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Using forward markets to improve electricity market design ☆

Lawrence M. Ausubel, Peter Cramton *

University of Maryland, College Park, MD 20742, United States

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ABSTRACT

Forward markets, both medium term and long term, complement the spot market for wholesale electricity. The forward markets reduce risk, mitigate market power, and coordinate new investment. In the medium term, a forward energy market lets suppliers and demanders lock in energy prices and quantities for one to three years. In the long term, a forward reliability market assures adequate resources are available when they are needed most. The forward markets reduce risk for both sides of the market, since they reduce the quantity of energy that trades at the more volatile spot price. Spot market power is mitigated by putting suppliers and demanders in a more balanced position at the time of the spot market. The markets also reduce transaction costs and improve liquidity and transparency. Recent innovations to the Colombia market illustrate the basic elements of the forward markets and their beneficial role.

1. Introduction

Electricity market design seeks to satisfy consumers' demand for electricity at minimum cost. This requires both short-run efficiency—the operation of existing resources at minimum cost—and long-run efficiency—investment in the right quantity and mix of resources. Both goals are made difficult by features of electricity markets. Supply and demand must be balanced at every instant and at every location. The physical constraints of the network must be respected. And demand often is unresponsive to spot price fluctuations.

Our thesis is that the goals of electricity market design are better met when the spot market is complemented with two forward markets, one medium term and one long term. A well-designed spot market is necessary for efficiency, but is not sufficient. Efficiency requires that issues of risk, market power, and investment be addressed. The two forward markets address risk by enabling the market participants to lock in prices and quantities, limiting exposure to the more volatile spot market. Market power is addressed by putting participants in a more balanced position entering the spot market, mitigating the incentive to distort bids. Finally, the long-term market coordinates investment in new resources, assuring that adequate resources will be available when they are most needed.

The California electricity crisis of 2000–2001 illustrates all too well the problems that can arise when one relies excessively on the spot market. Key conditions of the crisis were insufficient forward contracting and tight supply. During this prolonged period of tight supply, the unhedged demanders were exposed to sustained high spot prices. Suppliers, also positioned without forward contracts, had strong incentives to exercise market power further exacerbating the high prices. The load serving entities, despite initially being well capitalized, ultimately teetered toward bankruptcy and the market collapsed.

The proposed forward markets would have reduced or perhaps prevented the crisis. To the extent that the crisis was caused by inadequate resources, the long-term market would assure sufficient investment to relieve the tight supply conditions that contributed to high prices. Even if spot prices became high for an extended period, with the forward markets the vast majority of the quantity would be transacted at sustainable forward prices, preventing the large wealth transfers that pushed utilities toward bankruptcy. Finally, suppliers in roughly balanced positions entering the spot market would have much reduced incentives to exercise market power, so the behavior of the spot market would have likely been less extreme.

Our view is that forward markets can address three of the pressing problems in current wholesale markets: investment, risk, and market power.

☆ Since 2006, Peter Cramton has advised the Colombian government on the design of long-term and medium-term forward markets for electricity; he advised ISO New England on the design of the Forward Capacity Market. Larry Ausubel has assisted the implementation of the Forward Capacity Market for ISO New England and has certified the first three Forward Capacity Auctions. This paper is based in part on this work. The paper also benefits from collaborations with Steven Stoft on forward reliability markets in both Colombia and New England. We are grateful to the National Science Foundation for funding.

* Corresponding author.
E-mail address: pcramton@gmail.com (P. Cramton).

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The need for forward markets and the form that they take will depend on the setting. We use Colombia to illustrate one approach to the forward markets. Colombia recently adopted both a long-term market and a medium-term market. Similar markets have been adopted in parts of the U.S., such as New England. We present the essential features of each market and discuss some of the design choices. We begin with the long-term market and then discuss the medium-term market.

The need for regulated forward markets in electricity comes largely from market failures on the demand side. Consumer demand response is limited; consumers have limited exposure to spot prices and have no ability to express preferences for reliability. As a result, in most markets, regulators establish the quantity of resources needed. The long-term market assures that adequate resources exist and establishes a transparent competitive process for identifying and pricing these resources. Regulation of medium-term (1–3 year) markets may be justified to avoid self-dealing by vertically integrated distribution companies, to address market power, and to reduce transaction costs.

2. Long-term: the forward reliability market for investment

Forward reliability markets now operate in Colombia and New England. These markets coordinate investment in new resources to assure that adequate resources are available when they are needed most. The two markets have the same basic features, although they differ in the definition of the reliability product.[1]

A fundamental characteristic of the Colombian electricity market is that it is hydro-dominated. Roughly 80% of Colombia's energy is produced from hydro resources, and about two-thirds of its capacity is hydro. As a result, the resource adequacy constraint in Colombia is having sufficient thermal resources and hydro reservoirs to provide energy during severe dry periods. Thus, Colombia has a "firm energy market" to assure resource adequacy, where the product (firm energy) is the ability to produce energy during severe dry periods.

By contrast, New England is a thermal-dominated system. The resource adequacy constraint is having sufficient resources to serve the annual peak. The reliability product is capacity—the ability to produce energy during a hot summer day. Thus, New England has a capacity market.

In both Colombia and New England, the regulator establishes the overall resource requirement and determines the individual contribution toward this requirement of each resource. For example, in Colombia each hydro unit (and thermal unit) is rated based on its expected energy output in a severe dry season. The system operator then procures on behalf of load enough firm energy to satisfy the requirement.

The first question is why have a forward reliability market. A main motivation is coordinating investment in new resources to assure resource adequacy. The absence of demand response is another factor. Spot prices tend to be too low during scarcity, either because of price caps or operator decisions, such as voltage reductions, which impact price. The forward reliability market reduces risk and addresses market power, while assuring that investment incentives are strong enough for efficient entry.

Issues of risk and investment incentives are especially important in Colombia. As a result of El Nino phenomena, sustained scarcity events from lack of rainfall occur about once every ten years. An investor is unlikely to build a thermal peaking unit anticipating the energy profits during these severe dry periods. These events, occurring perhaps two months in ten years, are simply too infrequent. The investment would entail too much risk. The reliability market provides a constant revenue stream in exchange for the obligation to provide energy at more moderate prices during scarcity events. Risk is dramatically reduced for the investor (Cramton et al., 2006). Risk is also reduced for the demand side, which is important in Colombia where the demand side cannot tolerate large and sustained price shocks. Finally, demand is growing rapidly in Colombia, so new investment is essential.

Previous to the firm energy market, Colombia generators received a reliability payment, but this payment was set administratively. The new market selects new projects and establishes the payment through a transparent competitive process.

A main feature of the design is that the procurement occurs well in advance of the commitment period. This allows new projects to compete in advance of entry, before significant costs are sunk, which increases competition and produces a meaningful price. It also allows for coordinated entry, reducing the boom-and-bust cycles that frequently occur in the construction of new power plants.

The coordinated entry reduces the uncertainty in achieving the target level of resources. Some over-procurement will occur as a result of the lumpiness of investment and mistaken load forecasts, but it is not necessary to deliberately procure extra resources in recognition of uncertain entry.

A further advantage of forward procurement is that new resources set the firm energy price directly. Foreclosure of the market is prevented with limits on excessive concentration of supply.

With forward procurement, it is possible to make a long-term commitment for new resources. This reduces investor risk and sends a price signal for new investment that is directly related to the cost of new entry.

The firm energy product is a financial call option backed by a physical resource rated by the regulator as capable of producing a particular level of energy during a severe dry period. The physical requirement guarantees that sufficient resources will be available to produce energy. The financial call option hedges load from high-energy prices during periods of scarcity.[2]

Bundling the physical resource to the product is essential. This assures adequate physical resources and enables the market to restore the "missing money" in the energy market, caused by too-low energy prices as a result of prices caps or operator actions during scarcity. Because of this missing money, the clearing price in the firm energy market exceeds the financial cost of the call option.

The supplier's generating units and fuel provide a physical hedge to limit the risk of selling the call option. Indeed, relative to an energy-only market, the supplier's risk is reduced, since the firm energy market substitutes highly variable energy rents with a constant firm energy payment.

The supplier's obligation is load following in aggregate: in each hour the total obligation is equal to load. A supplier's obligation in any day is equal to its share of firm energy. The obligation is distributed over the day based on the supplier's hourly dispatch. This definition—tying a unit's obligation to its hourly dispatch during scarcity—reduces supplier deviations. A baseload unit's obligation is spread throughout the day; a hydro unit with high opportunity cost has its obligation concentrated on the peak hours of the day.

[1] See Cramton and Stoft (2008) for a general analysis of forward reliability markets. Cramton and Stoft (2007) focus on the Colombia design; and Cramton (2006) focuses on the New England design.

[2] Many papers have suggested the use of call options. See Bidwell (2005), Vazquez et al. (2002), Chao and Wilson (2004), Cramton and Stoft (2006, 2007, 2008), and Oren (2005).