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ORIGINAL ARTICLE

A web-based three-tier control and monitoring application for integrated facility management of photovoltaic systems

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Abstract The architecture of a control system can be designed vertically with the distinction between functional levels. We adopt this layered approach for the design and implementation of a network-based control and monitoring application. In this paper we present the design and implementation of a network-based management application for controlling and monitoring the input and output data of remote equipment aiming at performance macro-observation, alarm detection, handling operation failures, installation security, access control, collection and recording of statistical data and provisioning of reports. The main services provided to the user and operating over the public internet and/or mobile network include control, monitoring, notification, reporting and data export. Our proposed system consists of a front-end for field (site-level) control and monitoring as well as a service back-end which undertakes to collect, store

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and manage data from all remote installations. Hierarchical data acquisition methodology and performance macro-observation are according to the IEC 61724 standard. We have successfully used our control and monitoring application for integrated facility management of photovoltaic plant installations; nevertheless it can be easily migrated to other renewable energy generation installations and remote automation applications in general.

1. Introduction

Due to the intensifying climate challenge, green growth is expected to be a very important issue in the next decades. Green growth strategies can help economies and societies become more resilient as they work to meet demands for food production, transport, housing, energy and water (Huang and Quibria, 2013; Jänique, 2012; Hallegate et al., 2012; Toman, 2012; Brown and Southworth, 2008; Gill et al., 2007; Rycrofta et al., 2000). A photovoltaic system (PV System) consists of one or more solar panels which convert sunlight into electric power. PV systems present a rapid growth with the installation of hundreds and thousands MWp (megawatt peak) per year and with a significant volume of clean power contributed to the electrical grid. The research in PV technology and inverters flourishes (Ekins-Daukes, 2013), while important capital is invested mainly because of favorable conditions in most markets, such as feed-in tariff, subsidies etc. (Fthenakis et al., 2009; Bagnall and Boreland, 2008). Combined with the various initiatives for energy efficiency, the installations of photovoltaic systems are steadily increasing. Photovoltaics are shifting from being a negligible power generation technology to a mainstream source of power (Woyte et al., 2013).

Such systems, however, cannot work efficiently if operations are not automated. Moreover, the need for improved performance of power systems in terms of reliability and higher productivity has necessitated more and more application of condition monitoring techniques (Wagle et al., 2008; Trovao et al., 2008). Therefore, the need of integrated facility management systems which control and monitor the solar park installations is imperative. The development of automated applications in the energy sector is significant, not only in industry but also for end-users. End-users increasingly demand products that use less energy, which conflicts with the growing demand for expanded functionality. Control and automation applications are developing solutions to reduce costs in time, money and effort of procedures aiming to improve the quality of relevant services and products. Fig. 1 depicts a PV system involving the photovoltaic and electrical equipment plus the monitoring system. The photovoltaic equipment comprises the solar panels, the solar panels mounting system, the inverters and the sensor box, while a controller implements the monitoring system.