



The electricity spot market: Is it future-proof?



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ABSTRACT

Are electricity spot markets in their current form sustainable in a future of renewable, volatile generation that has low or zero operational marginal cost and high fixed costs? This examination concludes that, where storage of generation fuel and electricity are common, these markets may continue their role of coordination of real-time supply and demand. Together with the hedge market for longer-term transactions, these markets deliver an efficient wholesale market for electricity.

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1. Introduction

There are many factors presently growing in influence on electricity markets. They include energy-saving inventions (e.g. LED lights) and management tools (e.g. devices and communication based on the services of instruments arising from the digital economy). They include batteries and electricity-producing products (e.g. solar panels and wind generators), and the rapidly declining unit cost of new products and services. In addition, there is growing demand for generation by renewable resources rather than fossil fuel. Plants that produce electricity from renewable resources commonly have significant capital cost and low, even zero, operational marginal costs.¹ The present common example of high fixed and zero operational marginal cost is hydroelectric generation. Presently, controllable generation from fossil fuel and hydro plants has been used to manage the volatility of electricity production that is due to factors that include variation in supplies of water or fossil fuels for generation. This paper explains that the complete replacement of fossil fuel generation with renewables – to pose the polar case – need not affect the principled role of the electricity spot market, and that the presence of batteries augments this conclusion. On information available at the present time, the current form of the wholesale market of spot and hedge

arrangements is sufficiently robust to enable evolution of an efficient electricity market into the foreseeable future.²

2. The spot market

The spot market analysis that follows is applicable to a wide class of wholesale electricity markets: an exemplar is New Zealand's modern electricity market (NZEM) (Evans and Meade, 2005). This market enables economy-wide decentralized decision-making by firms in all industries and consumers, under constraints necessary to the production and distribution of quality³ electricity over networks. An important determinant of the openness of the electricity market to producers and consumers is ready access to the spot and hedge markets. These markets are complementary (Tam and Evans, 2013: p.2),⁴ and together form the wholesale market which yields prices that provide incentives and ability to invest in new capacity, and replace inefficient plant. In this respect the New Zealand wholesale market has a normal form in that it functions just as other markets for goods, services, and commodities in the economy: it does so by enabling investment in plant and other infrastructure. Worldwide, a number of otherwise decentralized electricity markets have a separate market for industry capacity, as well as a spot market for electrical energy exchange.

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¹ I define operational marginal cost to be the financial payment the generator is obliged to make for resources extinguished in a trading period in the production of electricity. For example, if gas for generation could be purchased in any trading period at a price per unit, that price and the quantity used would constitute variable cost and the value per unit of electricity produced would be operational marginal cost.

² An increasing share of generation by renewables would pose network infrastructure and electricity-supply volatility management issues for the market as a whole (Ronnberg and Bolen, 2016) but these are not considered here

³ Quality includes meeting specified standards of voltage and AC cycles, and minimizing interruption events.

⁴ Although all electricity that passes through NZEM must pass through the spot market an approximate 85% is priced by hedge arrangements – these include generator vertical arrangements, and contracts for differences. The spot market effectively prices some 15% of electricity being trading-period unders and overs not covered by hedge arrangements.

The capacity markets vary in their details but have capacity determination and rules for capacity derived from central planning. Commonly they require that users be charged separately for the capital cost of plant deemed by regulation necessary to meet specified capacity of the market as a whole, as well as pay for electricity traded in the spot market. The capacity market approach is based upon the proposition that electricity demand and supply are so inelastic that spot market prices are insufficient to support investment of sufficient capacity to rule out involuntary disruptions to service, which consumers are willing to pay to avoid (Cramton et al., 2013).⁵ I consider only New Zealand's normal-form market, but my remarks on bids and offers in the spot market are also applicable to the spot markets of the capacity-market form of electricity market.⁶

The spot market operates in continuous time and its management is separated into contiguous half-hour trading periods. In advance of the trading period generators submit their price-quantity offers to generate, and the dispatcher – the system operator – assembles these in a supply curve ranking from lowest- to highest-price offer. The spot market price is the offer-price found by the point on the supply curve corresponding to the level of electricity consumption in that trading period.⁷ The result is the text-book static supply and demand determination of price. It is static in the sense that each trading period is such a short snapshot of time that all it concerns is trading electricity in the context of existing infrastructure: there is not time in a trading period for investment decisions to be taken that affect trading in that period. All electricity actually produced – dispatched by the system operator – in that trading period is priced at the price of that trading period. This spot price is common to all spot transactions.⁸ Those generators that submit offers priced at or below the trading-period spot price will have their electricity sold at this uniform price. The other generators will not be called upon to supply electricity, as their offer prices exceed the spot price. This trading process incentivizes generators to price their offers at the cost of electricity production to them. It is an efficient process when the cost of the resources used by generators to produce the trading-period electricity is their opportunity cost: being the highest-value alternative use of those resources in some other endeavor in that trading period. Trading periods are static and apply over a short snapshot of time. In consequence, the resource cost of generation in a trading period is the variable cost of plant: it excludes costs – such as capital costs – that cannot be varied in the half-hour window that is the trading period. In short, if the variable cost that generators use in their offer decisions is the opportunity cost of these resources, the spot market will be efficient.

⁵ The argument for the capacity-market framework is given by Cramton et al. (2013) in an environment where management due to storage availability is not considered and demand management mechanisms are assumed very limited. There is not space here to review the rationale for the capacity-market model.

⁶ Plant capacity in the New Zealand market is continually reviewed (for 2016 see Security and Supply Framework: information paper, New Zealand Electricity Authority, October 2016, accessed Dec. 18, 2016: <http://www.ea.govt.nz/development/work-programme/risk-management/review-of-stress-testing-regime/consultation/#c16205>). It has been found to approximate the efficient level since 1996 when the market was instigated (see for example the 2009 the Ministerial Taskforce Review of the NZ Electricity Market and Background papers (<http://www.mbie.govt.nz/info-services/sectors-industries/energy/previous-reviews-consultations/review-of-the-electricity-market-2009>), accessed Nov. 16, 2016) The criterion for efficiency being that there should be no involuntary black outs due to inadequate industry capacity in the presence of shocks to demand or supply; and that in a stationary or growing electricity market the hedge price should approximate the unit cost of least-cost additional capacity.

⁷ Where there is any demand response in the medium and short (trading-period) terms this equilibrium price will exist even when supply equals industry capacity.

⁸ A discussion of bidding in the uniform price auction that characterizes spot electricity markets is provided in Cramton (2004).

3. Spot price and opportunity cost

Spot-market efficiency requires that generators' offers include the full opportunity cost of the resources used in generation in each trading period. The opportunity cost includes the operational marginal cost and the value of the option to delay generation. The option to shift generation from today to some future trading period requires the ability to store generation fuel or electricity. For example, a profit-seeking generator that expects a higher price next trading period will, if it has the ability to do so, either delay generation until the next period or generate immediately but store the electricity so that it is available for later sale.⁹ Further, given that the expected price of the future period is an efficient price – for example, one produced in a competitive spot market – the delay is socially desirable. In short, where the generator has the ability to delay production or sale of electricity, the opportunity cost of generation in any trading period includes the operational marginal cost and the value of the option to delay. This ability is provided by storage.

Observation of the existing NZEM reveals that hydro generators generally do not offer in at their operational marginal cost of zero but rather seek to allocate their stored water – equivalently their generation – over time by offers priced much higher than zero. They have this option to delay generation because of control afforded by reservoirs. Indeed, the NZEM spot-market price in trading periods when hydro generation is active, but not operating at capacity, is the value of the option to delay generation (Evans et al., 2013).¹⁰ Without storage facilities there is no delay option, and the opportunity cost of resources used in a trading-period generation consists solely of operational cost. Hydro plant with no reservoir are termed run-of-river plants. These have no discretion¹¹ to shift generation between time periods, and would be offered to system dispatch at a zero price.

Options to delay, in addition to operational marginal cost, are important in efficient management of fossil fuel generation as well. In gas-fired generation, delay options arise because of pipelines and tanks that can be used for storage, and because of the nature of gas contracts. Where there are take-or-pay contracts for gas supply to generators,¹² assigning specific values to the particular gas used in a trading-period to calculate operating marginal cost is often artificial and not a meaningful component of an offer price. The offers will reflect the availability of gas over the period of the contract, and given trading in the electricity spot market, optimal timing of gas use will be achievable by basing decisions on the value of the option to delay. This decision-making will enhance the value of the generation firm as well as be socially desirable. Desirable timing of gas generation may be achieved by using the value of the delay option, together with any operational marginal cost, in offer prices (Evans and Guthrie, 2009).

The resulting widespread use of the value of delay options

⁹ The value of this option will depend on expectations of prices and physical factors such as the rate at which the reservoir can be replenished, as well as the amount of stored fuel (or electricity), and the capacity of each of the reservoir and generation plant.

¹⁰ Strictly, given that the operational marginal cost is zero, the spot market price lies between the option value of tranches of generation being dispatched and those that are not.

¹¹ Discretion includes the ability to generate at various rates of electricity production.

¹² The actual gas availability constraints depend upon the contract for the supply of gas; for example, provision for variation in gas-take over some period will affect the timing of gas generation. If gas used in generation was continuously traded in a liquid gas spot market accessible by generators; the spot price would be a reasonable component of the operational marginal cost of gas for generation.

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