Analyzing the Blackout Report's Recommendations: Alternatives for a Flexible, Dynamic Grid

The report shows that industry, regulators, and policymakers still take a very physical supply-oriented view of the system. They would be more innovative, and come up with better policies for more robust networks, if they treated the grid as an organic, dynamic system.

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I. Introduction

The government's final report on the Aug. 14, 2003, blackout, *The U.S.-Canada Power System Outage Task Force Final Report*, is a true tour de force.[1] Jam-packed with informative explanations and analyses, it provides a thorough examination of the blackout's causes and consequences. It explains the technical and institutional workings of the North American physical power system clearly and carefully. The report offers a snapshot of system conditions on Aug. 14, and a sense of the system dynamics leading up to the blackout. Specialists may continue to pick over the massive mounds of data collected, but the task force's story of what happened on Aug. 14 and why it happened will not be challenged.

What will be challenged, and should be, are the report's policy recommendations. The blackout report is a fine example of engineering detective work – they've done an excellent job of getting the details right – but when it comes to the recommendations it is clear that they are missing much of the bigger picture.

We need a more flexible, dynamic transmission system, a transmission grid that better

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adapts to the demands that are placed upon it. The recommendations should help us reach that goal. Instead, the recommendations propose more rules, mandatory reliability standards, more government oversight, penalties for non-compliance, regulatory review of a reliability surcharge to fund an electric reliability organization redesigned by government committee, and a number of other initiatives to achieve central control of a single, predetermined level of transmission system reliability. The primary ultimate impact of the 46 recommendations would be the expansion of regulatory oversight over supply side reliability decision-making.

What about the demand side of electric power markets? The demand side of the market gets two mentions in one recommendation calling for additional research funds. While we do not object to additional research – clearly there is much to be learned – existing research and programs in place have already demonstrated that consumers as well as producers can contribute to system reliability. Consumers need more than just research, we need to put what we already know into practice.

On the supply side, power grid operation and market procedures need to be reexamined for rules that unintentionally create conflict between private incentives and system reliability. One such conflict was created by the cost-based rules used to pay for reactive power. The blackout report identifies the problem and proposes a change that would eliminate the conflict. Current NERC procedures for transmission loading relief (TLR) are another candidate for this kind of review. The broader organizational framework of transmission also needs re-examination if we hope to resolve the current stalemate in transmission investment.

''What failed'' last Aug. 14 were physical components of the system, but the report rightly focuses on the systemic problems that allowed the failure of a few lines in Ohio to turn into an event that knocked out the power system throughout a good chunk of the Northeastern United States and Canada, too.

We may not need to invest in additional reliability, but we should allow consumer actions to reveal where and when investments in reliability should be made.

Our analysis of the recommendations in the blackout report leads to these claims, which form the foundation of our argument:

- We may not need to invest in additional reliability, but we should allow consumer actions to reveal where and when investments in reliability should be made.
- Technology and markets enable us to offer different levels of reliability, not one uniform level, even though the grid is so interconnected. These changes favor markets and contracting institutions over regulatory ''one size fits all'' institutions.
- Although tradition and the blackout report treat reliability as a supply issue, it is also a demand issue. Integrating demand into reliability, through dynamic retail pricing and through bidding demand reductions into capacity markets, harnesses the beneficial tensions between supply and demand and creates valuable information about customer willingness to pay for reliability.
- The interconnectedness of an increasingly complex grid environment means that the institutions under which the grid is managed have to understand and adapt to that ever-changing complexity.
- Treating grid ownership and management commercially, as a for-profit business, can deliver superior outcomes through increased transparency.

You can tell a lot about the report's perspective from the heading in Chapter 2: ''The North American Power Grid Is One Large, Interconnected Machine.'' But this ''one large machine'' picture produces a misconception, or at least an oversimplification, of reality on the grid. This misconception is that reliability on the bulk power grid is an either/or proposition: either it is working, or it isn't, and we're all in this together. The implication is usually that we're all bound together by one gigantic externality problem, and if you accept that framing of the problem then the answer will be that consumers need to pay a lot more for better supply-side system reliability.

This mechanistic perspective reveals just how deeply the industry, regulators, and policymakers still take a very physical supply-oriented view of the system. They would be more innovative, and come up with better policies for more robust networks, if they treated the power grid as an organic, dynamic system.

II. Do We Need More Reliability Mandates?

Why not ''no change'' as a possible policy recommendation? We may not need more reliability, or at least not more of a mandatory, uniform level of reliability. As the blackout report points out, big blackouts are not very common. The electric power system is already highly reliable, but every 10 years or so a significant blackout comes along. Seems to be a pretty good record.

Big blackouts are costly, and ''never again'' is a fine sentiment, but do we really want more reliability? Consumers already pay a lot for reliability, and whether we want to buy more depends upon how much will it cost us. The task force report has given us a long shopping list of top-down recommendations, but it didn't include a price tag.

There is a deeper problem. It is not clear that anyone knows whether a typical electricity consumer in the U.S. or Canada would rather have more reliability at higher power prices or less reliability and lower power prices. Some consumers would probably be willing to pay more to have more reliable service, and others would pick lower prices even if service quality went down a little. The existing top-down system offers no way for operators and policymakers to gather information on how different customers value reliability. Nor does it offer much in the way of buying different levels of reliability, instead treating reliability as a ''one size fits all'' characteristic.[2]

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Even residential customers may prefer different levels of reliability. Those who prefer more can purchase battery-backup power supplies to keep computers up and running even if the local distribution company is having problems: paying a little more to have more reliable service for a select appliance or two, and needing a little less average reliability from the local wires company. Businesses do the same thing on a larger scale, with companies that have special needs for highly reliable electric power spending millions of dollars to secure their supplies. This is a focused demand-side approach that provides very targeted power reliability, but this is only part of the picture.

What ability do consumers have to get the qualities of supply-side power system reliability for which they are willing to pay? Are there other ways to provide reliability that don't have the pitfalls of the uniform top-down system?

Currently, few avenues exist for consumer reliability choices to percolate up through the market, informing the system-wide choices about reliability that distribution and transmission system operators need to make appropriate maintenance and investment decisions. Hung-po Chao and Robert Wilson have suggested one approach, called ''Priority Insurance,'' that would produce this kind of information.[3] The essence of the idea is to have the electric company pay consumers when the lights go out. A simple idea, but they add a twist: The electric company offers different qualities of service. For a higher price, you get a lower probability of being cut off when the system is short of power (and a higher payment from the electric company when the lights go out); pay a lower price, get a higher

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probability of being cut off (and a lower payment). Customers would actually be able to choose between price and reliability, based on the individual tradeoff they perceive between them.

Charles Nossair and David Porter tested a version of this idea against a simple system of proportional rationing of shortages, and found that their version of Priority Insurance was more efficient.[4] Nossair and Porter added another twist in that in their version the number of levels of service and price levels were endogenous to the customer evaluations – it sounds more complicated, but it is easier than having the electric company try to figure out the ideal set of offerings, and more adaptable, too.

While one benefit of the Priority Insurance approach is that it allows the electric company to allocate a shortage efficiently by having customers prioritize their own use, a bigger payoff comes from the information created by the consumer actions. The Chao and Wilson approach enables consumers to express values separately for energy and for service reliability, allowing the company to target investments where they can provide the most long-term value to consumers. Companies could distinguish what customers are willing to pay for power from what they are willing to pay for reliability. Thus Priority Insurance enables the optimization of investment and capacity utilization over time.

III. Reliability Is a Supply *and Demand* Issue

A blackout is a supply failure, so naturally people look for supply-side solutions: more transmission lines, high-tech system monitoring devices, building power plants closer to population centers, better grid planning and testing procedures. Few people consider how effectively demand response and active retail markets can help reduce strains on the grid and forestall future grid and plant construction. We can, and should, use market-based retail pricing to communicate customer demand into the grid, and one reason to do so is that it would enhance reliability.

For the most part, the report is about a supply failure and supply-side proposals.

First, to give credit where credit is due, the Task Force final report does, in fact, address ''demand response.'' Twice. In two short paragraphs in the discussion of research needs, the report: (1) cites ''demand response initiatives to slow or halt voltage collapse'' as one aspect of research into ways to prevent cascading power outages; and (2) urges the ''study of obstacles to the economic deployment of demand response capability and distributed generation.''[5] In addition, with a little creativity, a role for demand response might be read into a few other recommendations.

For the most part, however, the report is about a supply failure and supply-side proposals. For 99-plus percent of the blackout report, end-use consumers are simply the ''load,'' a passive burden that the supply side must go to great lengths to serve.

Consumers are the sleeping giant of electric reliability. The North American Electricity Reliability Council (NERC) divides reliability into two categories: security of operating reserves and adequacy of installed reserves. Security is more of a short-run operational issue, while adequacy relates to planning for system growth. Demand responsiveness can contribute to both kinds of reliability.[6]

Retail electric choice puts more control in the hands of consumers and empowers them to make intelligent energy choices. Consumers could choose anything from a fixed price that incorporates an insurance premium to full real-time pricing, in which the customer bears the financial risk of price volatility, but could see electricity bills fall by shifting or reducing use.[7]

Dynamic pricing harnesses the dramatic improvements in infor-

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mation technology of the past decade to provide price signals that reflect variations in the actual costs of providing electricity at different times of the day. These same technological developments also give consumers a tool for managing their energy use. They can set electricity monitors to increase air conditioning temperatures if prices go above a certain amount, for example, or can shift manufacturing schedules to minimize electricity use during peak hours. Right now, with almost all U.S. consumers paying average prices (even many industrial and commercial consumers), consumers have little incentive to manage their consumption and shift it away from peak hours during the day.

That inelastic demand leads to more capital investment in power plants and transmission lines than would occur if consumers could make choices based on their preferences. Reducing peak use contributes to greater operational security, as fewer reserves are necessary to maintain reliability, and eases stress on adequacy planning, as the need for system expansion to support ever-greater system peak loads is diminished.[8]

Both historical experience and laboratory experiments show that electricity customers do respond to price changes, and that both suppliers and customers are better off from doing so.[9] This option does not currently exist for most customers in most places.

Another approach to enabling consumers to contribute directly to reliability comes from efforts to turn demand response into a tool that transmission system operators can call on in their efforts to keep supply and demand constantly in balance. Research by Brendan Kirby and John Kueck of Oak Ridge National Laboratory showed that a significant portion of the California Independent System Operator's spinning reserve requirement could be supplied from the California Department of Water Resources pumping load. The CDWR could stop pumps for brief intervals in response to specific short-term transmission system needs. Another scheme would enable controllable air conditioning units to be cycled off for brief periods when the system is stressed.[10]

Lack of reactive power support was cited as a contributing factor to the blackout.

Retail rate regulation is what put the demand side to sleep, but it is now time for consumers to wake up. Retail pricing is a crucial component of a healthy, dynamic electricity industry, and a reliable grid. Offering consumers service choices in a range of prices would make diverse consumers better off, and bolster system reliability.

IV. Conflicts Between Markets and Reliability

On the supply side, power grid operation and market procedures need to be reexamined for rules that unintentionally create conflict between private incentives and system reliability. The blackout report urges, ''Market mechanisms should be used where possible, but in circumstances in which reliability and commercial objectives cannot be reconciled, they must be resolved in favor of high reliability.''[11] Clearly there are times a transmission system operator must invoke emergency rules to maintain the short-term reliability of the grid, and market rules reasonably are suspended during the emergency. But the premature granting of a trump card to high reliability in cases of conflicts overlooks how poorly designed reliability rules can create the conflicts in the first place.

One example of the way transmission system rules can create conflict was identified in the blackout report. Lack of reactive power support was cited as a contributing factor to the blackout. Reportedly, system operators asked an independent generator to produce more reactive power, and the generator declined because it would make more profit selling real power. The general problem is that no matter how valuable reactive power becomes to the transmission system, in most of the country the prices that the transmission

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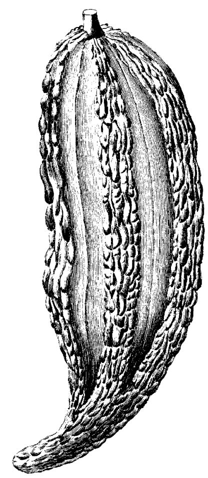
provider can pay for reactive power remain fixed in cost-based rate tariffs on file at the Federal Energy Regulatory Commission. When real power prices rise to high levels, the rules for reactive power purchases create conflict. The blackout report rightly recommends that when generators are called upon to sacrifice real power sales to provide reactive power for reliability purposes, the generators will be paid for any lost revenues. That change removes the conflict between private action and system reliability.

Current NERC procedures for transmission loading relief are another candidate for this kind of review. TLR procedures provide a set of administrative rules to cut back power transactions when congestion threatens to overload part of the grid. TLR rules are known to be economically inefficient at resolving congestion, and often are even inefficient in a technical engineering sense because the transactions that get cut off sometimes offer only slight relief of the problem.[12] The expectation that a TLR may be called can create sometimes perverse incentives for transactions in the neighborhood of the expected TLR. But the economics surrounding TLRs are murky, and a deeper examination is needed.

In some fairly limited circumstances concern for system reliability should trump market decision-making, but let us first make sure that it isn't poorly designed reliability rules that are causing the problem.

V. Connecting the Dots in Transmission

If we want a robust and reliable grid, then we also have to reconsider the ways in which we own, manage, and operate transmission. This question has been a core component of restructuring debates over the past four years, and disagree-



ment over the proper organization of transmission operations continues. But the management and organization of transmission systems are crucial to the development of robust, healthy wholesale markets.

The present organization of transmission operations is complicated and not particularly transparent. Currently most transmission is owned by regulated public utilities, though federal agencies and other entities own a large chuck of transmission, especially in the West. In the Northeast and in California, an independent transmission provider (RTO or ISO) manages transmission, while in the rest of the U.S. the local monopoly utility company manages most transmission.

Most transmission service is regulated by FERC, a federal government agency (but, paradoxically, FERC does not regulate transmission owned by other federal agencies). A great deal of transmission was built by local monopoly utility companies to serve ratepayers in their ''home'' service territory, under terms regulated by state utility commissions.

Most reliability rules, governing a great deal of the terms of transmission operation and the costs involved, are established by NERC and implemented in conjunction with 12 regional reliability councils. In regions with RTOs/ISOs, that organization usually acts as reliability coordinator. The reliability coordinators oversee control area operators. The control area operators are the ''front line'' system operators with the job of keeping the interconnected grid up and running.

The Midwest region is much more complicated than most of the country, and the explanation takes all of a half-page sidebar on page 14 of the blackout report. In the Northeast, the ISOs typically cover one or two control areas; the Midwest ISO ''provides reliability coordination for 35 control areas in the ECAR, MAIN and MAPP regions and 2 others in the SPP region.'' PJM now oversees nine control areas, but most of these are in the Midwest region, too.

This complex organizational structure to control reliability arose out of the 1965 blackout,

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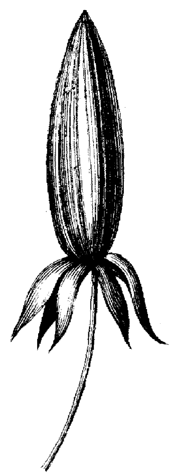
which occurred at a time when wholesale power transactions were few, and not much trade crossed control area lines. Now, with power flows crossing borders between reliability coordinators and through multiple control areas, things have changed. Any lack of clarity or transparency – about who is responsible for system status, about information flows among control areas, or about funding of reliability investment – becomes more problematic as trade increases and the quest for efficiency increasingly puts pressure on these worn-out, opaque institutions.

Investment in transmission has been lagging for years, and the regulatory response has been to offer more incentives and more assurances that cost recovery is available. In April, FERC issued a policy statement on reliability that again assured transmission owners that prudent reliability costs could be passed along in transmission rates. It is more of the same regulatory approach, and maybe this time it will work.

A recent paper by Paul Kleindorfer, a professor at the University of Pennsylvania, makes some of these same points and offers a different vision for promoting investment in the grid: treat transmission service as a commercial, for-profit business.[13] He argues that ''the complexity and interdependence of the power grid . . . [makes it] difficult for distributed owners to come to grips with who should pay for reliability.'' Kleindorfer points out that existing rules governing transmission ownership and operation do not provide the transparency and clarity necessary to any commercial ventures. ''The urgent matter of providing incentives for coordinated resolution of interdependent reliability and congestion problems,'' he said, ''will remain unresolved until we move from the autarchic



perspective of 'every man for himself' to the view that emphasizes the need to see transmission service provision as a business.''

His discussion focuses on four commercial principles that he argues would make transmission a forward-looking venture that would attract investment in, among other things, reliability. First, transmission entities (let's call them RTOs for brevity) have to face performance standards and be accountable for their achievements and failures. This is the role that capital markets and shareholders play in for-profit companies. Second, RTOs should focus on customers. Third, operations and planning in RTOs must integrate the engineering of the system with its economics. Finally, the RTO governance structure must be responsive and decisive.

FERC's current ''ideal'' organizational structure for transmission, in which transmission assets from several companies are combined and turned over to a independent organization to manage, does not connect the economic dots well enough to inspire the commercial creativity necessary to motivate capital markets to invest in transmission.

In a recent presentation, Kleindorfer observed that the underlying structural issues may not just be vague, but even actively harmful: Incumbent transmission owners may face economic incentives contrary to overall system quality and performance.[14] A paper on the economics of networks by Jacques Cremer, Patrick Rey, and Jean Tirole makes the essential point in a different context: The benefits of network quality improvements may go disproportionately to the creative upstarts in the industry, but the quality of the network is largely determined by the investment decisions of larger, established firms.[15] If you are the established firm, how much do you want to pay in order to throw the door open wide to your new competitors?

The current regulatory/administrative approach to transmission planning and operations has, along with a substantial dose of regulatory uncertainty, given us the current mess in the transmission business. The solution may be to treat the transmission business as more of a business.

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VI. Getting Reliability

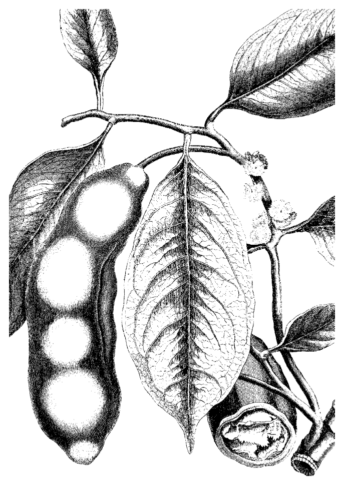
The most obvious lesson learned from the blackout report is that the electric power industry and its regulatory organizations are better at diagnosing system failure *ex post* than at divining ways to foster growth of a self-correcting, self-reinforcing, and dynamically reliable system.

The blackout report does an excellent job of diagnosing the recent failure, and provides a helpful tutorial on power system operations for the non-specialist at the same time. But the 46 recommendations it offers will not get us to success we want.

In some sense the report is trapped by the ''one big interconnected machine'' picture of the grid, and an accompanying view that reliability is a public good that can only be attainted by a mixture of planning, regulation, spending, and hope. But reliability on the transmission system is not the mystery that it once was.

The relevant factors that add to or subtract from system reliability are well understood. Most of these factors are attributed to, or could be measured and attributed to, the responsible party. The responsible party could then be either charged or paid an appropriate amount. The key is to bring reliability into the commercial realm, where choices can be made in the presence of relevant trade-offs.

The ultimate objective is healthy, thriving wholesale power markets, and a healthy wholesale market requires a robust transmission network. Reliability is a crucial element in enabling those power markets to continue developing. But that doesn't mean that reliability is a ''one size fits all'' characteristic of the network. Treating reliability as a public good leads to conflicts; treating it as a private good could avoid those conflicts. The metering, monitoring, and switching



technology exists to treat reliability as a private good. Now we just need the institutional and legal structure.

Healthy, thriving markets are a pipe dream without a demand side. Active retail demand transmits end-customer preferences into the wholesale market, smoothing out peaks and optimizing load factors (and curbing the exercise of supplier market power along the way). Furthermore, allowing demand reduction to bid into capacity markets can reduce the construction of new generation and transmission capacity, and is therefore a good long-run strategy for conservation of resources and for making investment more efficient. Demand response is the Swiss Army Knife of the electricity policy world – it is one compact tool that does a lot of things in a very parsimonious way.

In the end, we think that the most important changes to make in the industry are really just a continuation of industry restructuring. Let's commercialize reliability – reform the reliability rules to properly line up incentives and information flows. Reliability is valuable to consumers. What has been lacking is a way for consumers to express that value, and for suppliers to be paid appropriately for providing it.

VII. Conclusion

The introduction to the Task Force's chapter of recommendations is telling both in its focus – fixated on the supply side – and its proposed measure for success. The report provides four broad themes to use in thinking about the recommendations. Distilled to their essence the four themes are:

1. Regulators and industry must commit themselves to the highest reliability standards in ''the planning, design, and operation of North America's vast bulk power system.'' Market mechanisms ''should be used where possible,'' but not if they would conflict with reliability.

2. High reliability is costly, regulated firms must be assured of cost recovery, and unregulated firms must believe that reliability investments will be profitable.

3. Recommendations must be implemented to work, and in-

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dustry and government should commit themselves to the task.

4. While the Aug. 14 blackout was not caused by a malicious act, a number of physical and computer security improvements are called for.[16]

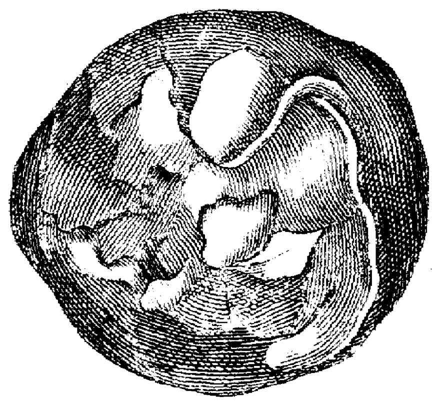
The demand side of the equation – consumers – get explicit mention only in theme No. 2. The report tells consumers (and regulators) that reliability isn't free. Ironically, it is the same message that consumers must tell the Task Force: Reliability isn't free. Before we commit to the ''highest reliability standards,'' we as consumers, ratepayers, and taxpayers should ask how much will it cost? Better still, what is the value on the margin: How much more reliability will we get as spending on reliability increases?

Another important demand-side question is: How will we know if we get the level of reliability that we pay for? The Task Force proposes to measure the success of its program by how many of its proposals get implemented: ''The metric for gauging achievement of this goal,'' says the report, ''will be the degree of compliance obtained with the recommendations presented below.'' It is typical of the supply-side focus of the Task Force, trying to gauge the value of a process by how much goes into the effort. The consumer, who will be stuck with the bill, cares more about how well the resulting system works.

The regulator's report provides a regulatory solution. That fact in itself is not too surprising. But the regulatory solution won't give consumers what they could really use, which is a more efficient, more resilient and more dynamic power grid.■

Endnotes:

1. U.S.-Canada Power System Outage Task Force Final Report, available at https://reports.energy.gov.



2. Richard Hunter, Ronen Melnik, and Leonardo Senni suggest that consumers that have relatively reliable power would rather see improvements in call center waiting times and other service improvements instead of even more-reliable power. See *What Power Consumers Want*, McKinsey J., 2003 No. 3, available at http://www.mckinseyquarterly.com/ab_g.asp?ar=1320.

3. H. Chao and R. Wilson, *Priority Service: Pricing, Investment and Market Organization*, Amer. Econ. Rev. 77 (1987), 899–916; see also H. Chao and S.C. Peck, *An Institutional Design for an Electricity Contract Market with Central Dispatch*, Energy J., Jan. 1997, at 85–110.

4. Charles Noussair and David Porter, *Allocating Priority with Auctions: An Experimental Analysis*, J. Econ. Behavior & Org., Oct. 1992, at 169–195.

5. Recommendation 13: *DOE should expand its research programs on reliability-related tools and technologies. U.S.-Canada Power System Outage Task Force Final Report*, at 149.

6. See ''Reliability,'' NERC Glossary of Terms availability at www.nerc.com/glossary/glossary-body.html.

7. See Eric Hirst, *The Financial and Physical Insurance Benefits of Price-Responsive Demand*, Elec. J., May 2002.

8. Vernon L. Smith and Lynne Kiesling, *Demand, Not Supply*, Wall Street J., Aug. 20, 2003.

9. Stephen Rassenti, Vernon Smith, and Bart Wilson, *Controlling Market Power and Price Spikes in Electricity Markets: Demand-Side Bidding*, Proceedings of the National Academy of Science, 100 (2003), at 2998–3003; see also Stephen Rassenti, Vernon Smith, and Bart Wilson, *Using Experiments to Inform the Privatization/Deregulation Movement in Electricity*, Cato J. 21 (2002), at 515–545.

10. See http://certs.lbl.gov/CERTS_P_Load.html. The research was supported in part by the DOE's current research program in transmission reliability.

11. *U.S.-Canada Power System Outage Task Force Final Report, supra* note 1, at 139.

12. See Fernando L. Alvarado and Rajesh Rajaraman, *On the Inherent Inefficiencies of TLR for Trading Electricity*, Presentation, MEET 2000, Stanford, CA, Aug. 17–20, 2000; and Potomac Economics, *2002 State of the Market Report: Midwest ISO*, May 2003.

13. *Economic Regulation under Distributed Ownership: The Case of Electric Power Transmission*, Jan. 2004, available at http://www.charlesriverresearch-corp.com/Kleindorfer.pdf.

14. Available at http://www.pff.org/publications/energy/.

15. *Connectivity in the Commercial Internet*, J. Ind'l Econ., 48 (2000), at 433–472. See also Amitai Aviram, *Regulation By Networks*, BYU Law Rev., 2003, at 1179–1238.

16. *U.S.-Canada Power System Outage Task Force Final Report*, *supra* note 1, at 139.

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