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Follow the missing money: Ensuring reliability at least cost to consumers in the transition to a low-carbon power system

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ABSTRACT

Electricity markets must ensure reliability, deliver value for money, unleash technology and service innovation, and empower and protect consumers. This article offers a brief refresher on how we should expect energy prices to form in a modern system and the ways in which they should be expected to shape critical investment decisions. The author lays out a robust and sustainable approach to ensuring a reliable, low-carbon electric supply at the lowest reasonable cost.

1. Introduction[2]

Competitive wholesale electricity markets are often said to suffer from a "missing money" problem. This refers to the idea that for various reasons prices for energy in these markets may not fully reflect the value of investment in the resources needed to meet customers' expectations for reliable electric service. While the analysis behind these claims is often muddled, there can be legitimate concerns about the quality of implementation of electricity markets and whether prices in these markets adequately reflect demand for reliability. The possibility that money is "missing" from the market can, in turn, impede needed investment.

That said, there is no single pathway to a reliable power system, and different pathways come with different price tags. Experts agree that a growing share of variable renewable resources increases the value of flexibility elsewhere in the system,[3] value that can only be seen clearly in prices reflecting real-time conditions in the wholesale electricity market. Yet many of the measures proposed to replace missing money operate outside of that market, on different time scales and using different parameters. They dilute and thus subvert the unique role energy prices can and should play in shaping investment to meet the other half of the reliability challenge—reliable service *at the lowest reasonable cost to consumers.* As a result, in trying to restore missing money they create a new problem: misallocated money, that is, overcompensating some resources and undercompensating others.

Misallocation can create structural incentives to invest in a mix of resources ill-suited to the underlying needs of the system, particularly a low-carbon power system. It can obscure the true value of energy storage and flexible demand as supply becomes less controllable. As a result, the business case for innovation can be seriously compromised and consumers can face significantly higher costs for reliability.

"Keeping the lights on" is about more than just investment in generation. It's about delivering value for money, and it's about empowering and respecting consumers. Getting energy price formation in wholesale electricity markets right remains a key to tying these pieces together. This article briefly recaps the principles behind electricity market pricing, considers some of the ways those prices can go wrong in practice, and proposes a robust and sustainable market approach to meeting expectations for reliability at the lowest reasonable cost to consumers.

2. Energy prices in electricity markets

Misguided approaches to the missing money problem often originate in a flawed understanding of how energy prices are

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1 Regulatory Assistance Project.

2 The topics discussed in this article are explored at more length in Hogan (2016). *Hitting the Mark on Missing Money: How to ensure reliability at least cost to consumers.* Brussels, Belgium: Regulatory Assistance Project. Retrieved from http://www.raponline.org/knowledge-center/hitting-mark-missing-money-ensure-reliability-least-cost-consumers/

3 For a comprehensive reference see International Energy Agency (2014). *The Power of Transformation – Wind, Sun and the Economics of Flexible Power Systems.* Retrieved from https://www.iea.org/publications/freepublications/publication/The_power_of_Transformation.pdf

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meant to be formed in the electricity market and how they are expected to support needed investment.

The competitive wholesale electricity markets introduced in regions including North America and Europe over the past thirty years were conceived of as true commodity markets in which the wholesale price of electricity is the price at which the quantity of supply willing to sell matches the quantity of demand willing to buy (the "market clearing price"). The clearing price of electricity was meant to be the principal basis for decisions regarding investment, production, and distribution.[4] That is, wholesale electricity markets were, in principle, meant to be no different from any other commodity market. That a low-carbon power system may be more capital intensive than in the past does not change this—the electric industry has always been highly capital intensive, and many, if not most capital-intensive commodity industries recover their capital costs as well as operating costs in markets based on unit pricing. Examples include petroleum refining, real estate, and commercial airlines.

In practice, few commodity markets live up to the theoretical ideal, which is why various forms of regulatory and administrative intervention can be appropriate. The more important the commodity, the more important it is that the integrity of the market be reinforced by judicious interventions. Electricity is both an especially important commodity and one that has historically exhibited its own particular set of challenges.

First, electricity is more difficult and expensive to store than most commodities. As a result, electricity markets are more susceptible to being manipulated by the withholding of production. This puts a high premium on reducing market concentration, and it means the competitiveness of the market must be monitored and enforced as close to real time as possible. In many cases, the response to these challenges has been to impose various forms of direct and indirect price controls in an attempt to mitigate possible market power abuses. This both undermines legitimate price formation and simply postpones the necessary work of ensuring competitive markets, because no market, however constituted, can function without effective competition.

Second, even when wholesale prices have been allowed to reflect more closely the conditions in the real-time market, demand for electricity has tended to be "inelastic"—relatively unresponsive to higher costs during shortages or to greater opportunities during surpluses. While the value of uninterrupted service can be quite high for some energy services, the inelasticity of demand is more generally attributable to the common practice of non–time-varying retail pricing. This practice arose, in turn, from the combination of monopoly retail franchises and the historical impracticality of serving any but the largest individual customers selectively based on their willingness to pay. The result has been that virtually all loads in a given area are served for the same price in shortage hours and in surplus hours, until none of them are served.[5] Consequently, the demand impacts of fluctuating wholesale prices have played out only in longer time frames, if at all.

The fact that demand has historically been relatively inelastic does not mean consumers place an unlimited value on reliability. The value of continuous service (the "value of lost load" or VoLL) varies widely, from near zero (for example, when charging an electric vehicle at 2am) to tens of thousands of euro per megawatt-hour (MWh) (say, at a hospital). While cheap and convenient options for consumers to act on that range of values are expanding rapidly, for now we continue to rely principally on standards set by public officials that impute a single reliability value for all loads. That imputed value varies but is typically set toward the upper end of the range.

System operators apply that value by acting, in effect, as the buyer and seller of last resort, procuring the various reserves and other services needed to be able to comply with the public standard in real time. System operators procure these services from the same pool of resources that are expected to meet the demand for energy. When production to meet the demand for energy begins to eat into what is needed in reserve by the system operator to comply with the reliability standard, the true marginal cost of producing a kilowatt-hour (kWh) of energy—the true basis for "marginal cost pricing"—includes the cost system operators should be willing to incur to reserve additional resources, or should charge to release resources to meet the rising demand for energy. If we believe what we say about the value consumers place on reliability, then this "opportunity cost" is as real as any other marginal cost reflected in market prices.

In this way, wholesale energy market pricing is meant to reflect not just the short-run marginal cost of energy sold in the forward energy market but the marginal cost of all actions required to meet the demand for reliable energy (see Table 1).[6] When supply margins are tight, the demand for energy and balancing services can drive marginal costs well above the variable cost of the last kWh sold in the forward market. This in turn reveals the true window of opportunity for consumers to play their role in balancing supply and demand.

Fig. 1 illustrates how this might be expected to affect market pricing during a typical period of tight supply margins on a hypothetical system (resulting either from high demand or from the unavailability of a significant amount of generation). In Scenario a, demand for reserves is not reflected in the demand curve, the marginal costs of "emergency" resources available to the system operator are socialized or ignored and thus not reflected in the supply curve, and the price of supply is capped well below the imputed VoLL. The result is market clearing price p_1. In Scenario b, the marginal costs of all actions available to balance the system are reflected in the supply curve, the price cap has been lifted to imputed VoLL, and the demand curve now reflects total demand

Table 1
Representative Rank Order of Marginal Costs (Excluding Price Responsive Demand).[11]

System Resource	Full Marginal Cost (€/MWh)
Generation capacity	20–250
Imports	20–1000
Secondary (operating) Reserves	250–5000
Emergency generation	500
Primary (regulation) reserves	500–9000
30-min responsive back-up	1400
30-min controllable demand response	2400
10-min controllable demand response	2600
10-min responsive back-up	3700
Emergency load-shedding	9000

[4] See Joskow (2008). Lessons Learned from Electricity Market Liberalization. *The Energy Journal*. Special Issue. Retrieved from http://economics.mit.edu/files/209 "The overriding reform goal has been to . . . ensure that an appropriate share of [societal] benefits are conveyed to consumers through prices that reflect the efficient economic cost of supplying electricity and service quality attributes that reflect consumer valuation." (Page 11)

[5] It is this characteristic, referred to as "non-excludability," that has led to the treatment of electricity as a "public good." Technology is rapidly eroding the non-excludability of electricity.

[6] In essence, this describes the difference between a market based simply on "economic dispatch" (as commonly misconstrued) and the actual design basis of "security-constrained economic dispatch."

[11] Adapted from Pfeifenberger et al. (2013). *Resource Adequacy Requirements: Reliability and Economic Implications*. The Brattle Group; and Newell et al., 2014. *Estimating the Economically Optimal Reserve Margin in ERCOT*. The Brattle Group.