Chapter 16
Methods of Forecasting Solar Radiation

Rubita Sudirman
Universiti Teknologi Malaysia, Malaysia

Muhammad Noorul Anam Mohd Norddin
Universiti Teknologi Malaysia, Malaysia

ABSTRACT

Extreme demands on the methods used for forecasting solar radiation has been the driving force behind the efforts to find the best method available. An extensive study of different techniques available was conducted. Methods studied in this research can be classified as time series and neural network approach. Time series approaches considered are autoregressive (AR), moving average (MA), autoregressive moving average (ARMA), and autoregressive integrated moving average (ARIMA). In neural network approaches, multi-layer perceptron networks are used. The error back-propagation learning algorithm is utilized in the training process. Comparison of methods and performance of different methods are presented in the result and discussion section of this chapter. The solar radiation data used were a collection of past data acquired throughout the US continent for 10 years period. These data were used to forecast future solar radiation based on the past trend observed from the database using both time series and neural network approaches. Finally, this chapter makes general comparison among the methods used and outlines some advantages and disadvantages of using the neural network approach.

INTRODUCTION

Energy resources that are renewed on short term basis are designated as renewable energy resources. Almost all renewable energy resources considered for utilization at the present time are traced back to the sun. Wind energy, solar radiation and heat, waterfalls, and biomass are different manifestations of solar energy and they have received most of the attention. They are fairly evenly distributed around the world and are plentiful (Ramakumar, Allison, and Hughes, 1974, pp. 107-115). However, these resources are dilute and conversion to usable forms requires quite an expensive tools.
Solar radiation is the emission of photons from the sun. One of the ways these photons can be utilized is by means of the photoelectric effect: the primary effect of photons on solids. This effect was discovered by H. Hertz in 1887. The generation of a potential when the region in or near the built-in potential barrier of a semiconductor ionized by radiation is known as the photovoltaic effect. Photovoltaic effect was known long before its feasibility for direct energy conversion (Chaplin et al., 1954, pp. 676-677).

The concept of utilizing solar radiation for power generation using solid-state power plants has gained momentum (Moore, 1985, pp.6-19; Hoff and Shushnar, 1986; Calvo, 1995, pp. 916-921). The recent interest is primarily due to the decreasing cost of photovoltaic devices, coupled with their increasing conversion efficiencies. Solar heat is due to thermal agitation of matter initiated by the absorption of solar radiation. The sun has been used as a source of heat for a long time. For example, solar heat has been used, and still is, in many countries by farmers to dry their crops (Morhenne, et al., 1985, pp.1072-1076).

Solar energy has been used for space heating and cooling since the fifth century B.C. Recently, the concept of utilizing the sun as a source of energy for heating purposes has also been gaining momentum (Kenna, 1984, pp.687-705).

Solar radiation is probably the most fundamental source of energy on earth. It activates not only the vital biological processes but also all meteorological systems. This is a significant variable that can affect the growth rates of crops, and is used in numerical models to estimate soil moisture, potential evapotranspiration, and photosynthesis (Tarpley, 197; pp.1172-1181). During recent years there has been an increasing trend in the study of solar radiation, due to the fact that the sun is practically the sole source of energy in the earth-atmosphere system. The requests for international solar radiation information have increased with the growing interest, especially in the use of renewable energy resources.

### Solar Activity

Early earth-based measurements suggested that solar output was nearly constant; it varied within one percent imposed by absorption and scattering of sunlight in earth atmosphere (Gopal and Scuderi, 1995, pp.42-59). Satellite measurements made from the Solar Maximum Mission and Nimbus-7 showed constant changes of up to 0.1 percent for the most recent eleven-year sunspot cycle of the solar activity (Gopal and Scuderi, 1995, pp.42-59). The maximum of sunspots and solar activity is associated with a brighter sun.

Solar activities are rising rapidly. This causes an increase in the production of x-rays and extreme ultraviolet radiation (EUV) in the range of 100 and 1000 angstroms. The ultraviolet (UV) and EUV radiation varies and this matter has as a strong influence on the upper atmosphere of the earth. High solar activity also increases EUV radiation; it results in an increase in the temperature of the ionosphere. This temperature is three times greater than normal at 100 kilometers and above in the atmosphere. The increase in ultraviolet radiation in the upper atmosphere is also important because it affects stratospheric ozone levels (Gopal and Scuderi, 1995, pp.42-59). High solar activity can effect communication, computer systems, and can produce geomagnetic storms. These storms can induce electrical currents in power lines and oil pipelines at the earth’s surface (Gopal and Scuderi, 1995, pp.42-59).

### Nature of Solar Radiation

Solar energy has consistently been the most popular customer energy option in surveys conducted over past 20 years, prompting dozens of customer-focused utilities to exploit the solar energy to gain a competitive edge. Although such utilities are enticed in term of operating cost reduction, the chance to offer profitable and appealing products, and the chance to serve new customers their interest is not limited to what is cost effective and available.