Solar thermal power plants

Predicting solar radiation for the short term

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WobaS

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CONTACT PERSON FOR THE PROJECT

Dr. Stefan Wilbert

+34(0)950-277619

DLR e.V.

Linder Höhe

51147 Köln

www.dlr.de/sf/

CSP Services GmbH

www.cspservices.de

TSK Flagsol Engineering GmbH

www.flagsol.com/flagsol/cms/

ADITIONAL LINKS

[Translate to English:]

AIP Conference Proceedings

Nowcasting of DNI maps for the solar field based on voxel carving and individual 3D cloud objects from all sky images

AIP Conference Proceedings

Modelling an automatic controller for parabolic trough solar fields under realistic weather conditions

Wiley Online Library

Validation of an all-sky imager–based nowcasting system for industrial PV plants

ScienceDirect

Shadow camera system for the generation of solar irradiance maps

ScienceDirect

Determination of the optimal camera distance for cloud height measurements with two all-sky imagers

NEWS FOR THE PROJECT

Energy research makes patents possible and brings innovations to the market

QUINTESSENCE

- **Cloud cameras provide high quality, high contrast images of the sky**
- **The system's analysis software generates solar radiation predictions immediately after the images are taken**
- **Every 30 seconds, a location-resolved radiation prediction for the next 15 minutes is supplied for the area around the cameras (about four kilometres)**
- **The flow of the heat transfer fluid can be controlled to maintain the desired temperature level even with variable solar radiation. This increases the power plant's electricity production.**

If the expected solar radiation is known precisely, solar power plants can be operated more efficiently. The aim of the research partnership was to define the operating strategies for solar thermal power plants based on weather forecasts of the location-resolved direct normal radiation. The research teams also developed the new prediction tool WobaS. The solar radiation predictions are derived with a system consisting of several cloud cameras by taking photos of the sky from different positions within a solar field. This makes it possible to determine the coordinates of the clouds and their vectors of motion.

Project context

The level of incident solar radiation is one of the most important parameters for operating solar power plants efficiently. For concentrator systems like CSP power plants, direct normal irradiance (DNI) is the decisive factor. If the operator is able to take into account the expected irradiance values and their spatial distribution over the solar field, the power plant can be operated more efficiently. Solar power will become cheaper and its availability more predictable.

The prediction window provided by the cloud cameras is not covered by other methods in the required spatio-temporal resolution. In particular, prediction methods describing the behaviour of individual clouds or small cloud groups in the power plant area were missing. Knowledge of the development of solar radiation for the next fifteen minutes allows, for example, with variable solar radiation, to control the flow of the heat transfer fluid in the power plant so that the desired temperature level can be maintained. This has a positive effect on the electricity production of the power plant and the service life of the power plant components.

Cloud cameras provide up-to-date irradiance values

The aim of the research team was to develop and demonstrate methods that increase the yield of solar thermal power plants by generating and using short-term DNI predictions. Based on cloud cameras, they further developed a nowcasting system and integrated it into the CSP-FoSyS forecasting system, which is available as a prototype and uses satellite data and weather models. Predictive operating strategies are additionally available, which are evaluated, documented and integrated into the CSP-FoSyS Forecasting System to increase yield.

For the analysis and prediction of the irradiance on the solar field, the project team positioned four cloud cameras on the outer corners of the power plant. Using a 180-degree fisheye lens, each of them takes pictures of the cloud formations above the solar field and its surroundings. Special software uses this

data to derive the cloud coordinates and their motion vectors. The cloud cameras provide an up-to-date irradiance map of the solar field and its development in sub-minute time steps for the next 15 minutes. Within the scope of the project, a camera system was installed in the CSP power plant La Africana, coupled to CSP-FoSyS and operated.

Image taken by one of the prediction system's cloud cameras

Predicting direct solar radiation

In the La Africana solar thermal power plant, the WOBAS system provides predictions of direct radiation. WOBAS meets two important requirements for generating reliable predictions:

- its cloud cameras provide high quality, high contrast images of the sky
- the system's analysis software is able to accurately evaluate large amounts of data immediately after they have been captured

The system also generates global radiation maps - even on inclined surfaces, which are required for photovoltaic systems. If the operator uses the information provided by the prediction system, the abrupt interruption or increase in the infeed of PV power can be avoided.
Based on the ground measurements of direct radiation available in the power plant, the WOBAS system calculates the current irradiance values on the solar field and their development for the next fifteen minutes in time steps of one minute. The location resolution of the maps with the irradiance values is five by five metres. The radiation transfer through the clouds is included when the maps are created. What is the advantage for the operation of the power plant if the solar radiation development for the next fifteen minutes is known? For example, even with variable solar radiation, it is then possible to control the flow of the heat transfer fluid so that the desired temperature level can be maintained. This increases the power plant's electricity production. The lifetime of the components is also extended, as the technology helps to prevent lower thermal stresses, which otherwise occur in the event of abrupt changes in radiation.

Ready for use in commercial power plants

The WOBAS system is available for use in commercial power plants as well as large-scale PV systems and power grids. It is currently being used in La Africana and for the CSP test systems in Evora and Jülich. Another system was ordered for a commercial CSP tower power plant just a few months after the end of the project and enquiries for further CSP power plants have been received. It also serves (with over 30 cameras) as a basis for various investigations of power grids in Oldenburg.
The tool has been connected to the satellite and weather model based prediction system CSP-FoSyS by TSK Flagsol.
The economic payback of the cloud camera system in CSP power plants of approximately 50 megawatts is achieved through the increase in efficiency. Simulation studies show that the costs are amortized after less than a year, and even earlier in the case of larger power plants.

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