

Chapter 28

Application of Data Mining and Analysis Techniques for Renewable Energy Network Design and Optimization

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ABSTRACT

Energy supply is characterized by its diversity, including traditional energy, such as fossil fuels, nuclear power, as well as renewable energy, such as solar, hydroelectric, geothermal, biomass, and wind energy. It involves a complex network system composed of energy generation, energy transformation, energy transportation, and energy consumption. The network does provide the great flexibility for energy transformation and transportation; meanwhile, it presents a complex task for conducting agile energy dispatching when extreme events have caused local energy shortages that need to be restored timely. One of the useful methodologies to solve such a problem is data mining and analysis. Their main objective is to take advantage of inherent tolerance of the imprecision and uncertainty to obtain tractability, robustness, and low solution-cost. The applications and developments of data mining and analysis have amazingly evolved in the last two decades. Many of these applications can be found in the field of renewable energy and energy efficiency where data mining and analysis techniques are showing a great potential to solve the problems that arise in this area. In this chapter, data mining and analysis techniques are briefly introduced. Then the implementation procedures are presented to demonstrate the application of curve fitting for renewable energy network design and optimization, which has the capability to handle the restoration during extreme and emergency situations with uncertain parameters.

INTRODUCTION

Renewable energy is a socially and politically defined category of energy sources. Renewable energy is generally defined as energy that comes from resources which are continually replenished

on a human timescale such as sunlight, wind, rain, tides, waves and geothermal heat. About 16% of global final energy consumption comes from renewable resources, with 10% of all energy from traditional biomass, mainly used for heating, and 3.4% from hydroelectricity. New renewable

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energy (small hydro, modern biomass, wind, solar, geothermal, and bio-fuels) accounted for another 3% and are growing rapidly. The share of renewable energy in electricity generation is around 19%, with 16% of electricity coming from hydroelectricity and 3% from new renewable energy (Energy Information Administration, 2013). These energy types have realized multiple choices to form a complex network system composed of energy generation, energy transformation, energy transportation, and energy consumption. The network should provide the great flexibility for energy transformation and transportation; meanwhile, it should also complete a complex task for conducting agile energy dispatching when extreme events have caused local energy shortages. Actually, any type of dispatched energy under certain emergency condition has its own characteristics in terms of availability, quantity, transportation speed, and conversion rate and efficiency to other types of energy. Thus, different types of energy should be dispatched through a superior plan. For instance, energy sources such as petroleum or coal can be directly transported to a suffered area; meanwhile, they can also be converted to electricity in a source region and then sent to the suffered area through an available electricity network. Sometimes, even the transportation of the same type of energy may have different alternative routes for selection, which needs to be optimally determined from the view point of the entire energy dispatch system.

One of the useful methodologies to solve such kind of problem is data mining and analysis (Fayyad, Piatetsky-Shapiro, Smyth, & Uthurusamy, 1996). Actually Data mining is an interdisciplinary subfield of computer science to discover the knowledge in the database process (Hand, 2007). It is the computational process of discovering patterns in large data sets involving methods at the intersection of artificial intelligence, machine learning, statistics, and database systems (Han,

Kamber, & Pei, 2006). The overall goal of the data mining process is to extract information from a data set and transform it into an understandable structure for further use. Aside from the raw analysis step, it involves database and data management aspects, data pre-processing, model and inference considerations, interestingness metrics, complexity considerations, post-processing of discovered structures, visualization, and online updating. Their main objective is to take advantage of inherent tolerance of the imprecision and uncertainty to obtain tractability, robustness and low solution-cost. The applications and developments of data mining and analysis have amazingly evolved in many applications in the last two decades (Fayyad, Piatetsky-Shapiro, & Smyth, 1996). It can also be used in the field of renewable energy and energy efficiency where data mining and analysis techniques are showing a great potential to solve the problems that arise in this area, such as energy network dispatch (Cai, Zhao, & Xu, 2012). In this chapter, several data mining and analysis techniques will be briefly introduced. Then the methodology framework and implementation procedures will be presented to demonstrate the application of artificial neural networks and curve fitting for renewable energy network design and optimization which has the capability to handle the restoration during the extreme and emergency situations with the uncertain parameters.

MOTIVATION

The energy analysis and impact assessment provide analysis on the energy consumption and the associated social, economic, and environmental impacts, including human health, greenhouse gas emissions, and global climate change. Facing the challenges of emergency response to energy shortage, decision makers often encounters various

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