Two-Settlement Electric Power Markets with Dynamic-Price Customers

Huan Zhao, *Student Member, IEEE,* Auswin Thomas, *Student Member, IEEE,*
Pedram Jahangiri, *Student Member, IEEE,* Chengrui Cai, *Student Member, IEEE,*
Leigh Tesfatsion, *Member, IEEE,* and Dionysios Aliprantis, *Senior Member, IEEE*

***Abstract*—This study will report both analytical and computational testbed findings regarding the effects of retail dynamic-price contracting on power system operations. The key issue under study is the extent to which the introduction of dynamic price contracts for retail consumers affects the efficiency of both retail and wholesale power market operations through changes in price volatility and load profiles at wholesale, and through re-allocations of risk between load-serving entities and retail consumers.**

***Index Terms*—Restructured electric power markets, two-settlement system, locational marginal pricing, retail dynamic pricing, agent-based testbed**

I. Overview

CURRENTLY in the U.S. over 50% of generation capacity is operating under some version of the wholesale power market design recommended by the Federal Energy Regulatory Commission (FERC) [1]. The core element of FERC's market design is a two-settlement system to be managed by some form of independent market operator.

A *two-settlement system* refers to the combined workings of a day-ahead energy market and a real-time energy market that are separately settled each day by means of *Locational Marginal Pricing (LMP)*. Under LMP, a separate price for power is determined at each point of the transmission grid at which power is injected or withdrawn.

The wholesale day-ahead energy market in a two-settlement system is structured as a double auction. Wholesale buyers are permitted to submit hourly demand bids consisting of both fixed and price-sensitive hourly demands, and wholesale sellers are permitted to submit hourly supply offers consisting of price-sensitive hourly supplies.

In actuality, however, in current implementations of FERC's design the day-ahead energy market effectively functions as a single-sided seller auction because the bulk of the demand takes the form of fixed hourly loads (i.e., load profiles) implying essentially vertical hourly demand curves. As elaborated in [2], a key difficulty is that downstream retail power markets in the U.S. are still largely regulated with cost-based pricing, so that LSEs in fact have little incentive to submit price-sensitive demand bids. As experimentally shown in [3], under this scenario wholesale sellers of electric power can quickly learn to tacitly collude on strategic supply offers that result in much higher market operating costs.

These adverse technical and economical performance characteristics suggest the need for an integrated restructuring of both retail and wholesale power markets. Rather than use actual systems as testbeds, however, our ISU research group is developing an agent-based testbed that seams together two previously developed agent-based testbeds:

- AMES [4], an open-source software platform developed by a team of researchers at Iowa State University for the study of strategic trading in ISO-operated restructured wholesale power markets with congestion managed by LMP.
- GridLAB-D [5], an open-source software platform developed by DOE at PNNL for the study of power distribution systems for end-use customers with power loads arising from a variety of modeled appliances and equipment.

The resulting seamed testbed will permit the study of integrated retail and wholesale power system operations under various types of retail restructuring intended to achieve a more flexible price-responsive load.

This study will report both analytical and computational testbed findings regarding the effects of retail dynamic-price contracting on power system operations. The key issue under study is the extent to which the introduction of dynamic price contracts for retail consumers affects the efficiency of both retail and wholesale power market operations through changes in price volatility and load profiles at wholesale, and through re-allocations of risk between load-serving entities and retail consumers.

More precisely, in the six regions of the U.S. that have actually implemented a version of FERC's wholesale market design,[1] the resulting LMPs can be quite volatile, particularly in the real-time energy market and particularly during peak-

H. Zhao is a Ph.D. candidate in the Economics Department at Iowa State University, e-mail: hzhao@iastate.edu

A. Thomas is an M.S. student in the Electrical and Computer Engineering (ECpE) Department at Iowa State University, e-mail: auswin.george@gmail.com

P. Jahangiri and C. Cai are Ph.D. students in the ECpE Department at Iowa State University, e-mail: pedramj@iastate.edu, ccai@iastate.edu

L. Tesfatsion (corresponding author) is Professor of Economics, Mathematics, and ECpE at Iowa State University, Ames, IA, 50011-1070 USA, e-mail: tesfatsi@iastate.edu

D. Aliprantis is Litton Industries Assistant Professor of ECpE at Iowa State University, Ames, IA, 50011-3060 USA, e-mail: dali@iastate.edu

Preliminary Draft: Latest revision 15 November 2010

[1] These six regions are the Midwest (MISO), New England (ISO-NE), New York (NYISO), the Mid-Atlantic States (PJM), California (CAISO), and the Southwest (SPP). Texas (ERCOT) has agreed to move to a two-settlement system with LMP pricing, but the implementation of these changes has been repeatedly delayed.

978-1-4577-1002-5/11/$26.00 ©2011 IEEE

load hours. Part of this peak-load volatility arises from *out-of-merit-order* generation dispatch, i.e., the need to dispatch more expensive generation in place of less costly generation because of the inability to get the less costly generation to the load over congested transmission lines.

Ideally, high LMPs at certain buses in certain periods of time should result in reductions in load at these buses in these time periods through curtailment and/or shift decisions on the part of retail consumers, thus resulting in a lowering of these LMPs. In principle, these load reductions could be implemented through some form of "dynamic price" contracting at the retail level.

Dynamic pricing refers to electric power contracts provided by retail suppliers to retail consumers that involve some degree of pass-through of wholesale power prices on a relatively short time basis.[2] In addition to encouraging lower peak-hour consumption, dynamic pricing could also help to increase capacity factors and line usage rates through lowered congestion on transmission lines. To the extent that the more efficient usage of existing generation leads to less need for new coal-fired power plants, hence lower carbon emissions, dynamic pricing might also result in environmental benefits.

Currently, however, the LMP signals in the six U.S. regions operating under a two-settlement system are not passed through to retail customers to induce price-responsive decisions to curtail or shift load. Instead, retail consumers for the most part pay administratively determined flat rates for their electric power usage. This creates a potential wastage of resources (i.e., a loss of efficiency) to the extent that retail consumers would be willing to flexibly respond to higher LMPs by curtailing and/or shifting their usage in a manner leading to lower overall generation costs.

This disconnection between wholesale and retail power market operations also puts *load serving entities (LSEs)* in a financially risky position. The LSEs must buy power at wholesale at potentially volatile price levels, yet they must resell this power at retail at regulated rates. In response, LSEs have resorted to long-term bilateral contracting with *Generation Companies (GenCos)* in an attempt to secure power at more stable prices. Indeed, reliance on long-term bilateral contracts in the six regions operating under a two-settlement system is typically around 70%. Long-term bilateral contracting dampens the incentives of LSEs and GenCos to ensure the efficient operation of the two-settlement system, defeating the basic purpose of FERC's restructuring efforts.

This study will use both analytical modeling and computational testbed experiments to investigate the efficiency implications of introducing dynamic-price retail contracting within a power system operating under a two-settlement system.

REFERENCES

[1] Federal Energy Regulatory Commission (FERC), "White paper on bulk power market design, Docket No. RM01-12-000," Apr. 2003. [Online]. Available: http://www.ferc.gov/news/news-releases/2003/2003-2/White_paper.pdf

[2] A. N. Kleit, *Electric Choices: Deregulation and the Future of Electric Power*. New York: Rowman and Littlefield Publishers, 2007.

[3] H. Li, J. Sun, and L. Tesfatsion, "Testing institutional arrangements via agent-based modeling: A U.S. electricity market application," in *Computational Methods in Economic Dynamics*, H. Dawid and W. Semmler, Eds. Springer Verlag, 2010.

[4] AMES wholesale power market test bed homepage. [Online]. Available: http://www.econ.iastate.edu/tesfatsi/AMESMarketHome.htm

[5] U.S. Department of Energy at Pacific Northwest National Laboratory. GridLAB-D, power distribution simulation software. [Online]. Available: http://www.gridlabd.org/

[2] Currently Texas (ERCOT) is the only U.S. energy region that has widely and systematically introduced dynamic pricing for its retail customers.