Chapter 7

Fuzzy Logic in Wind Energy

Imanol López Goiti
University of the Basque Country, Spain

ABSTRACT

The use of wind energy for power generation purposes plays a major role in the current electrical market and is becoming increasingly attractive. The good exploitation of this kind of energy may improve the power generation capabilities and therefore reduce generation costs. Fuzzy Logic methodology can be used to improve the current technology. In this chapter, Fuzzy Logic is proposed as a technique that assesses wind sites and predicts annual generation for wind turbines. Moreover, it is also proposed to maximize the power search and control the power electronic converter of the wind turbine. Fuzzy Logic should be considered as a real alternative to the typical methods for the exploitation of wind energy. It can improve wind power generation with high performance and efficiency.

INTRODUCTION

Due to the increase of the environmental concern during the 20th Century, researchers’ focus has recently been moved from conventional electricity sources, to renewable and alternative energy solutions. In fact, several renewable power generation sources have rapidly been developed in the last decades: solar energy, wave energy, hydro power and, last but not least, wind energy. In renewable power generation, wind energy has been the fastest-growing energy technology in the world. This is due to the huge resources of wind energy and the technological development of recent years, bringing more efficient and more reliable wind turbines (EWEA, 2012). Main current technological advances in variable-speed wind turbines, power electronics, drives, controls and grid code compliances, have made wind energy really competitive with conventional electricity sources.

Wind energy is a technology which offers remarkable advantages that should be pointed out: it produces no greenhouse gases and can make a significant contribution to the regional electricity supply. Moreover, it requires a very short lead time for planning and constructing as compared to conventional power projects. Finally, wind energy projects are flexible with regard to an increasing energy demand (single turbines can easily be added to an existing wind farm).

DOI: 10.4018/978-1-4666-6631-3.ch007
The good exploitation of this kind of energy may improve the power generation capabilities and, therefore, reduce generation costs. At this point, the development of several Soft Computing techniques could help to improve it, maximizing its capacity factor and participating in the generation of electricity at even better costs. These are some practical examples of Soft Computing applications in wind power:

- Development of a control system capable to protect the energy conversion system from gusts, using Recurrent Neural Network.
- Development of a control system to extract the maximum energy from variable speed wind turbines, using Fuzzy Logic.
- Site selection, performance prediction and planning of wind turbines, using Artificial Neural Networks.
- Online condition monitoring, failure detection and diagnostic, predictive maintenance scheduling…, using Artificial Neural Networks and Fuzzy Logic.

Fuzzy Logic methodology is a Soft Computing technique that can help to develop current technology in several fields:

- Evaluation of wind sites in the bases of their benefits and costs and prediction of the annual generation.
- Maximization of the power delivery to the grid from the available wind power.
- Control of the power electronic converter and self-tuning of Proportional Integral (PI) regulators for grid code compliance.

This chapter will show how theoretical implementation of a Fuzzy Logic system can be applied to improve wind energy technology in the previously mentioned fields.

BACKGROUND

As it has just been mentioned, Fuzzy Logic can be applied to improve several fields of wind energy (wind site assessment, maximum power search and control of power electronic converter). So as to understand how this Soft Computing methodology can be combined with wind energy, it is advisable to initially include a broad definition of a Fuzzy Logic system and also, generic techniques employed in each of those fields.

Fuzzy Logic System

The process of Fuzzy Logic is explained now: firstly, a crisp set of input data are gathered and converted into a fuzzy set using fuzzy linguistic variables, fuzzy linguistic terms and membership functions. This step is known as fuzzification. Afterwards, an inference is made based on a set of rules. Lastly, the resulting fuzzy output is mapped to a crisp output using the membership functions, in the defuzzification step. This is shown in Figure 1.