Fraunhofer ISE.

### Precise Monitoring

Performance monitoring requires well-founded expertise in combination with the professional use of exact measuring devices. All influencing factors must be correctly identified and professionally assessed in order to secure the return on invest of PV power plant projects.



5 Performance evaluation.