Optimization of Power and Yield in Photovoltaic Systems

Solarpark 2.0

Aim: Increase the yield of large photovoltaic systems

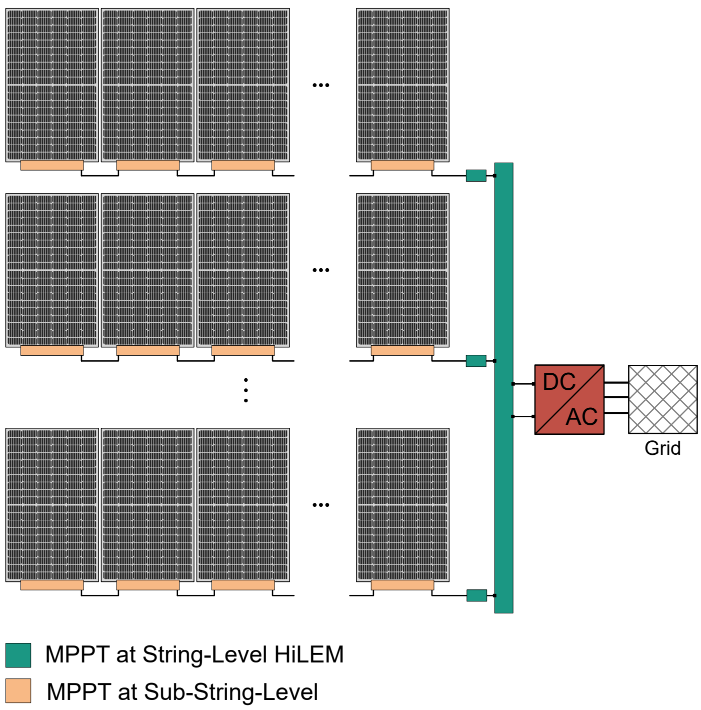
Shading, soiling or ageing are examples of unfavourable conditions that can significantly reduce the yield of large-scale ground-mounted photovoltaic systems. In the research project Solarpark 2.0, the Karlsruhe Institute of Technology (KIT) and partners from science and industry are working to reduce these losses. Innovative circuits, novel power electronics and AI-supported optimisation are to increase the yield and lifespan of plants and reduce operating costs

Optimization by Multilevel MPP Tracking

So-called maximum power point (MPP) trackers are already used in virtually all solar parks. This special technology sets the system's optimum operating point to generate maximum power. The MPP of a module depends on solar radiation and temperature. These factors are influenced by a variety of factors, such as location, time of day and year, weather, shading or dirt. Some of these factors are constantly changing. Therefore, the power optimisers must continuously search for the MPP and regulate the voltage and current in such a way that the system delivers the maximum electrical power.

In large plants, often only one MPP tracker is used in the central inverter. However, especially in large plants, different influences on the modules can occur from time to time. In this case, for example, only part of the park could be shaded by a cloud.

In such a case, MPP tracking via a single power optimiser is not optimal, since each solar module or solar cell has an individual MPP. In the Solarpark 2.0 project, a multilevel MPP tracking with optimisers in the sub-strings (modules) and the PV strings is therefore being developed.



String MPPT through highly efficient HiLEM circuitry

The HiLEM (High Efficiency Low Effort MPPT) circuit developed at the KIT is used for the project. This combines the individual PV strings by means of several partial DC/DC converters to form a common DC output and regulates each string in its individual MPP. The HiLEM circuit replaces the conventional combiner boxes used to connect the module strings in parallel in central inverters and the conventional DC/DC converters in string inverters. The HiLEM circuitry realises its full potential for efficient operation in large systems with high string voltages. Its special design as a partial DC/DC converter enables an efficient and cost-effective solution, since the high voltages of the strings do not have to be switched by the semiconductors.

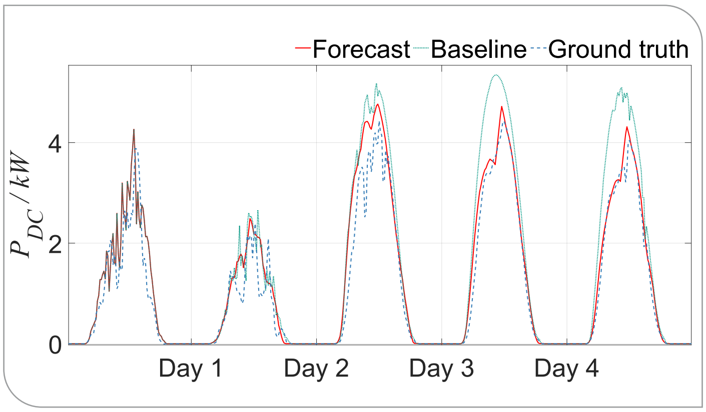


Figure 2 Solar power forecast by use of LSTM networks

Using AI methods to increase the economic efficiency of photovoltaic systems

A key objective is the development of an AI-driven power forecasting model for photovoltaic (PV) systems that can dynamically adapt to changing environmental conditions. By continuously analyzing operational data, the model will accurately quantify losses caused by shading and soiling and assess their impact on overall system performance.

These forecasts serve as the basis for evaluating the economic feasibility of retrofitting power optimizers. By estimating potential power losses, the model can identify specific locations in solar parks where optimization would be most cost-effective. The necessary training data will be generated from both existing PV installations and newly established test facilities.

Together with the detection of shading, soiling and degradation, this should also reduce the cost of electricity. Maintenance, cleaning and inspection intervals can thus be intelligently planned. This should reduce downtimes and lower operating costs.

Own testing facility

In order to validate the advantages of the Multilevel MPPT with the HiLEM circuit, a 60 kWp field test system is being built on the premises of KIT Campus North. This will be divided into two identical plants. One part of the plant will be equipped with the new technologies and validated against the other part of the plant with standard technologies as a reference.

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