Solar thermal and photovoltaic power plants in comparison

How will the market for photovoltaic and solar thermal power plants develop in the coming decades? Which technology is economically more efficient? And what opportunities are offered by combined power plant systems in sunny regions? A study carried out by the German Aerospace Centre (DLR) has investigated the development of these power plants until 2030.

How can solar power plants generate cost-effective electricity that is available and plannable at any time – especially when the sun does not shine? In order to find out, researchers and industrial partners have investigated various solar photovoltaic- and solar thermal-based power concepts as part of the ThermVolt study. The aim of the study was to compare the costs of these power plants and their combinations. Here they wanted to find out which power plants are capable of reducing greenhouse gas emissions during electricity production and are simultaneously the most cost-effective. During the course of the study, the scientists simulated the costs of different photovoltaic and solar thermal power plant concepts as well as combinations of both systems with identical boundary conditions. "In order to compare the systems in the analysis, it is very important that all systems have a fixed load curve at all times," explains Professor Robert Pitz-Paal, Director of the DLR Institute for Solar Research.

Photovoltaic (PV) power plants generally offer low generation costs and volatile electricity production, but cannot secure supplies by themselves. Solar thermal power plants (Concentrated Solar Power, CSP for short) on the other hand provide fixed capacities, since they have integrated heat storage systems and partly pursue a solar-fossil hybrid operating strategy. The investigated CSP plants have a thermal energy storage system and a fossil burner that is only used in case of need. The PV combined power plants have a battery storage system and a fossil reserve system, for example a gas power plant with which they are operated in combination.

The maximum power plant size was 100 megawatts and was investigated at typical locations in sunny regions such as Morocco and Saudi Arabia. The calculation model covered the years 2015, 2020 and 2030. Detailed calculations were conducted for an entire year with an hourly resolution, whereby the optimum size of the solar array and the storage system were determined. In order to calculate the electricity generation costs for the optimised plants, the authors of the study then developed a cost-effectiveness model that takes into account different effects – such as wear and various cost scenarios.

Study findings
The results showed that, under current conditions, combining CSP and PV is more cost-effective in most scenarios than using only one of the two technologies. The photovoltaic part of the power plant preferably supplies the electricity directly into the grid during the day, whereas the solar-thermal component stores the solar energy in the thermal storage system in order to generate electricity as required, i.e. usually at night.

When there are high electricity requirements during the night hours, the CSP-based power plants are at an advantage thanks to their thermal storage capabilities. At the same time, a hybrid operation with fossil or alternative energy sources can be integrated relatively easily with low additional costs.

In 2015, the photovoltaic systems had the highest electricity generation costs due to the still expensive battery storage costs. "However, significant cost reductions can still be expected for both technologies, so it is still open as to which options will offer the more cost-effective solution for covering the load curve by 2030," says Pitz-Paal, in commenting on the results.

It is planned to publish the complete study by the end of 2016. In addition to the DLR Institute for Solar Research and Technical Thermodynamics, Lappeenranta University of Technology in Finland and the two industrial partners Fichtner and the M+W Group were also involved. The German Federal Ministry for Economic Affairs and Energy sponsored the study with funding amounting to around 500,000 euros.