Chapter 27
Grid Stabilization Effect of Combined Electricity Generation From Wind and Photovoltaic Systems in Murcia, Spain

Gino de Jesús Roa Escalante
Technical University of Cartagena, Spain

J. Miguel Sánchez-Lozano
University Centre of Defence at the Spanish Air Force Academy, Technical University of Cartagena, Spain

Juan-Gabriel Faxas
Technical University of Cartagena, Spain

M. Socorro García-Cascales
Technical University of Cartagena, Spain

Antonio Urbina
Technical University of Cartagena, Spain

ABSTRACT

In this chapter, a model that calculates the impact on the grid of the simultaneous injection of electricity both from photovoltaic and wind sources is presented. The best locations for wind and photovoltaic technologies within Región de Murcia, southeast Spain, have been selected from a GIS database and evaluated and classified using a fuzzy version of the multicriteria decision method called Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). After the classification, the best locations are selected for each technology. Then, the impact on the grid arising from the injection of power generated in wind of photovoltaic systems installed at these specific locations and that are connected to the grid has been calculated in a power range of several kWp, including random steps of up to 50kW. The results show that stable grid parameters are obtained within 500ms in all cases, even when this relatively large power surge (or variation) is considered.

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INTRODUCTION

Nowadays, industrial and urban development are mostly driven by fossil fuels thus creating important environmental problems, being green-house-gases (GHG) emissions the best known. Alternative resources in power generation are being developed with the aim of meeting the increasing demand of energy but at the same time reducing the GHG emissions: renewable energy technology is the best choice for this purpose. Within the broad range of renewable options, wind and photovoltaic technology have been the most rapidly growing technologies worldwide. The electricity generation mix of any country in the world is increasingly incorporating a larger contribution of renewable energy supply (International Energy Agency, 2012; European Commission, 2013; Red Eléctrica Española, 2013). The electricity grid of such countries needs to match in real time the supply and demand of electricity, i.e. the electricity injected to the grid at a given time has to be the same as the electricity consumed by the users at the same time (European Commission, 2013). This is a challenge when renewable sources represent a large share of the electricity mix, and the road toward sustainability will require management of different intermittent sources probably with a storage back-up (International Energy Agency, 2012). This matching is usually guaranteed by the grid manager, which has the authority to allow or block the electricity input to the grid from different suppliers, and usually prioritizes generation from renewable sources. It has been alleged that a large amount of renewable electricity supply could become unmanageable because it depends strongly on uncontrollable environmental parameters such as wind speed or irradiance, which may vary strongly with geographical location or time (during same day or seasonal variations) (Prescott, 2004). Nevertheless, contrary to these allegations, a larger input of renewable energy, in particular from wind and photovoltaic sources in a given geographical region of large enough size can have a stabilizing effect to the grid (Chu, 2012), even for PV-only integration (Lund, 2006; Marcos, 2012). In order to benefit from this complementarity, a careful selection of the best location for installing the energy system is required.

The search and selection of optimal locations to install renewable energy facilities, requires not only to have an advisory group able to assess and analyze alternatives, but also to apply a set of tools and methods to facilitate the decision making process (Pohekar & Ramachandran, 2004). The problem of selecting the optimum location for renewable energy facilities is a complex problem because it needs to handle a great variety of criteria of different nature and origin, as well as to evaluate, in most cases, a large number of alternatives. For this purpose, Multicriteria Decision Methods (MCDM) (Roy, 1968; Saaty, 1980; Hwang & Yoon, 1980) are the main methods to tackle this type of problems (Al-Yahyai, Charabi, Gastli, & Al-Badi, 2012) by combining them, on the one hand with Geographical Information Systems (GIS) (Janke, 2010; Van-Haaren & Fthenakis, 2011) that will be used as support database to our problem, and on the other hand, with Soft Computing (Zadeh, 1994) tools applied to the own decision methodologies which gives them the uncertainty modeling and vagueness typical of the data used in this type of problems.

Once the first step of selection of the optimum location is accomplished, it is necessary to monitor the environmental parameters (or access to databases) which provide a measure of the potential renewable energy resource is required. From this data, simple models to calculate the electricity output provided by the technology of choice can be easily implemented, thus completing the required amount of information before taking any decision about the final installation of the energy systems, which usually involves a large economic investment.

For the particular case study proposed in this chapter, a combination of multicriteria decision methods with GIS as support database and Soft Computing, specifically the Fuzzy Logic (Zadeh, 1965) and