Adaptive solar power forecast

Solar park 2.0 project

Motivation

Accurate solar power forecasting is essential for the efficient operation, energy marketing and grid integration of photovoltaic systems. However, traditional, physics based forecasting models often reach their limits in practice. Their prediction quality drops significantly, especially in the presence of changing environmental conditions such as shading, soiling or degradation. AI-based predictions can achieve around 10-15% higher accuracy than traditional models. One reason for this is that data-based methods can detect and account for effects that are difficult or impossible to capture in physical models - such as incomplete information about local sources of shading.

Model description

he core of the prediction model developed in the Solarpark 2.0 project is an adaptive, modular method that dynamically adapts to the real operating conditions of photovoltaic (PV) systems. PV systems are assigned according to orientation, inclination and system type. The combination of weather forecasts and continuously measured PV power creates an adaptive system that continuously optimises its forecast quality. The core of this adaptive behaviour is a continuous analysis of forecast deviations.

The model predictions are adapted by updating the model's internal parameters, e.g. by using online learning methods, which successively update the model with new measured power data. These procedures allow the model to be continuously „retrained" in the background, without manual intervention and without the need for complete re-parameterisation.The adaptive structure improves the robustness of the forecast, particularly in real operating scenarios, such as dynamically changing environmental conditions and increasing power losses over the system life cycle. Instead of making fixed assumptions, the model learns on the basis of real operating data.

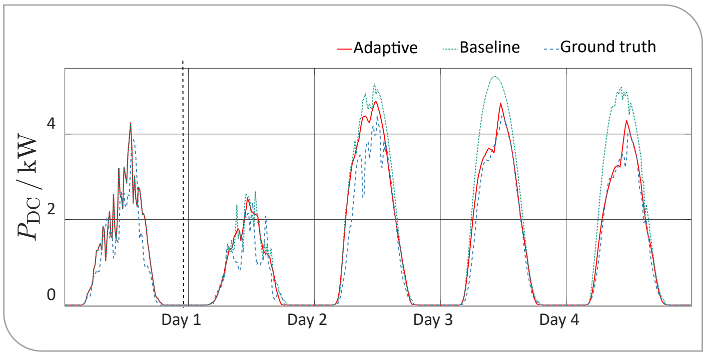

Figure 1: Adaptive forecasting (Tim Kappler/KIT)

This enables more realistic forecasts of PV yields, more precise control of storage control systems, and maximization of revenues from direct marketing. The result of data-driven adaptation is an intelligent, self-optimising forecasting system. Taking into account real operating conditions is crucial as it significantly improves the accuracy of energy forecasts throughout the day - a key prerequisite for efficient energy management strategies (EMS).

The developed model also provides information that is important for operational diagnostics, particularly with regard to shading. The systematic evaluation of the forecast error - defined as the deviation between modeled and measured PV power - enables the identification of location- and time-dependent power losses. These are an indicator of external disturbances, such as shading. Recurring, diurnal or seasonal deviation patterns can be attributed to specific sources of shade, such as trees, masts or structures in the vicinity of the system. Statistical methods are used to identify such correlations.

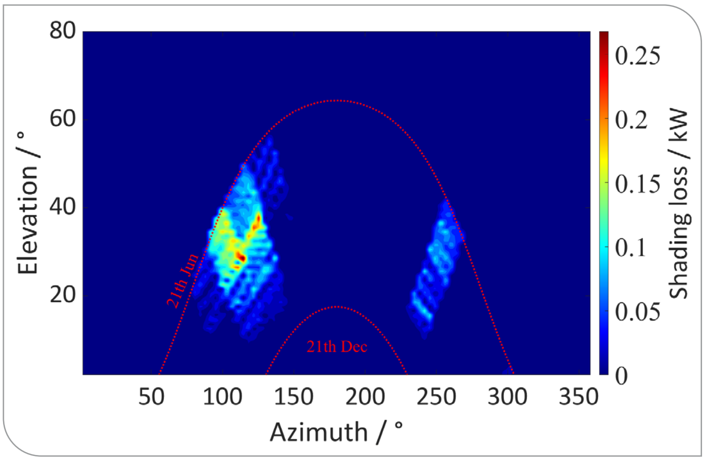

Figure 2: Intensity and time of detected shading over one year (Tim Kappler/KIT)

It is also possible to quantify the intensity of shading by comparing actual power losses with reference values. This provides the operator with a tool for detecting, assessing and optimising the yield reduction caused by shading in the long term. In combination with measured irradiation values - e.g. using a reference cell - it is possible to further differentiate the causes of losses. In particular, shading losses can be distinguished from those caused by surface soiling, as both manifest themselves in characteristically different deviation patterns between measured irradiation and the resulting module output.

The prediction model is currently being extended to allow a quantitative assessment of the use of module power optimisers. This is based on the recording and analysis of power losses, particularly those due to shading. By resolving forecast errors and attributing them to potential causes of shading, scenarios can be simulated in which power optimisers can contribute locally to increasing yields.

The aim of the extension is to provide a reliable estimate of the potential additional yield from the use of module power optimisers under real operating conditions. In particular, it takes into account the duration, intensity and distribution of shading. Based on this, the model is intended to provide a sound basis for deciding when such optimisers are economically appropriate. This will allow investment in additional components to be more accurately planned and evaluated on a system-specific basis.

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Supported by:
Federal Ministry for Economic Affairs and Climate Action
on the basis of a decision by the German Bundestag