Chapter 1

Load Management Using Swarm Intelligence:
Dynamic Economic Emission Dispatch Optimization

Oliver Dzobo
https://orcid.org/0000-0001-9602-6835
University of Johannesburg, South Africa

Yanxia Sun
University of Johannesburg, South Africa

ABSTRACT

This chapter presents a generalized day-ahead combined dynamic economic emission dispatch (DEED) problem incorporating demand response (DR) strategy for power system networks with mutual communication between electricity customers and power utility. A nonconvex mixed binary integer programming technique is used to solve the demand response optimization problem. Fixed and flexible home appliances connected as load to the power system network are considered in the demand response strategy. The optimization of the DEED problem is done using particle swarm optimization (PSO) technique. The proposed PSO algorithm takes into account thermal power generation unit ramp rates and their power generation constraints.

INTRODUCTION

The current planning, implementation and monitoring of power utility activities is now designed to influence electricity customer's use of energy in ways that will produce desired changes in the power system network load shape (Sethaolo, Xia, & Zhang, 2014; Morais, Faria, & Vale, 2014; Yoon, Bladick, & Novoselac, 2014; Parvania & Fotuhhi-Firuzabad, 2010). This is enabled by embedding intelligence into the power system network grid so that electricity customers and the power utility are able to mutually

DOI: 10.4018/978-1-5225-8551-0.ch001

communicate between each other (Khajavan, Monsef, & Abniki, 2010; Alami, Yousef, & Moghadam, 2010; Fahrioglu & Alvarado, 2001). Demand response and dynamic economic dispatch are two control strategies that are employed by electricity customers and power utility.

Demand response plays a very important role in facilitating the interaction between the electricity customers and the power utility. It has been estimated that it could translate into as much as US$ 59 billion in societal benefits. There are two basic demand response strategies employed by most power utilities (Nwulu, Xia, & Zhang, 2013; Fahrioglu & Alvarado, 2000). The first strategy is incentive based demand response where incentives options are given to electricity customers to reduce or curtail their loads when the power system network is stressed. The incentive can be in the form of rebates or lower electricity tariffs. The second strategy is price based DR strategy which uses time-of-use (TOU) or real time electricity tariffs to encourage electricity customers to curtail their loads during periods of higher electricity price and take advantage of favorable lower electricity prices. An example of a price based DR strategy is when the price of electricity is calculated using a three-tier electricity pricing; at peak, off-peak and standard times.

Dynamic economic dispatch (DED) results in great economic benefits in power system operation. The objective of the DED is to minimize the fuel consumption cost of committed thermal power generation units used to supply a given power system network load over a time horizon under ramp rate constraints and other constraints (Elaiw, Xia, & Shehata, 2012; Basu, 2006; Xia & Elaiw, 2010). Most recently pressure from environmental agencies have forced many power utilities to consider the amount of emissions from their thermal power generation units. Power utilities are requested to reduce emission of gaseous pollutants such as SO2; NOx; CO; and CO2 from fossil fuel fired thermal power generation units as they are hazardous to human health and the environment (Nwulu & Xia, 2015; Talaq, El-Hawary, & El-Hawary, 1994; Jeddiand & Vahidinasab, 2014; Xia & Elaiw, 2010; Basu, 2014). Commonly, the dynamic economic emission dispatch (DEED) mathematical problem is used to determine the optimal scheduling of the committed thermal power generation units output whilst supplying the power system network load over a scheduling period at minimum fuel operating cost and emission simultaneously under a set of constraints. In Xia & Elaiw (2010) and Basu (2014), a review of various dynamic economic dispatch (DED) mathematical formulations and solutions methods that have been applied to solve the problem are presented. In most cases, power utilities solve DEED with other associated tasks like unit commitment and also most recently with the incorporation of renewable energy sources like wind and solar energy (Osorio, Lujano-Rojas, Matias, & Catal, 2015; Aghaei, Niknam, Azizipanah-Abarghooee, & Arroyo, 2013).

Several research studies have considered DEED and DR optimization models separately when applying it to power system network management. The DEED optimization model is solely concerned with the supply end of the power system network while the DR optimization problem is applied to the demand side of the power system network. The shortfall of these approaches is that they are presented as a simplified problem without considering the cost saving opportunities that may exists between the simultaneous interaction of DEED and DR optimization models. Thus, they may forge some practical suboptimal electricity customer energy usage behavior as well as higher short-term marginal electricity production costs than they would otherwise be in an optimally efficient system. The disconnection between electricity production costs and overall electricity usage may lead to inefficient retail electricity price rates paid by electricity customers, higher fuel consumption cost and large amount of gaseous pollutants emission. This problem has resulted in an increasing need to convert electricity customers into active participants who engage with the power utility to balance electricity production costs and overall

Related Content