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Failure Detection Routine for Grid Connected PV Systems as Part of the PVSAT2 Project

(Applicable subject number: 6.1 PV Systems in grid-connected applications)

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The Failure Detection Routine is developed in the scope of the project PVSAT2, which is part of the EU programme „energy, environment and sustainable development“ and is assisted in Switzerland by BBW. The project started in November 2002 und will last until October 2005. The commercial application will start in 2005.

PURPOSE: Especially minor energy losses of PV systems often are not recognised by the operator and even in case of major energy losses, a time intensive analysis of the PV system is needed to identify the failure. The Failure Detection Routine relieves the operator of this burden by analysing daily and automatically the performance of the PV systems and, in case of a malfunction, determining its cause. A broad spectrum of different failures, e.g. shading, string or module failure, part time outages, snow cover, soiling and wrong inverter control may be detected. Due to the detailed information given by the Failure Detection Routine, the maintenance effort of PV systems is reduced und system outage time is minimised.

APPROACH: As pre-conditions, hourly values of the effective and theoretical energy yield of the grid connected PV system have to be known. Acquisition of these data is also developed within the PVSAT2 project [1]. The Failure Detection Routine analyses every day if the energy yield comes up to one’s expectations. If the effective energy yield is significantly lower than the theoretical energy yield, an ingenious analysis automatically searches for the reason of the reduction in energy yield. This checkup explores the extent and the duration of the energy loss, compares with the performance of neighbouring PV systems and calculates the influence of the temperature. Furthermore, a footprint algorithm investigates the longterm correlation of hourly energy losses with daytime and irradiance. All these attributes of the energy loss are compared with the characteristics of different frequent failures of PV systems. Basing on this checkup, the Failure Detection Routine calculates failure indicators for different reasons of energy losses.

RELEVANCE: The Failure Detection Routine automates the monitoring and failure analysis of grid connected PV systems. Thus especially small and medium PV systems can appropriately be checked. Considering that even a 1 % improvement of annual performance can be worth € 40 to € 60 per kWp for a typical European climate, the higher productivity of the PV systems due to reduced system outage time is relevant. Additionally, maintenance effort for PV systems is drastically reduced.

RESULTS: First tests with historic data show the expected results. The test phase of the Failure Detection Routine with 100 PV systems distributed over Switzerland, Germany and the Netherlands will start in January 2005 [2]. Besides a description of the Failure Detection Routine including the footprint algorithm, in this presentation an evaluation of the efficiency of the Failure Detection Routine will be included. Based on historic data and the first results of the test phase, the correctness of the results of the Failure Detection Routine and its power to distinguish failures with similar error patterns will be included in this presentation.

CONCLUSIONS: It is anticipated that this tool will become a standard for the automated surveillance of grid connected PV systems.

[1] E. Lorenz *et al.*: Accuracy of PV system performance estimation based on remote data sources within PVSAT-2.[a]

[2] A.C. de Keizer, W.G.J.H.M. van Sark *et al.*: PVSAT2: Intelligent performance check of PV system operation based on satellite data, results of a field test.[a]

[a]Abstract 20th European Photovoltaic Solar Energy Conference and Exhibition, Barcelona, 6-10 June 2005

Explanatory pages

PVSAT

The Failure Detection Routine is an integral part of the EU project PVSAT2. The goal of this project is the satellite based monitoring of grid connected PV systems to reduce outage time and maintenance effort. Figure 1 describes the functional principle of the PVSAT procedure as a whole:

- The hourly energy production of the PV systems is electronically registered and forwarded daily to a central server with a low cost hardware device.
- The theoretical energy yield of the PV system is calculated hourly with values of the global irradiation derived from satellite and ground measured data and with technical information about the properties of the PV system
- Daily the Failure Detection Routine runs on the central server . It compares the effective and the theoretical energy production and searches for failures in the PV system
- In case of a severe malfunction, the operator of the PV system is instantly informed per email. Permanently, all information about the performance of the PV system and the results of the failure detection routine are available on the internet for registered users.

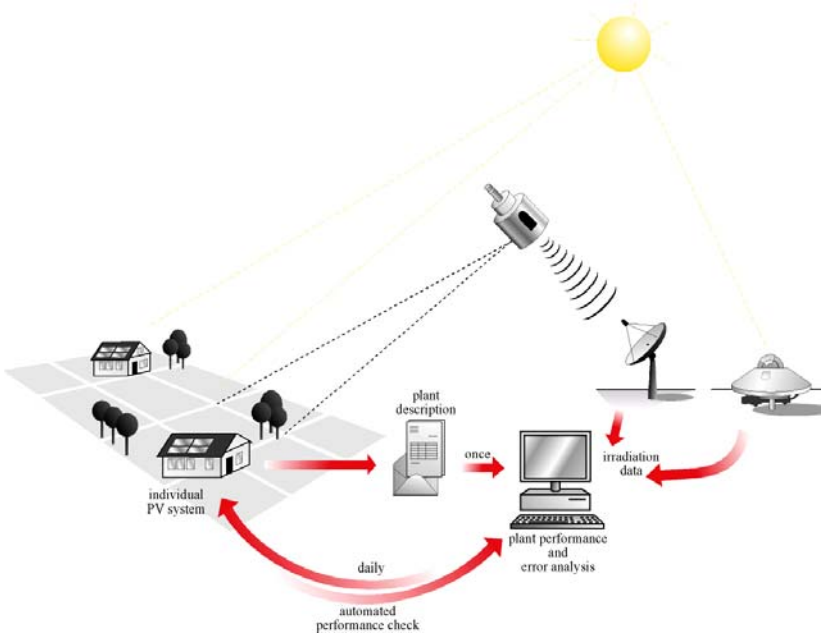

Figure 1: Functional principle of the satellite based monitoring of PV systems

Functional principle

The Failure Detection Routine analyses every day if the energy yield comes up to one's expectations. If this is not the case, an analysis automatically searches for the reason of the energy yield reduction . An integral part of the Failure Detection Routine is the footprint method, which detects energy losses correlated with daytime or irradiance. The results of the footprint method and the actual performance of the PV system are used to decide, if an energy loss occurred and the Failure Detection Routine continues. The Failure Detection Routine only continues, if the performance of the PV system is insufficient. The routine consists of six different subroutines, which analyse the properties of the energy loss (duration, extent, dependency of weather and irradiance, etc.). This checkup explores not only the short and long term behaviour of the energy loss, but also compares with the neighbouring PV systems and calculates the influence of temperature (see figure 2).

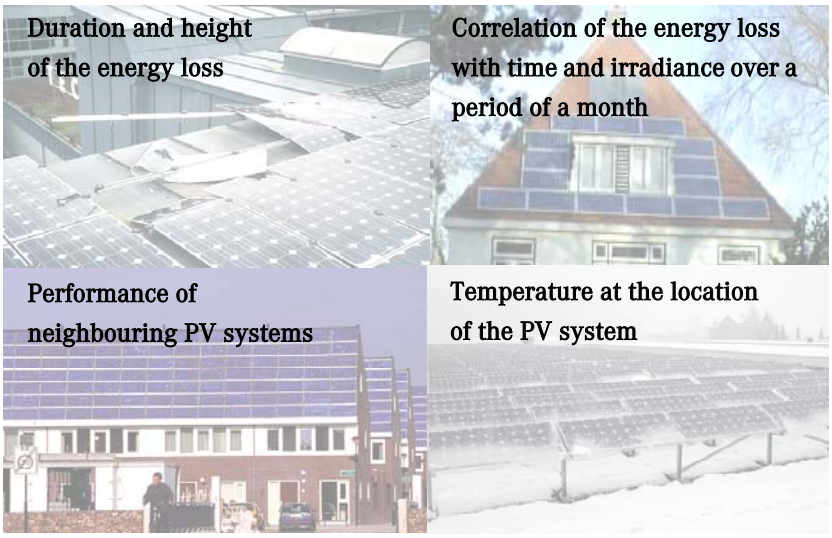

Figure 2: Analysed parameters in the Failure Detection Routine

Results

With the analysis of the six different methods, a portrait of the malfunction is created and then compared with the characteristics of several frequently occurring malfunctions in PV systems like string outage, inverter failure, snow cover etc. The better the characteristics of the observed energy loss fits to one of these malfunctions and the more frequent this malfunction occurs in PV systems, the higher is the indication that this malfunction caused the energy loss. Based on a comparison of the investigated parameters with the characteristics of frequently occurring malfunctions in PV systems, the failure detection routine calculates failure indicators for different reasons of energy losses (see figure 3). In case of a strong indication for a serious system failure, like e.g. a defect inverter or a string outage, the operator of the PV system is informed instantly per email about the energy loss. For registered users further information about the performance of their PV system is available on the Internet.

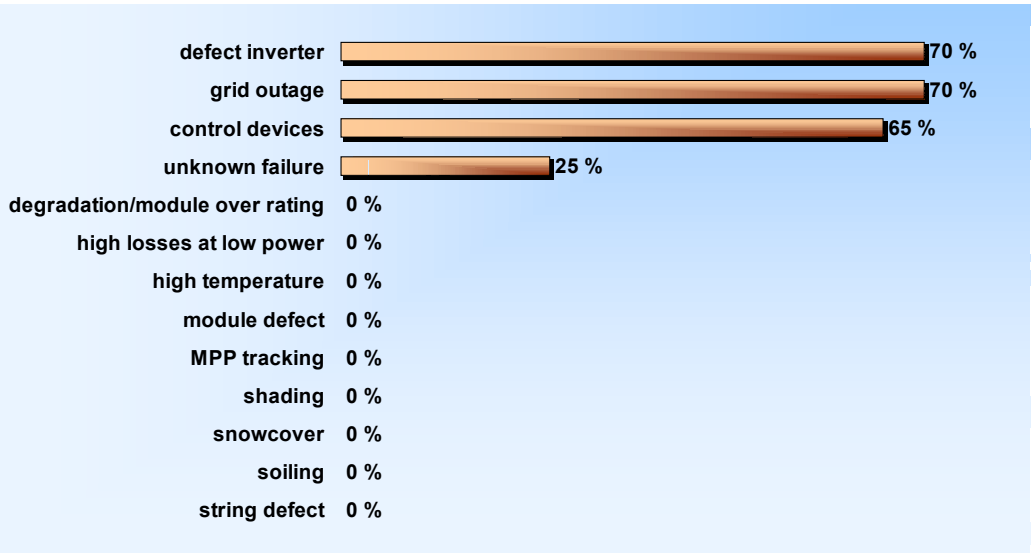

Figure 3: Failure indicators for different reasons of energy losses