Chapter 13
Prediction of Solar and Wind Energies by Fuzzy Logic Control

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ABSTRACT

Nowadays, the use of renewable energy has become increasingly significant, and cost-effective. Between all existing sources of energy, solar and wind energies are the highly exploited. However, solar and wind energies are not available all the time and their performance is affected by unpredictable weather changes, therefore, it is not always feasible to obtain an accurate mathematical model of the controlled system. Various mathematical modeling methods were used to predict wind and solar powers using natural parameters but considering multiple parameters in equations makes the solution more complex. In addition to complexity, some coefficients are uncertain and based on probability. Fuzzy logic is a perfect tool to model any kind of uncertainty related to vagueness. This chapter presents a computer algorithm based on fuzzy logic control (FLC) to estimate the wind and solar energies using natural factors. As input parameters, the wind speed was used to predict the wind power and the temperature and the lightening were used to estimate the solar power.

INTRODUCTION

Recently, governments and industries all around the world are progressively trying to find alternatives to overcome the significant increase in the prices of conventional energy sources and to minimize the greenhouse gas emissions (GHC) and the resulting global warming. For these reasons, the implementation and diffusion of renewable energies as well as the establishment of a low-carbon economy have been subject of research in many regional and international initiatives, institutions and financial mechanisms

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(Fritzsche, Zejli, & Tanzler, 2011). In contrast to fossil energy, renewable energy comes from resources which are continually refilled such as:

- Sunlight,
- Wind,
- Rain,
- Tides,
- Waves, and
- Geothermal Heat, and it must be harvested when it is available.

From all existing renewable energy sources, solar energy especially photovoltaic panels (PV) and wind turbines are the best shared resources of energies and therefore those that lend themselves best to the decentralized production of electricity. However, solar and wind energies are not available all the time and their performance is affected by unpredictable weather changes. They also rely on natural factors which require the use of many variables to simulate the operation of the renewable sources as accurate as possible. It is also difficult to predict the power as it is not always feasible to obtain an accurate mathematical model of the simulated system.

Over the past three decades, several models have been developed in order to generate the solar irradiance data based on stochastic models such as:

- Autoregressive (AR),
- Autoregressive moving average (ARMA),
- Autoregressive integrated moving average (ARIMA), and
- Markov chain (Aguiar & Collares-Pereira, 1992; Mora-Lopez & Sidrach De Cardona, 1998; Santos, Pinazo, & Canada, 2003; Maafi & Adnane, 1989).

Nevertheless, these models, based on the probability estimation, do not always give accurate results as they require the precise definition of problem domains as well as the identification of mathematical functions. This is why most stochastic models were found with relatively big errors and sometimes difficult to be adopted widely. Fuzzy modeling was also used with neural networks in (Chen, Gooi, & Wang, 2013) to forecast solar radiation at different weather conditions for a grid-connected photovoltaic system. It was also used in (Rizwan, Majid, Kirmani, & Kothari, 2014) to model and estimate the global solar energy in smart-grid applications using various parameters that require precise measurement. These parameters are:

- The mean duration sunshine per hour,
- Temperature,
- Latitude,
- Longitude,
- Altitude, and
- Months of the year.