Multi-Unit Auctions with Complementarities: Issues of Efficiency in Electricity Auctions

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Abstract

In this paper, we analyze the ability of different auction structures to induce the efficient dispatch in a one-shot framework where generators know their own and competitors' costs with certainty. In particular, we are interested in identifying which, if any, rules in an auction structure yield only the efficient dispatch in equilibrium. We find that a critical component to a successful auction design is the way in which demand is bundled and hence the way bids are defined. While an auction mechanism which allows for more than one winner in an auction may support inefficient dispatches in equilibrium, we find that an auction where there is exactly one winner per lot, where the lots are formed to capture the cost structure of generation plants, and all lots are auctioned simultaneously, supports only efficient dispatches in equilibrium.

Keywords: *multi-unit auctions, complementarity, bundling, electricity, efficiency*

1 Introduction

Many governments believe that it is in their and their constituents' best interest to restructure their electricity supply industries. The goal of the regulators is to introduce competition into their electricity supply industries and create the appropriate medium through which electricity buyers and sellers can actively trade electricity, in the hope that such a competitive market will promote efficiency. Auction-based mechanisms for electricity dispatch have already been implemented in various countries around the world (e.g. the United States, United Kingdom and Australia). The design of an electricity auction which induces an efficient use of generation resources is complicated by the fact that electricity demand, which fluctuates from hour to hour, must be satisfied by many suppliers with different costs, and that the generators lack the ability to store electricity in

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inventory. It is proving to be a great challenge to design an efficient auction where the generators' schedules can no longer be dictated by a central planner, but must result as a consequence of their submitted bids.

The road to deregulation has been very bumpy; for example, California, the first state in the US to create an electricity auction, was forced to shut-down operation of its electricity auction early in 2001 due to exorbitant electricity prices and the resulting threat of bankruptcy of its load serving entities (see Borenstein (2002) for an excellent discussion of the failed California electricity market). The exercise of market power as well as inefficient utilization of generation resources were both cited as problems plaguing the California design. In their original auction design, generators were allowed to submit (energy-only) bids for each hour of the day; each hourly market was then cleared independently of the bids in all other hours. We refer to an auction where each (sub-)auction is cleared independently as a *simple* auction. In their redesigned auction, California will abandon the simple auction format and will join the ranks of the Northeast power pools (e.g. Pennsylvania-New Jersey-Maryland and the New York Independent System Operator) and solve a unit commitment problem over the entire day to establish a dispatch schedule.

The question that this paper poses is: Is it possible to design a simple (sealed bid) auction for electricity that supports only the efficient dispatch (in equilibrium)? That is, was there is a way that the CA auction design could have been altered while maintaining its simple format so as to result in productive efficiency?

There are two forms of inefficiency which may arise from an ill-designed market; productive inefficiency and allocative inefficiency. Productive inefficiency implies an inefficient use of resources in the production of goods, while allocative inefficiency occurs when the goods are not consumed by those who value it the most. Currently, most retail consumers do not see the real-time price of electricity and hence have limited ability to respond to changes in electricity prices. Rather, their demand is represented in the wholesale electricity auction by a (forecasted) inelastic demand curve. While there has been much discussion as to the importance of allowing consumers to respond to electricity prices in real-time, Stoft (2002) calculates the expected savings from doing so, and hence achieving allocative efficiency, to be small. "Fully implemented real-time pricing ... would reduce the cost of supply by approximately 2.25% of retail costs. (Stoft (2002) pg. 14)". As a result, the most promising efficiency gains to be had from the proper design and use of an electricity auction lies within the efficient use of generation resources. The purpose of this paper is to study the impact of various auction rules on yielding productive efficiency, referred to as the efficient dispatch. We are interested in identifying if there exists a simple auction structure that yields *only* the efficient dispatch in equilibrium.

In order to gain a better understanding of the incentives created by different auction structures and the ability of each auction structure to induce the efficient dispatch, we focus only on the generation (supply) side of the market and we assume that electricity demand is both deterministic, inelastic, common knowledge