

Spot market mechanism design and competitiveness issues in electric power

Michael J. Denton^a, Stephen J. Rassenti^b, Vernon L. Smith*

^a *Utilities International, Tucson, AZ 85721-0108, USA*

^b *Economic Science Laboratory, University of Arizona, College of Business & Public Administration, McClelland Hall 116, Tucson, AZ 85721-0108, USA*

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Abstract

The performance of a sealed bid-offer and an open display real time uniform price double auction in a three-node radial network and compared in terms of efficiency, price competitiveness and the distribution of surplus over a demand cycle. We also compare three versus six independent generation companies who own the same aggregate portfolio assets. The environment provides a stressful market for wholesale buyers on-peak (the competitive price is above resale value) and for baseload generator units off-peak (the competitive price is less than cost). Three firms are as competitive as six under sealed bid-offer, but not the double auction. © 2001 Elsevier Science B.V. All rights reserved.

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1. Introduction

We report new experiments which compare the sealed bid offer (SBO) market mechanism, studied in Backerman et al. (1997; hereafter BDRS), with a uniform price double auction mechanism (UPDA) that updates nodal prices and allocations continuously as new bids and offers arrive in real time down to the close when the market is “called” and all standing accepted bids and offers become binding spot contracts. We compare the performance of the SBO and UPDA institutions in terms of their impact on incentives affecting market efficiency (the ability to exhaust the gains from exchange), generator and wholesale buyer profitability, and delivery price. Under each of the two trading institutions we compare

* Corresponding author. Tel.: +1-520-621-4288; fax: +1-520-621-5642.
E-mail address: smith@econlab.arizona.edu (V.L. Smith).

markets in which the available generator capacities and their costs are held by three versus six independent companies. We also vary the minimum loaded capacity of baseload units below which avoidable fixed cost penalties are incurred. Wholesale buyers also face large penalties if they fail to serve all of their noninterruptible demand. These nonconvexities combine to produce a very stressful market for buyers on-peak, and for sellers off-peak peak. Finally, in UPDA only, we study the impact of varying the proportion of peak demand that is noninterruptible and subject to must-serve avoidable fixed cost penalties. We do not address the effect of a transmission line constraint—this is central to the market power issue—because it is already addressed in Backerman et al., 1997. Also we do not address the so-called “loop-flow” issue in triangular and more complex networks, because (a) it is essential to first examine mechanism design and nonconvexity issues in a baseline that controls for loop flow effects, and (b) such issues constitute one of the next steps in our research program underway.¹

2. Experimental environment

In all experiments we use a three-node radial network consisting of four wholesale buyers at the center demand node, B , two (or four) generators companies at the left supply node, G_1 , and one (or two) generators at the right node, G_2 . (Refer to the network diagram below in Fig. 1).

2.1. Generator parameters

Most large capacity turbine generators have minimum and maximum loaded capacity constraints, with modestly increasing marginal heat rates (and fuel costs) over the range from minimum to maximum capacity. Average cost varies little on baseload units over this capacity range, most often declining slightly until maximum capacity. Minimum loaded capacity is typically 40–50% of maximum capacity, often more. This is in part because marginal cost is declining up to “minimum” capacity and it is not generally optimal, in terms of minimizing energy cost, for on-line generators to operate where output exhibit declining marginal cost.² We approximate these characteristics with the cost and capacity parameters for all generators shown in Table 1. Each power plant facility consists of three generators whose respective marginal costs are constant up to maximum capacity: (i) a low cost baseload unit with a minimum loaded “must-run” (the industry term) capacity of

¹ We found it interesting that industry representatives, while recognizing that academics are mesmerized by network externalities (loop flow problems), consider this a lower priority issue than studying market performance and behavior in the context of generator supply inflexibilities and the limited current technical ability of local distribution companies (wholesale buyers in our market) to interrupt demand. Hence, they were comfortable with the simple quadratic loss, radial network, used below, provided that the supply and demand inflexibilities were incorporated into the system.

² If you have $n \geq 2$ generator facilities, it is never optimal to operate more than one of them at declining marginal cost, and “if one facility is operated at declining marginal cost the rate of decrease of its marginal cost curve must be smaller in absolute value than the rate of increase of the horizontally summed marginal cost curves of all other facilities.” (Smith, 1961, p. 247).

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