A Theoretical Analysis of Pricing Mechanisms and Brokers' Decisions for Real-time Balancing in Sustainable Regional Electricity Markets

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Abstract

In electricity markets, supply and demand have to be balanced perfectly in real time. A major task of the Independent Systems Operator (ISO) on the wholesale (transmission) level and of the Distribution Utility (DU) on the regional (distribution) level is to monitor the grid and to maintain balance while keeping voltage, frequency, and power factor within very tight bounds. This task gets more challenging as more renewable energy sources, such as solar and wind, are connected to the grid. Many of these sources (e.g. wind) are only partially predictable. The grid balancing problem has been studied on various levels (wholesale vs. retail) and with different approaches.

We study the problem of how to determine the price that energy brokers (retailers) need to pay in case their profile of consumption and production of electricity is imbalanced in the current time slot. In a retail electricity market, brokers have the possibility to control some portion of customer production and consumption, such as by offering price concessions in exchange for the ability to remotely interrupt loads or sources for limited periods of time. Examples of such controllable capacities are remotely controlled CHPs (Combined Heat and Power -- gas turbines that supply both heat and power, and allow some control of production) and domestic water heaters that can be remotely turned off to temporarily reduce consumption.

We present two different scenarios and the related market mechanisms to balance supply and demand: I) without controllable capacities, and II) with controllable capacities for the current time slot. Our main mechanisms for a regional real-time balancing market are efficient, and create an incentive to resolve imbalances in the day-ahead market. An advantage of our methods is that they are compatible with existing energy market structures (keeping the day-ahead market as a given), and therefore the required restructuring would be less disruptive than with other methods currently suggested. Our testbed is the Power Trading Agent Competition (Power TAC). Power TAC is a competitive simulation of retail electric power markets that models a market-based management structure for local energy grids.

Speaker bio

Wolfgang Ketter is Associate Professor of Information Systems at the Department of Decision and Information Sciences at the Rotterdam School of Management of the Erasmus University. He received his PhD in Computer Science from the University of Minnesota in 2007. Dr Ketter founded and leads the Learning Agents Research Group at Erasmus (LARGE) and the Erasmus Center for Future Energy Business. The primary objective of LARGE is to research, develop, and apply autonomous and mixed-initiative intelligent agent systems to support human decision making in the area of business networks, electronic markets, energy grids, and supply-chain management. The energy research enables the robust, intelligent, efficient, and sustainable energy networks of the future.

Dr Ketter co-chaired the TADA workshop at AAAI 2008, was the general chair of the Trading Agent Competition (TAC) 2009, is member of the board of directors of the Association for Trading Agent Research (ATAR) since 2009, and its chair since 2010. He is now leading Power TAC - a TAC competition on energy retail markets; Dr Ketter also serves as the chair of the IEEE Task Force on Energy Markets and was the programme co-chair of the International Conference of Electronic Commerce (ICEC) 2011. Dr Ketter's research has been published in various information systems, and computer science journals such as *AI Magazine*, *Decision Support Systems*, *Electronic Commerce Research and Applications*, *Energy Policy*, *European Journal of Information Systems*, *INFORMS OR/MS Today*, *INFORMS Information Systems Research*, and *International Journal of Electronic Commerce*.