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Agent-based Simulation of Retail Electricity Markets: Bilateral Contracting with Demand Response

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Abstract—**The novelty of the evolving electric power industry implies that researchers lack insight into numerous open problems. There is a growing need for advanced modeling approaches that simulate the behavior of electricity markets over time. Accordingly, this article looks at using software agents to help manage the complexity of electricity markets, particularly retail markets, towards ensuring long-term capacity sustainability. The article focuses on bilateral trading and describes some important features of an agent-based system for bilateral contracting with demand response. Special attention is devoted to two strategies for promoting demand response: a "volume management" strategy, for Buyer agents, and a "price management" strategy, for Seller agents.**

Keywords-**Bilateral contracting; demand response; electricity markets; multi-agent systems; trading strategies.**

I. Introduction

Traditional vertically integrated power utilities around the world have evolved from monopoly structures to open markets that promote competition among suppliers and provide consumers with a choice of services. Competition, open access, and the break-up of the traditional vertically integrated utility structure led to a radically different industry. In particular, the extensive restructuring process led to the establishment of a wholesale market for electricity generation, where competing generators offer their electricity output to retailers, and a retail market for electricity retailing, where end-use customers choose their supplier from competing electricity retailers.

Bilateral contracting has been a key market model and involves mainly the sale of large amounts of power (hundreds or thousands of megawatts) over long periods of time (several months to years). Market participants set the terms and conditions of agreements independent of a market operator—that is, the negotiating parties specify their own contract terms [4].

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The novelty of the evolving electric power industry implies that researchers lack insight into numerous open problems that are being raised. Chief among these are the technical difficulties to understand the internal dynamics of deregulated electricity markets and the additional complexities to coordinate economic and financial issues. Clearly, there is a need for advanced modeling approaches that simulate the behavior of electricity markets over time and how market participants may act and react to the changing financial and regulatory environments in which they operate. Computational tools relying on software agents can play a particularly important role in the power industry, providing a source for strategic insight into the diverse aspects of the emerging electricity marketplaces. Software agents can be designed to act in open and distributed environments and to deal with complex dynamic interactions with limited resources.

An ongoing study is looking at using the potential of agent-based technology to help manage the complexity of electricity markets (EMs), particularly retail markets, towards ensuring long-term capacity sustainability. This paper focuses on bilateral trading and describes some important features of an agent-based system for bilateral contracting with demand response (DR). Buyer and Seller agents are equipped with a generic framework that handles two-party and multi-issue negotiation. They interact according to the rules of an alternating offers protocol and can pursue several negotiation strategies. Special attention is devoted to two strategies for promoting demand response: a "volume management" strategy, for Buyer agents, and a "price management" strategy, for Seller agents.

The remainder of the paper is organized as follows. Section II introduces demand response in the context of EMs. Section III presents some key features of an agent-based system for bilateral contracting with demand response, focusing on the DR management strategies. Section IV is devoted to related work and describes some prominent EM simulators. Finally, section V summarizes the most important conclusions and indicates avenues for future research.

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