

## Yield assessment for photovoltaic systems

The yield assessment report of SERIS gives a prognosis for the mean energy output in kWh of a projected solar electricity generating system. We focus on photovoltaic systems in the South of Asia and Asia/Pacific regions.

The service will be provided by SERIS in cooperation with Fraunhofer Solar Energy Systems ISE (www.ise.fraunhofer.de) 

### 1 Scope and contents of yield assessment

The bases for the yield assessment calculations are solar irradiation data and characteristics provided by the component manufacturers for the chosen modules and inverters (see page 4 for necessary detailed data). The report contains a description of the physical calculation models used and all assumptions for the calculation. The yield assessment is obtained with the use of intensively validated software.

The yield assessment covers the following services and results:

- Mean annual system yield, absolute value and value relative to the installed nominal system power
- Calculation of the performance ratio of the system on the basis of technical data for the components
- Summary table with monthly data for the horizontal irradiation, irradiation on the tilted surface, DC-energy and AC-energy outputs

All losses that might occur during system operation are described and quantified in the yield assessment report. This analysis is based on long term experience in the monitoring and detailed analysis of grid-coupled PV systems.

For grid-connected photovoltaic (PV) systems, two main performance indicators will be used: the yield and the performance ratio:

$$\text{Yield (Y)} = \frac{\text{annual AC electric energy output of the system}}{\text{rated power of the installed system}}$$

The yield is expressed in kWh/kW<sub>peak</sub>

$$\text{Performance Ratio (PR)} = \frac{\text{annual AC electric energy output of the system}}{\text{"ideal" annual DC electric energy output of the PV modules}}$$

The "ideal" conditions are defined as an irradiation of 1 000 W/m<sup>2</sup>, spectrum AM 1.5 and module temperature of 25°C.

The following items will be discussed in detail in the report:

- Reflection losses due to non-vertical irradiation on the module surface, separated into direct and diffuse parts of the solar irradiation
- Yield reduction as a result of deviations of the real spectrum of the solar irradiation from the standard AM 1.5 – Spectrum
- Energy losses due to soiling of the module surface
- Losses because of the deviation of the solar irradiation from the standard testing conditions (STC), irradiation different from 1 000 W/m<sup>2</sup> and temperatures different from 25°C
- Losses produced by serial connection of modules with slightly differing characteristics
- Wiring losses on the DC- and AC cabling
- Losses in the inverter (efficiency and power limitation)
- Assessment of losses in the medium voltage (MV)/ low voltage (LV) transformer for systems connected to the MV grid
- Assessment of shading losses

## 2 Irradiation data

Data for the horizontal global irradiation will be obtained from several sources. All values will be compared and assessed regarding their reliability. Using approved scientific calculation models, hourly average irradiation values on the tilted surface will be generated from the horizontal irradiation values.

Further irradiation data supplied by the customer are highly welcomed. The precision of the yield prediction depends strongly on the characteristic and quality of the irradiation data available.

## 3 Assessment of technology and risks

SERIS evaluates the customer's chosen technical concept and components based on the planning documents, the technical data of the components and our experience with the monitoring of photovoltaic components and systems.

Additionally, the yield assessment report includes an evaluation of the technical risks and recommendations to minimize those risks. Values for realistic uncertainties of the yield prognosis are also given in the report.

#### 4 Preparation of the detailed yield assessment report

The yield assessment report will be sent to the customer by e-mail (PDF version) in advance. After that, two printed and signed copies will be mailed to the customer.

#### 5 Pricing

- Basis assessment: SGD 8 000
- For power plants > 1 MW: SGD 10 000
- For power plants > 10 MW: SGD 12 000
- Additional charges\*: SGD 1 000

\* For each additional PV technology (module type) being applied; or for systems using tracking devices

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## Minimum necessary data for yield assessment report

### Location

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City  
Coordinates  
Altitude  
Photos of the area

### Modules

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Manufacturer  
Type  
Nominal power  
Data sheet  
Temperature coefficient for  $P_{\max}$ ,  $V_{OC}$ ,  $I_{SC}$   
Number of modules

### Inverter

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Manufacturer  
Type  
Data sheet  
Part load efficiency (at 10%, 50%, 100% of full load)  
Number of inverters  
Modules per string  
Strings per inverter

### Transformer

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Nominal power  
Number of transformers  
No-load losses  
Short-circuit losses  
Without information about no-load losses and short-circuit losses, we will calculate with standard values

### Plant

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Orientation  
Tilt angle compared to horizontal  
Distance between rows  
Number of modules on top of each other  
Way of assembling modules (vertical or horizontal)  
Height and distance of external shading sources  
Site plan  
Electric wiring concept up to feed-in point  
DC total power  
Cabling losses for maximum generation (DC, AC)  
Without information about cabling losses (or detailed information on cabling), we will calculate with 2.5% loss for maximum generation