Investigating two thousand PV rooftop systems in the UK: Performance analysis and fault diagnosis

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The number of domestic PV systems has grown significantly in the UK in recent years, reaching over 660K installations by 2015. The largest PV monitoring effort to date in the UK has been the PV Domestic Field Trial (DFT) between 1999 to 2007. Up to the present time, numerous studies have been based on DFT datasets to explore performance issues and develop fault diagnosis methods (see for e.g. [1]). Over 15 years later, the DFT is still the only readily available dataset with both climatic and electrical readings of relatively high resolution. Today, domestic PV datasets are scarce and mostly comprise energy readings only, however, performance analysis is complete only when irradiance incident on the device is known. Moreover, due to the increasing number of domestic PV installations, it is important to collect and analyse performance data from as many current installations as possible. Several authors have worked towards this goal by delivering UK domestic sector performance statistics based upon energy readings donated directly from owners [2] often leading to biased results.

In the work presented here, monitored data from about 2000 domestic installations have been gathered from a monitoring portal, where installation dates are from 2011 and onwards. The aim is not only to deliver statistical analysis of energy production but also to investigate these systems in terms of both quality of measurements as well as reliability of PV system components. Therefore, the project aims at providing sensorless monitoring solutions and give the possibilities of carrying out "fleet-analysis. The objectives of the work are twofold; firstly to deliver useful data on specific yield (kWh/kWp) and performance ratio (PR), as well as to explore specific “problematic” systems further. The first aspect comprises an oversight of all systems’ performance whilst the second attempts to identify and evaluate causal factors for the highest deviations in the kWh/kWp distribution. The sources of problematic aspects might derive from a) bad quality measurements (missing data, wrong input information etc.), b) failure of PV components or c) sub-optimal installation characteristics. An initial insight into these systems is depicted in Figure 1, which shows that about 24% of the systems are worthy of further investigation. This could be due to erroneous or incomplete data, inverter failure, shading etc. Climatic data are not available, and therefore synthetic irradiance and temperature data will also be produced by using a methodology described in previous work [3] in order to deliver performance ratio analysis as a next step.
Annual kWh/kWp (2014) was calculated for 1750 systems installed in close geographic proximity. Results were normalised to the output of a system of similar average characteristics based on a PV-GIS prediction. Initial analysis shows that about 76% of the systems exhibit “expected” results while about 1% of the systems show abnormally high output, 5% show very low output and overall 20% generate well below expectations. The high number of systems requiring further analysis contradicts studies based on donated data which as it seems may not always be a reliable source. The paper develops a methodology designed to distinguish between the different causes of observed performance deviations including a) modelling system power output using a full PV system model and utilising available information on PV panels and inverters and b) modelling the local environment in terms of shading. The results of this work will be used in terms of rapidly identifying performance issues that are likely to exist in all domestic systems as well as providing guidelines for future installations.

