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PV Panel Grid Connectivity: Monitoring Applications

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***Abstract**: The effectiveness and efficiency of conversion is assessed by having a continuously monitored grid connected photovoltaic system. The monitoring system understands when power fluctuations and anomalous actions take place in order to complete the needed tasks. It enables the application of connectivity strategies, as well as optimizing control laws. It is also applied to analyze the impact of penetration of solar energy on cost effectivity. As a result, a database of measured values on parameter values, which affect performance of the system is trained. The result is updated frequently as a way of enhancing the accuracy of the result for more real time decisions. This work also applies a presentation technique of values of these parameters to deduce performance and identify abnormal processes on the spot. Observations are carried out at Centre of Renewable Energy Sources.*
***Keywords**: PV panels, distributed generation, renewable energy, grid-connect, and monitoring systems.*

I. Introduction

Nowadays, photovoltaic solar panels are something widespread known for being a big power generation tool. Further, in 40–50 years the rate of production will grow to tens of gigawatts. On the renewable energy side, this PV conversion method is quiet, portable, modular and easy to install in comparison to wind conversion. One does not need long transmission lines to generate the power where it needs to be. Solar panel applications on land are real, although they constitute supplementary power generation. Furthermore, the solar panels are placed where, alternatively, it would be more expensive to have electricity. Moreover, a socially beneficial type of installation also benefits rural communities everywhere in the world. Although its poor efficiency and high capital cost are still too high to allow its widespread adoption, research is still steadily reducing these barriers and PV electrical sources are increasingly being used. Research on how distributed electrical resources connected to the grid can be used to complement rather than compete with megawatt PV farms is the primary obstacle to scaling of these farms and their use on a broader scale. As these installations require constant observation to provide feedback on how to improve on the connectivity performance, output and the control tatics, all these must be maintained at a constant observation.

The first section of this paper provides a wide overview of PV panel grid connectivity in the future. The third part describes how these systems are tracked and stresses factors affecting output and performance. In the fourth part the system used to collect the measurements and the database to store them will be described. The final section presents such a technique for displaying and evaluating measured values.

II. Key Features of PV Grid Connected System

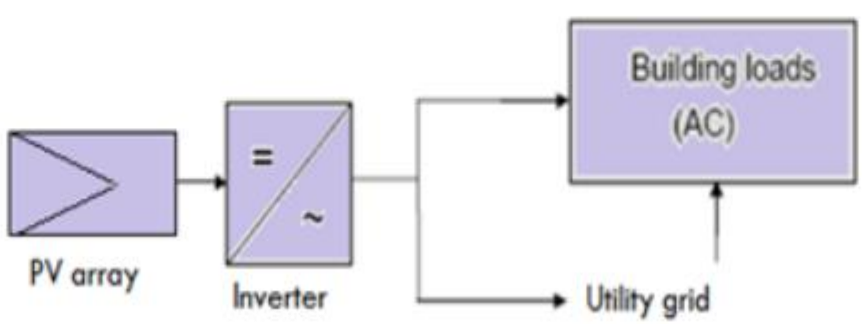

Fig. 1. Schematic diagram of grid- connected photovoltaic system

PV systems can be either grid connected or stand alone. Only the second arrangement of the above is addressed in this study and is applied for powering loads which also feed electricity to the grid or may be fed from the grid distribution system. Several papers have already elaborated on the issues concerning the PV grid connected systems. This section has a brief summary of what one needs to consider. As depicted in figure 1, the key performance that has to be guaranteed is the ability to convert DC to AC by an inverter. The IEEE 1542 and UL 1542 standards seek to advocate for utility interconnection of the PV systems.

The two main safety issues are grounding configurations and island operation. When the grid is no longer providing electricity, the situation becomes islanding. So in this case, the inverter should turn off by itself. The time as specified in the standards should not exceed for this operation. Unfavorable phase to ground voltages may occur even on the hazardous phase to ground voltages, before islanded status is achieved if the grounding design is not in accordance with the specified specifications. Standards related to the distributed resources consider control of the voltage at the point of common coupling (PCC) or the location where a solar system is connected to the grid.

III. Grid System connected to Photovoltaic Panels

There are three options available for providing information on the operational status: Its operational can be a simple LED on the inverter or a display panel providing different operational details or an interactive control panel. Assessment of the system: Depending on results, financial resources could have been allocated to the system. Comparison of the system's assertions to the actual result must then take place over time. Verification is the process of testing for performance in the sense that it examines data acquired and other information to verify system performance. This research proposes a monitoring system taking into account additional problems than the IEC standard 1742 addresses. It sets operational temperature and data permeability of the systems.

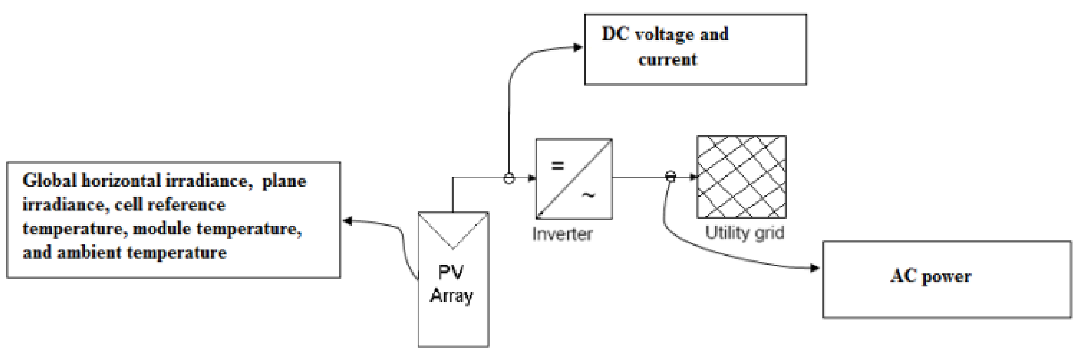

Fig. 2. Levels of measurements acquired by the DAS

The DAS includes a PC based data logger, a pyranometer to measure global horizontal irradiance, a calibrated reference PV module to measure plane irradiance, a sensor to measure temperature of ambient air and PV module temperature, and electrical measurement equipment to monitor voltage, current, power and energy at DC and AC sides of a PV array. Figure 2. shows more thoroughly how each measurement obtained this level. Matlab and Excel is used to show the collected data in the form of tables, charts and graphs. The DAS saves acquired data as ".text" files, one per day. These daily files are a program which chooses the data within a user specified time frame. The system performance is inferred from the yield numbers. The daily final and reference yield are computed by a program to directly assess performance. An AC power generation daily profile with respect to plane irradiance is presented. It also shows ambient and module performance, temperature, data accessibility and sun radiation.

III. Following up on Results and Analysis

Metrics measured on the CRES system between June 8 and August 21, 2014 have yielded the following findings. The bar chart in Figure 3 shows a plot of the reference yield compared with the final yield. It evaluates the performance ratio by each day calculating the relative difference between the two bars. Irradiance is the principal parameter affecting this value, and is measured in order to determine whether the system is functioning properly. The operation is considered abnormal when the performance is poor and the irradiance is high. Good performance ratio is defined with a minimum of 80%. The performance is not 98%, as losses in the converters and cabling prevent it.

The situation to which this illustration applies includes a time frame expressed in hours, days, weeks, or months. In the case that the system is operating normally, maxima and minima of both curves should have the same shape with proportions between maxima and minima. Usually, power is proportionate to the sun irradiation.

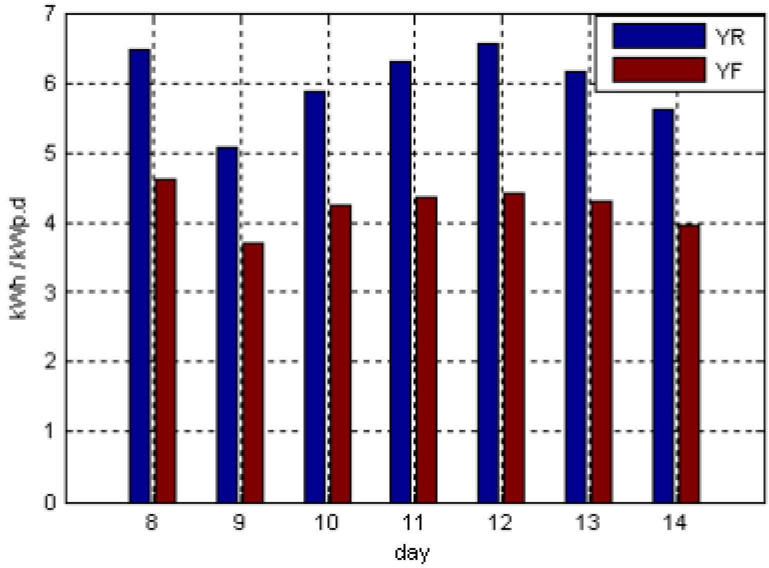

Fig. 3. Final yield (YF) and reference yield (YR) between June 8 and June 14, 2014

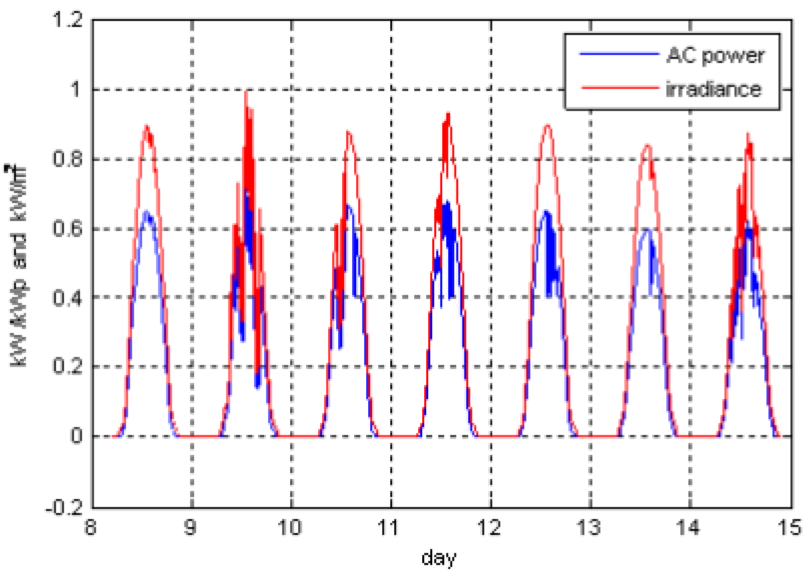

Fig. 4. AC power and plane irradiance CRES-5 (8-14 June 2014)

Figure 5 shows the average daily data displaying as Pr, the mean PV module temperature (degrees Celsius (^{0}C)), the mean PV module planate irradiance by day, and the inverter availability. Before this depiction is analyzed, the availability of the inverter's must be verified. So, in most inverters the tripping protection mechanism kicks in when an overload or overheat occurs and it cuts the power. This is why checking the temperature in concert with the availability of the inverter is important. For example, Figure 5 shows that the inverter is 98% operational within the time frame of interest.

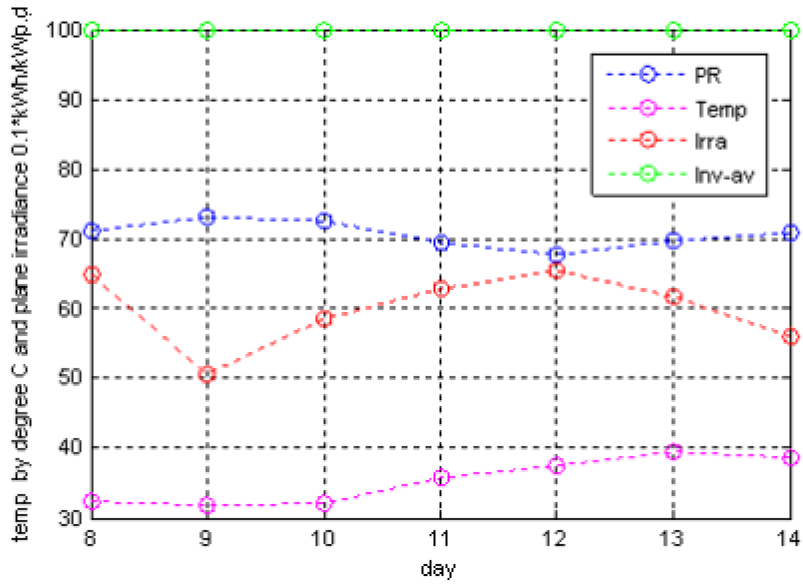

Fig. 5. Performance (PR) variation in terms of the daily variation (8-14 June 2014) of the temperature (Temp), the plane irradiance (Irra) and the availability of the inverter

Relationships between parameters are displayed in the other set of findings. These are statistical calculations that are produced by gathering database data. The performance ratio with various mean PV module temperatures is displayed in Figure 6. August 2014 values are taken into account. As the mean temperature rises, the performance ratio decreases. In May 2014, Figure 7 displays the generated AC power as irradiance at the same temperature. This indicates that when the PV planar irradiance increases, the AC power generation increases linearly. The performance ratio in relation to the reference yield (DC energy) is displayed in Figure 8. At a reference yield for a specific ambient temperature, performance is observed to decrease.

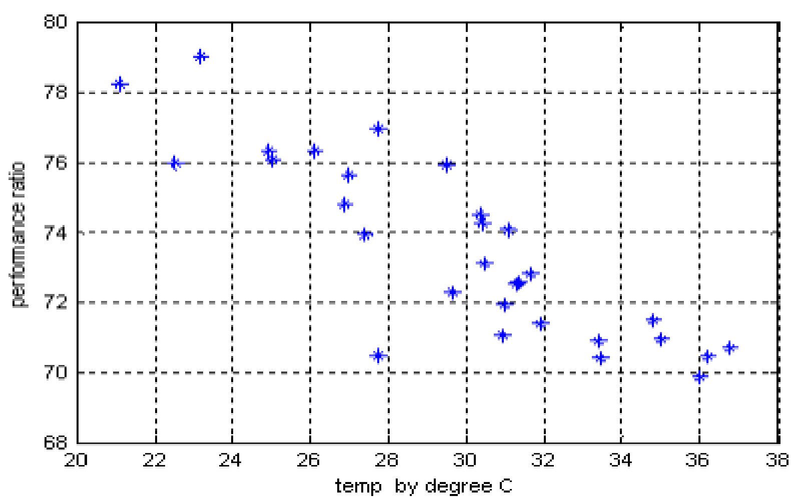

Fig. 6. Performance ratios versus mean PV module Temperature

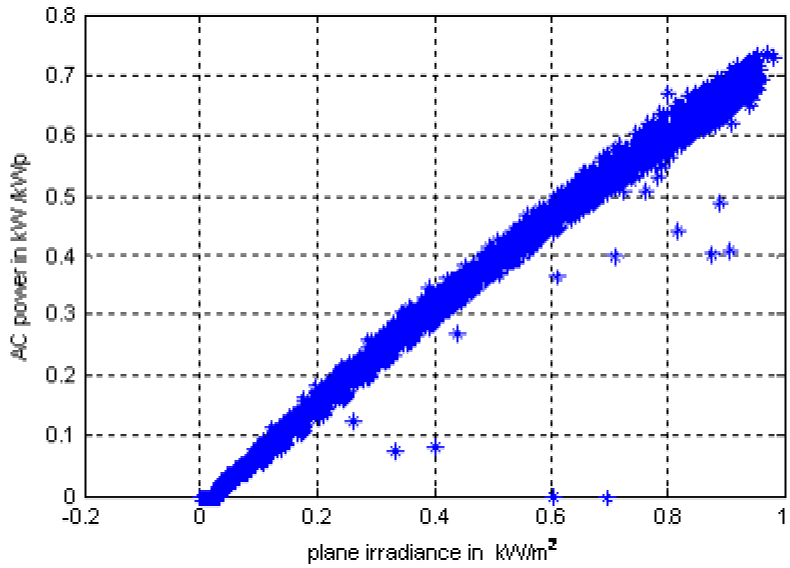

Fig. 7. AC power versus the PV plane irradiance

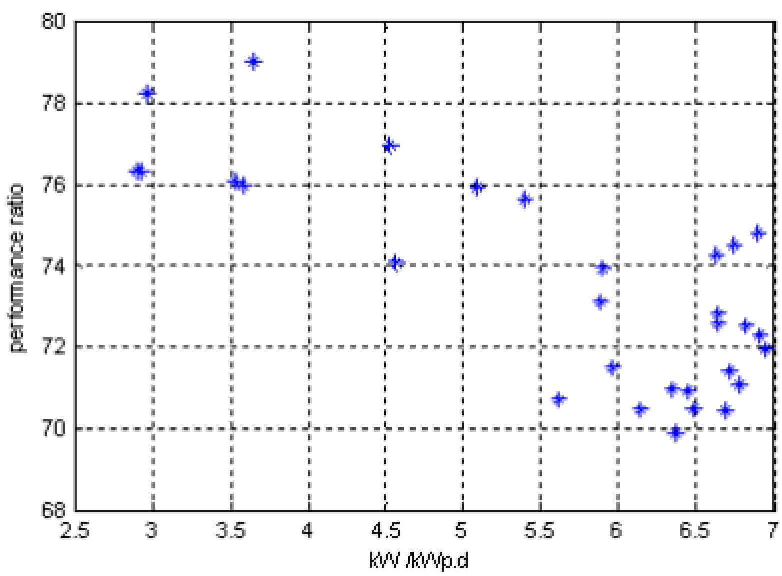

Fig. 8. Performance ratio versus reference yield (DC energy)

III. Conclusion

The results of this study show how monitoring this grid connected photovoltaic systems is still significant. The collected data is then processed, presented and stored in a database. In one set of these presentations the values of the parameters are stated in terms of time, while in the other the relation between the parameters is stated. We could render it easy to infer immediately the performance and capacity of the system as well as the system's operational state through the presentation formats that have been proposed in this study. Future research will focus on the installation of controllers that will keep the system operating at peak efficiency under all circumstances. Also, data is stored in a database, so this will be done because measurements are made in real time.

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