Chapter 7
Application of Soft Computing Techniques for Renewable Energy Network Design and Optimization

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ABSTRACT

Energy operation can be characterized by its complex network system composed of energy generation, energy transformation, energy transportation, and energy consumption. The network has provided 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 timely be restored. One of the useful methodologies to solve such a problem is soft computing, which conducts collaboration, association, and complementariness of the different techniques that integrates them. The applications and developments of soft computing 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 soft computing techniques are showing a great potential to solve the problems that arise in this area. In this chapter, several soft computing techniques are briefly introduced. Then the methodology framework and implementation procedures are 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 restoration during extreme and emergency situations with uncertain parameters.

INTRODUCTION

Nowadays 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

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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. The design and optimization of energy network needs to investigate the environment impact of current power plants in order to replace the fuel combustion method with renewable energy facility and integrate the consideration of the energy restoration during the emergency situation of regional shortage.

The energy network optimization actually involve a lot of factors such as climate change trend, regional energy demand forecast and regional environment impact assessment of traditional power plant operation with fuel combustion. The modeling and optimization to reversely determine the dynamic emission rate and search for the optimal energy restoration is always a high nonlinear multi-objective MINLP (Mixed Integer Nonlinear Programming) problem, which is difficult to solve with current deterministic MINLP solvers. Thus, the solving algorithm of multi-objective genetic algorithm (MGA) will be a good choice. MGA can directly obtain Pareto frontier of the raised two objectives from all possible patterns under different optimal scenarios. Furthermore, since the entire local area might be investigated, the whole region needs to be partitioned into a large number of grid cells and energy condition and its impact of each cell will be calculated. Thus, the optimization will involve lots of simulations, causing the simulation duty during the optimization is very heavy. All these operations are full of uncertain situations.

Facing these challenges, decision makers often encounters various uncertainties that inevitably influence the performance of a being designated energy dispatch plan. The uncertainties can upset the optimality and even the feasibility of the dispatch plan. Thus, quantitative analysis on the impact of uncertainties is of great significance for the study of energy network optimization. Technically, a viable approach is to conduct a full evaluation of the effects of uncertainties based on all their possibilities. This will provide decision makers a complete roadmap of the space of uncertainty parameters. Through this way, the objective function and the optimization parameters are represented as functions of uncertainty parameters (i.e., parametric programming); meanwhile, the regions in the space of the uncertainties characterized by these functions can be obtained. Therefore it is very useful for the stake holders to apply spatial and temporal predictive analysis techniques during the optimization of energy network operation. Among them, the soft computing techniques and artificial neural networks can be adopted to achieve the above purpose.

SOFT COMPUTING TECHNIQUES

Soft computing is a term applied to a field within computer science which is characterized by the use of inexact solutions to computationally hard tasks such as the solution of NP-complete problems, for which there is no known algorithm that can compute an exact solution in polynomial time. Soft computing differs from conventional (hard) computing in that, unlike hard computing, it is tolerant of imprecision, uncertainty, partial truth, and approximation. In effect, the role model for soft computing is the human mind. In computer science and related fields, artificial neural networks (ANNs) are computational models inspired by animals' central nervous systems (in particular the brain) that are capable of machine learning and pattern recognition. They are usually presented as systems of interconnected "neurons" that can compute values from inputs by feeding information through the network. These techniques have a very wide application(Ganesan, Elamvazuthi, Shaari, & Vasant, 2013; Elamvazuthi, Vasant & Ganesan, 2013; Vasant, 2013; Ganesan, Vasant, & Elamvazuthi, 2013; Ganesan, Elamvazuthi, Ku Shaari, & Vasant, 2013)