Chapter 2
Energy Cost Saving Tips in Distributed Power Networks

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ABSTRACT

This chapter studies energy cost saving strategies in power networks. A prosumer is a user that not only consumes electricity, but can also produce and store electricity. Three tips are considered: distributed power network architecture, peak energy shaving with the integration of prosumers' contribution and prosumers market. The proposed distributed power network architecture reduces significantly the transmission costs and can reduce significantly the global energy cost up to 42 percent. Different types of prosumer who use self-charging renewable energy systems, are able to intelligently buy energy from, or sell it, to the power grid. Therein, prosumers interact during the purchase or sale of electric power using a double auction with negotiation mechanism. Using a two-step combined learning and optimization scheme, each prosumer can learn its optimal bidding strategy and forecast its energy production, consumption and storage. Our simulation results show that the integration of prosumers can reduce peak hour costs up to 17 percent and 6 percent for eligible prosumers.

INTRODUCTION

As energy efficiency and clean energy technologies become more common, system challenges require to rethink traditional paradigms of energy system planning and operation. Historically, central plants have been an integral part of the electric grid, in which large generating facilities are specifically located far from populated load centers. These, in turn, supply the traditional transmission and distribution grid that distributes bulk power to load centers and from there to consumers. Nowadays, distribution generation technologies have open the door to decentralized or distributed power network management systems. For reasons of reliability, distributed generation resources would be interconnected to the same transmission grid as central stations. Various technical and economic issues will occur in the integration of these

DOI: 10.4018/978-1-5225-0072-8.ch002

resources into a grid. Technical problems arise in the areas of power quality, voltage stability, harmonics, reliability, protection, and control. Behavior of protective devices on the grid must be examined for all combinations of distributed and central station generation. A large scale deployment of distributed generation may affect grid-wide functions such as frequency control and allocation of reserves. As a result smart grid functions, virtual power plants and grid energy storage such as power to gas stations are added to the grid. At the energy market, Wholesale transactions (bids and offers) in electricity are typically cleared and settled by the market operator or a special-purpose independent entity charged exclusively with that function. Market operators do not clear trades but often require knowledge of the trade in order to maintain generation and load balance. The commodities within an electric market generally consist of two types: power and energy. Wholesale transactions (bids and offers) in electricity are typically cleared and settled by the market operator or a special-purpose independent entity charged exclusively with that function. Market operators do not clear trades but often require knowledge of the trade in order to maintain generation and load balance. The commodities within an electric market generally consist of two types: power and energy.

At the consumer level, there is an opportunity for consumers to play a significant role in the operation of the electric grid by reducing or shifting their electricity usage during peak periods in response to time-based rates or other forms of financial incentives. The goal of this chapter is to analyze the energy cost saving tips in centralized and decentralized power network. The chapter is structured as follow: The first section offers an introduction on power networks. It focuses on power network operation and explores different aspect of energy production, transmission and consumption in both the centralized and decentralized power approach. The section gives also a background of learning and optimization techniques used in the chapter. Then different energy saving approaches are presented from consumer incentive to renewable energy sources integration into the distributed power network. Next, we study the prosumer energy profiling in a distributed power network. Therein, prosumers interact in a distributed environment during the purchase or sale of electric power using a double auction with negotiation mechanism. Using a two-step combined learning and optimization scheme, each prosumer can learn its optimal bidding strategy and forecast its energy production, consumption and storage. The simulation results show that the integration of the prosumer in the power grid help to reduce the peak energy consumption and to lower the electricity cost for the population of prosumers. Discussions and future research directions are presented in the last part of the chapter.

BACKGROUND

Reinforcement Learning

In the field of machine learning, one way for an intelligent agent to interact dynamically with the environment from which it has no information is to use reinforcement learning techniques (Barto et al (1983)). The reinforcement learning can be subdivided into 2 steps: the choice of the action to be executed and the reward to be assigned to that action. As the agent has no exact information about the state of the environment (it depends on the behaviour of other agents involved), the choice of an action is made probabilistically, according to a distribution which depends on past experiences. The reward assigned