Chapter 13
Integration of Demand-Side Management Programs and Supply-Side Alternatives for Decentralized Energy Planning:
An Analysis of Energy Import and Export Effects

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ABSTRACT

Optimally selection of an appropriate mix of renewable sources for supplying electricity of remote areas has been always an important challenge for policy makers. Also, in recent years, the great advantages of Demand Side Management (DSM) programs such as postponing investments in construction of new plants and/or desirably modification of electricity consumption pattern has turned great attention of energy planners to these programs. Moreover, the issue of global warming has caused the need for reduction of human use of fossil fuels and switching to employing green energy sources. To address the mentioned concerns, in this paper, an integrated mathematical formulation for selecting the best mix of renewable energy technologies is proposed. In this study, DSM considered as a competitive option against supply-side alternatives for making energy planning decisions. Additionally, by considering real data from a case in Iran, the effects of considering energy import and export has been taken into account. To validate the model, for smaller-scaled test problems the model has been solved by Lingo 8.0 software while for solving larger instances of problems (real scale of case study) a novel genetic algorithm (GA) is devised. The numerical results indicate that DSM policies have made use of their maximum capacity and resulted in significant improvements, especially in terms of reducing consumption and suitably changing the load shape.

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INTRODUCTION

Environmental concerns like global warming and climate change along with other factors such as recent financial crisis, the ever-increasing electricity demand, obligations to reduce greenhouse gas (GHG) emissions and current tendencies to achieve sustainable development, has led world leaders to expedite the process of replacing fossil fuels with renewable energies (RE) (Kyoto protocol - unfccc.int/kyoto_protocol/items/2830.php). Likewise, utilizing demand side management (DSM) strategies has ever more attracted the attention of policy makers. The higher the utilization of DSM policies is, the lower the need for investments in new power plants will be (Ardakani & Ardehali, 2014). As a result, not only GHG emissions will be remarkably reduced but also funds previously designated for constructing power generation plants will find the opportunity to be invested in more profitable settings.

There are a variety of RE technologies each of which has its own advantages and disadvantages. Thus, making a conscious decision on choosing an appropriate mix of different types of RE plants and determining their locations and capacities has always been a challenging task. Furthermore, there are different end-use sectors and accordingly different DSM programs suitable for each sector. Moreover, to reach the optimal energy planning decision, demand side resources must be compared to supply side alternatives (Kreith & Goswami, 2007). The above mentioned concerns show the need for an integrated modeling of the system such that helps policy makers come to the best decision.

Optimal designing wind park, solar plants, DSM programs and other RE systems have been extensively studied in the literature. However, none of which considers these different supply-side and demand-side alternatives all together. Because of this, we are going to integrate these options as a comprehensive model by considering effects of environmental parameters, possibility of importing and exporting of electricity, different RE options and DSM techniques and finally determining the best mix of energy technologies.

Among many approaches used for planning of energy in the literature, the most frequent ones include Linear Programming (LP) models (Ramakumar et al. 1986; Devadas, 2001), Delphi study (Iniyan & Jagadeesan, 1997), Optimal Renewable Energy Mathematical model (OREM) (Iniyan et al. 1998; Ini-yanet.al, 2000) and etc. Hiremath (Hiremath e al. 2007) provided a great literature review on the new approaches and models toward decentralized energy planning (DEP). (Senjyu et al. 2007) and (Lagorse et al. 2009) used genetic algorithm for solving a DEP model. Herran and Nakata (Herran & Nakata, 2008) employed a goal programming (GP) approach to obtain satisfactory pareto optimal solutions to a DEP problem. Hiremath et al. (Hiremath et al. 2009) and Kanase-Patil et al. (Kanase-Patil et al. 2010) developed new models for decentralized energy planning in rural areas while they used GP method to solve their multi-Objective optimization model as well. Hessami and Bowly (Hessami & Bowly, 2011) studied the economic benefits of utilizing large-scale and different energy storage systems. The objectives sought to be optimized in the above mentioned studies are of either minimization or maximization type. The former type includes objectives such as total cost, utilization of petroleum products, etc. while the objectives of the latter type are system performance, utilization of available local resources and so forth.

As discussed earlier, global warming and climate change have caused GHG emissions to be regarded as an important problem in the last decade (Leung & Yang, 2012). For this reason, recent studies have tried different approaches such as changing the type of fuel Consumed (Sims et al. 2003), utilizing different renewable energy sources (Panwar et al. 2011; Hessami et al. 2011), new energy planning methods (Tsioliaridou et al. 2011) by applying mixed integer programming, goal programming (Cristóbal, 2012) and multi-objective evolutionary algorithms (Hashim et al. 2005; Agustín et al. 2006; Katsigiannis et al. 2010) for reducing the amount of these pollutants.