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Pricing and Efficiency in “Lumpy” Energy Markets

An unavoidable characteristic of electricity markets is their lumpiness; generation and transmission capacity additions often come in inconvenient discrete sizes. Electricity markets need to be designed to accommodate their lumpy nature.

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I. Introduction

Many organized electricity markets have locational marginal pricing (LMP), financial transmission rights (CRRs) and a resource adequacy requirement.¹ At the heart of these markets is an auction that is used to determine the daily generation and consumption of energy. There has been some debate as to what market design the day-ahead and real-time auctions should take. In particular, there have been different schools of thought about what pricing mechanism to use to clear short-term energy markets (daily and hourly). Policymakers

and academics have discussed the relative advantages of discriminatory (non-anonymous) prices versus uniform (anonymous) prices and one-part versus multi-part pricing schemes [1–3].

Under some proposed market designs, a system operator, such as a regional transmission organization (RTO), establish a security-constrained day-ahead and real-time market for spot energy in the form of an auction. Pricing in the auction is through locational marginal pricing, in which the market clearing price at each location is the shadow price on the energy balance constraint for that location. Bids and

offers into this spot auction can represent startup costs and no-load costs in addition to incremental energy. The payment rule is that each winning bid or offer is provided with a revenue guarantee that provides an additional payment if daily energy market revenues are not sufficient to cover the start-up costs.

The relative merits of discriminatory and uniform price auctions have been researched at length in standard auction settings (see [4] for an excellent overview of the literature).

However, electricity markets are very different from the standard auction and even from more general convex-market settings. An unavoidable characteristic of electricity markets is their lumpiness. Generation and transmission capacity additions often come in inconvenient discrete sizes and can adversely affect the rights of others in ways unique to electricity markets. In the short term, a generator has startup costs, a minimum run level, and a minimum downtime. (There may also be important ramp rate constraints, but these are not considered here.) The objective is to design auctions that efficiently and reliably choose the exchanged products, efficiently price them, and then send signals to market participants that allow them to formulate intelligently efficient bidding strategies for the future.

The purpose of this article is to discuss the relevance of current market practices on efficiency.¹ Via simple examples, we illustrate

the issues and difficulties involved in designing an efficient energy auction. We use a stylized representation of the an energy auction for a load pocket with transmission constraints to illustrate the difficulties of designing an efficient auction in the face of lumpy technologies, and the conflict between short- and long-run efficiency.

This article is organized as follows. Section II outlines what

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properties we would like a pricing mechanism to possess. Section III presents a convex market and the signaling role of a single commodity price, for contrast in later sections. Section IV examines the shortcomings of a single commodity price in lumpy markets, and suggests alternative bid and payment formats to support short-term efficient allocations. Section V highlights the negative impact a vertical demand curve can have on productive and allocative efficiency, as well as on determining “efficient” short- and long-term prices.

It is critical to note that the discussions here do not deal

with market power, i.e., we assume that market participants bid their true valuations into the energy auction. Market power and the inefficiency it can cause must be dealt with outside of the analysis here either by finding a way to force bidders to bid their true costs when their market power would make them prefer to bid differently, by making sure that no bidder possesses market power, or by accepting the inefficiencies and unfairness the exercise of market power can produce.

II. Auction Design

Ideally, we would like to create an “efficient” electricity auction. We say that an auction is efficient if it,

(1) Maximizes the gains from trade given the submitted bids and yields a “competitive” short-term allocation, and

(2) Offers proper signals for long-term investment.

It is highly desirable that an electricity auction and the prices it produces should support efficient consumption and production decisions across consumers and generators, when each bidder is bidding its true cost. In theory, efficient short-term prices result in consumption/production decisions that maximize gains from trades and serve as a “proper” signal for market participants to change their generation or consumption in the short-run. In addition, short-term energy prices should help guide market participants in making long-term

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