Chapter 16
Big Data Storage for the Modeling of Historical Time Series Solar Irradiations

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ABSTRACT

This chapter proposes Big Data Analytics for the sizing and locating of solar photovoltaic farms to reduce the total energy loss in distribution networks. The Big Data Analytics, which uses the advance statistical and computational tools for the handling of large data sets, has been adopted for modeling the 15 years of solar weather data. Total Power Loss Index (TPLI) is formulated as the main objective function for the optimization problem and meanwhile bus voltage deviations and penetrations of the PV farms are calculated. To solve the optimization problem, this study adopts the Mixed Integer Optimization using Genetic Algorithm (MIOGA) technique. By considering different time varying voltage dependent load models, the proposed algorithm is applied on IEEE 33 bus and IEEE 69 bus test distribution networks and optimum results are acquired. From the results, it is revealed that compared to single PV farm, the integration of two PV farms reduced more energy loss and reduced the total size of PV farms. Big Data Analytics is found very effective for the storing, handling, processing and the visualizing of the weather Big Data.

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INTRODUCTION

Due to the inadequate fuel reserves, the power producers are considering to use renewable energy sources for the development of new power plants. Unlike the conventional large scale power stations, the new small and medium sized power stations are installed near the distribution stations, also known as Distribution Generation (DG) (Liu, Wu, Tu, Huang, & Lou, 2008). The concept of using renewable energy resources for producing electricity has been globally accepted and it is expected that electricity production in coming years will mainly depend on solar and wind energy (Lee et al., 2012).

The major advantages of using renewable energy sources over the traditional power producing technologies are reflected as environment-friendly and fuel-free sources. Some of these sources especially wind and solar energy are rapidly growing and are becoming more competitive, because per unit cost of electricity, produced through wind turbines and solar Photovoltaic (PV) modules is much cheaper than the cost of electricity produced by conventional power generation technologies (Kost et al., 2013). In recent years, several studies have covered the technical possibility of an electric system that can be powered through renewable energy sources (Ćosić, Krajačić, & Duić, 2012; Plebmann, Erdmann, Hlusiak, & Breyer, 2014). Research suggests that in 2050, 80% of total U.S. electricity demand could be supplied by using existing renewable electricity technologies (Bazilian et al., 2014).

Among the other renewable energy sources, solar PV technology is getting more mature and popular (Tyagi, Rahim, Rahim, Jeyraj, & Selvaraj, 2013). This is mainly due to the availability of solar irradiances, ease of operation & maintenance (O&M), environmental benefits, increasing efficiency and reduced cost of PV panels (Aman et al., 2015; Devabhaktuni et al., 2013). The Photovoltaic (PV) technology converts sunlight directly into electricity without using any fuel. The upper surface of the atmosphere of the earth receives 174 Peta Watts (PW) of solar energy, and it is naturally available across many parts of the world. Most PV modules come with 15 - 25 years of warranties of their rated power outputs and these modules require virtually no maintenance during their life. The efficiency of commercial silicon modules has dramatically seen improvements since the last decade and in recent days, some manufacturers are claiming to have prototypes of PV modules with efficiency up to 22.5% (Panasonic, 2015). The maintenance required for solar PV systems is mostly the cleaning of the panels.

The output of PV module mainly depends on the solar irradiations but this is also affected by temperature. Surface irradiations are measured as Watt/m^2. The ideal irradiation required for a PV module to produce maximum power output is 1000 Watt/m^2 at temperature of 25 ^{0}C (Al Riza & Gilani, 2014). For a single day, total irradiations for any location are measured as Watts/m^2/day. This value for any location varies seasonally and depends on duration of sunny hours of a day. Normally summer months have longer days and therefore have more Watt/m^2/day and winter months have shorter days and have less Watt/m^2/day. Average daily irradiation for a sunny country is about 5-6 kilowatt/m^2/day. So a 1 kW solar PV system can produce 5-6 kilowatt-hour energy on daily basis. However this may be affected if temperature of the location is high.

In addition to the supply of electricity, distributed generators or generation (DGs) are considered beneficial for reducing system losses, voltage improvement, system load-ability enhancement and network upgradability (Theo, Lim, Ho, Hashim, & Lee, 2017). However, one should expect these benefits if installation of DG is done without any planning. If not properly designed, the installation of oversized DGs in distribution network will increase the overall system losses (Passey, Spooner, MacGill, Watt & Syngellakis, 2011). The negative effects of DGs in distribution networks were identified by (Acharya,