BIFACIAL PV MODULES – CHARACTERIZATION AND SIMULATION

Bifacial photovoltaic (PV) modules are able to utilize light from both sides and can therefore significantly increase the electric yield of PV power plants. The yield gain compared to monofacial modules is mainly determined by

- the conversion efficiency for solar irradiance incident on the rear side of a bifacial PV module, and
- the amount and quality of solar irradiance incident on the rear side.

Our comprehensive services for bifacial PV modules at Fraunhofer ISE include

- module calibration and characterization
- accurate simulation of bifacial irradiance in field operation, including partial shading
- yield simulation and optimization
- power plant testing and monitoring
- analysis and optimization of cell-to-module efficiency
- analysis and optimization of module-to-system efficiency including BIPV systems
- reliability assessment of module materials and design
- analysis of local climatic stress conditions.

**Yield Assessment**

We compile yield assessments for bifacial PV power plants. With our unique simulation algorithm, developed in-house, we can make accurate predictions for the irradiation not only on the front side, but also on the rear side of the module. The detailed analysis considers characteristics of the system and the site (such as the reflection of the underground, shading, mounting height and the inclination angle) and provides recommendations for optimizing system design and yield.
Calibration and Characterization

The calibration and characterization of bifacial PV modules is conducted by our accredited calibration laboratory CalLab PV Modules, the world’s leading laboratory regarding measurement precision.

For calibration of bifacial PV modules, we measure each side against a non-reflective (“black”) background to guarantee highest reproducibility and measurement accuracy. Optional measurements can also be performed against a reflective background or, for guidance, under bifacial illumination.

To characterize bifacial PV modules, we determine the most important yield-relevant properties, like lowlight performance, the temperature coefficient and the rear side efficiency. According to our customers’ special needs, we select the relevant properties for characterization. Beyond laboratory measurements, we also determine these properties in the field e. g. on a defined underground or in variable setup geometry.

Monitoring

To verify the yield of bifacial PV module technology, Fraunhofer ISE builds and monitors demonstration systems. The mounting system and the underground can be specified by the customer.

DC current and voltage, AC power, module temperature and irradiances are measured and monitored in this demonstration system. Simulations are used to verify the measured data.

Efficiency Analysis and Optimization

For optimal yield in bifacial operation, module design and bill of materials need to be carefully adjusted. Our electrical and optical simulation of module efficiency and performance supports both material and module manufacturers. In the Module Technology Center (Module-TEC) we apply innovative interconnection and encapsulation technology to manufacture samples from 1 to 60 cell format for characterization and testing purposes.

Reliability Assessment

Independent reliability assessment is an essential milestone on the way to bankability for bifacial PV technology. Based on comprehensive experience in environmental monitoring and simulation, we qualify new materials such as transparent back sheets, encapsulants and sealants. In our ISO 17025 accredited Test Lab PV Modules, we perform customized accelerated testing, precertification as well as certification testing.

We analyze the degradation behavior of bifacial PV modules under real weather conditions by exposing them at our four outdoor test sites. An important aspect is the influence of different material combinations on the longterm reliability.

Non-destructive monitoring of degradation indicators helps our customers to identify potential degradation paths at an early stage.

Customer-Specific Services

Our individual services can be combined in various ways according to our customers’ specific needs.

Yield gain depending on system design and conversion efficiency of module rear side

![Graph showing yield gain depending on system design and conversion efficiency of module rear side.](image)

1 Calibration against black background.
2 Bifacial PV module with translucent covers.
3 Simulated yield gain of four types of bifacial modules with different conversion efficiency of their rear side at various levels of irradiation.