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Impact of atmospheric parameters on the performance of photovoltaic systems - study of spectral effects

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Due to the policy goals for sustainable energy production, renewable energy plants such as photovoltaics are increasingly in use. The energy production from solar radiation depends strongly on atmospheric conditions. As the weather mostly changes, electrical power generation fluctuates, making technical planning and control of power grids to a complex problem.
Due to used materials (semiconductors e.g. silicon, gallium arsenide, cadmium telluride) the photovoltaic cells are spectrally selective. It means that only radiation of certain wavelengths converts into electrical energy. A material property called spectral response characterizes a certain degree of conversion of solar radiation into the electric current for each wavelength of solar light.
The AM 1.5 air mass is a standardized spectral composition of solar radiation widely used for testing of solar devices in the photovoltaic industry. It is enough to compare the photovoltaic modules with each other. However, real solar radiation during time does not have a constant spectral composition. The main drivers for spectral change are the path length through the Earth's selectively absorbing atmosphere and the opacity of the atmosphere. The site latitude determines the seasonal and daily variation in the path length and the opacity is due to the local climate and weather of the site.
A fundamental study of the impact of spectral effects on the time-fluctuating photovoltaic energy generation is essential, if the planning and control of the electricity grids are to succeed in the near future.

The current study is a part of the research project MetPVNet: "Satellite- and meteorology supported prediction of energy production from the photovoltaics at the distribution level: development, validation, application" supported by the German Federal Ministry of Economics and Energy (BMWi) and coordinated by the University of Bonn-Rhein-Sieg (H-BRS).
The aim of the study is to identify and quantify the influence of the variable spectral composition of solar radiation on the electrical yields of photovoltaic systems under real occurring atmospheric conditions. The model chain: spectrally resolved solar radiation (input) – photovoltaic module – electric energy yield (output) was created for this purpose. The model of photovoltaic module is realised in MATLAB/Simulink and its spectral resolution takes place directly inside the electrical circuit (the photocurrent is determined with help of the incident solar radiation and the above-mentioned spectral response). The spectral- and time-resolved radiation data calculated by the radiative transfer model LibRadtran builds up the PV-model input. The model chain allows the generation of several scenarios about the location (latitude, overall atmospheric composition), position of photovoltaic modules in relation to the sun (inclination, alignment) and atmospheric parameters (aerosols, clouds). The validation of the model chain is carried out with the spectral and time-resolved data from the MetPVNet measurement campaign (Allgäu, 2018-19).

The poster will present and discuss the above-mentioned spectral resolved model chain and the current state of the research in the frame of the project MetPVNet.