ELECTRICITY MARKET REFORM:
Market Design and the Green Agenda

William W. Hogan

Mossavar-Rahmani Center for Business and Government
John F. Kennedy School of Government
Harvard University
Cambridge, Massachusetts 02138

Renewable Energy Policy

University of Cambridge Electricity Policy Research Group
FTI Consulting
Compass Lexecon
Cambridge, England

May 13, 2011

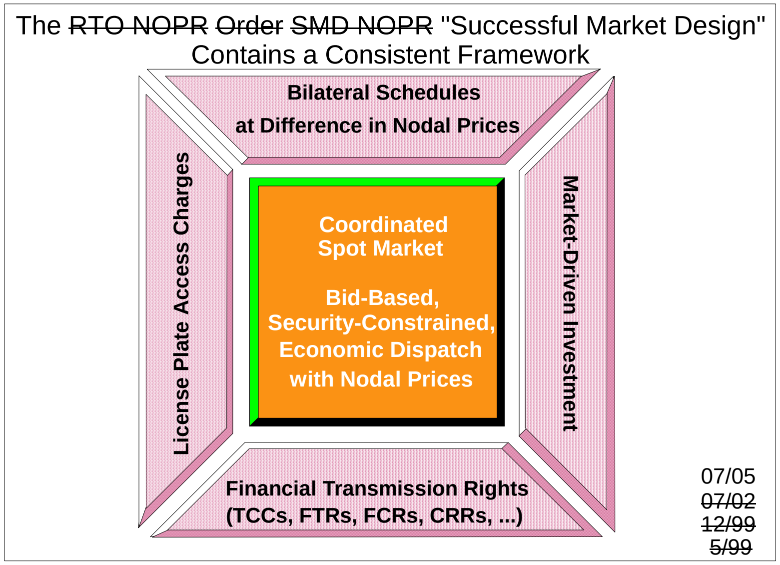
The focus on the electricity sector's role in addressing climate change through improved efficiency, development of renewable energy, and use of low carbon fuels creates expanded demands for and of electricity restructuring.

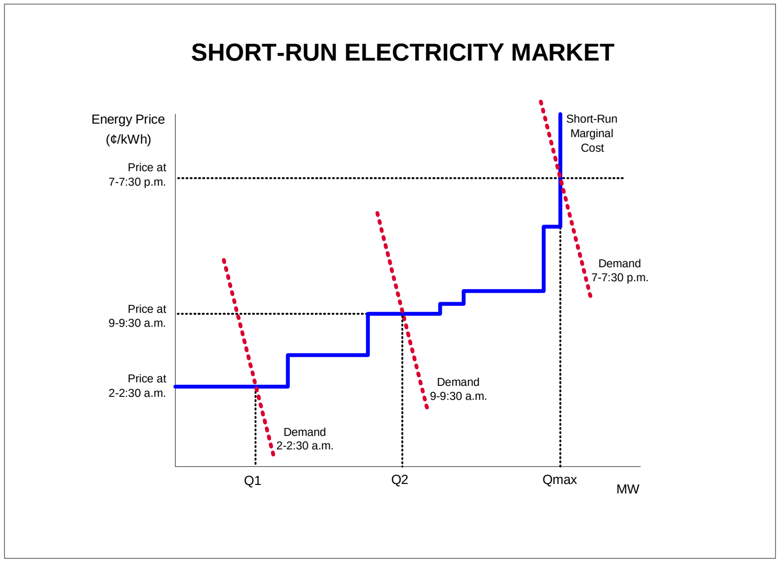
The transformation envisioned is massive, long term, and affects every aspect of electricity production and use.

- Uncertain conditions require a broad range of activities to integrate new technology and practices.
- Innovation requires promoting technologies and practices not yet identified or imagined. "Silver buckshot rather than silver bullets."
- Smart grids can facilitate smart decisions, but only if the electricity structure provides the right information and incentives.
    - Open access to expand entry and innovation.
    - Smart pricing to support the smart grid technologies and information.
    - Internalizing externalities, while exploiting the wisdom of crowds.
        - Price on carbon emissions.
        - ***Good market design with efficient prices.***
        - Compatible infrastructure expansion rules.

The example of successful central coordination, ~~CRT, Regional Transmission Organization (RTO) Millennium Order (Order 2000) Standard Market Design (SMD) Notice of Proposed Rulemaking (NOPR),~~ "Successful Market Design" provides a workable market framework that is working in places like New York, PJM in the Mid-Atlantic Region, New England, the Midwest, California, SPP, and Texas. This efficient market design is under (constant) attack.

> "Locational marginal pricing (LMP) is the electricity spot pricing model that serves as the benchmark for market design – the textbook ideal that should be the target for policy makers. A trading arrangement based on LMP takes all relevant generation and transmission costs appropriately into account and hence supports optimal investments."(International Energy Agency, Tackling Investment Challenges in Power Generation in IEA Countries: Energy Market Experience, Paris, 2007, p. 16.)





Market design in RTOs/ISOs is well advanced but still incomplete.[1]

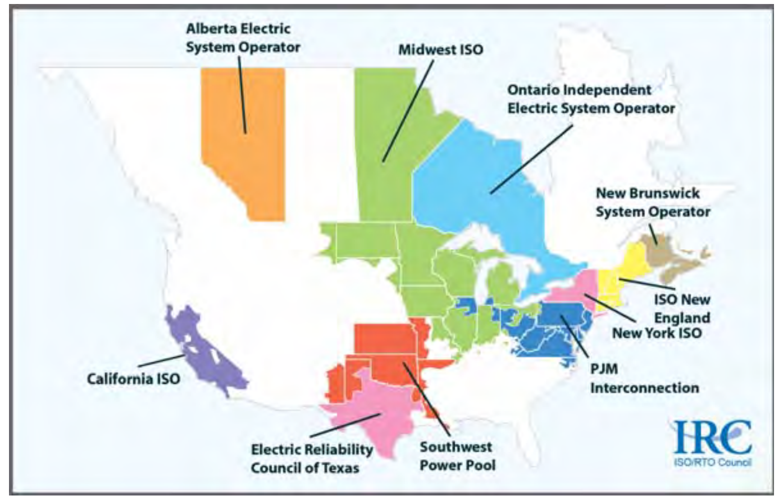
- **Regional Markets Not Fully Deployed**

- **Reforms of Reforms**

  California MRTU (April 1, 2009) and ERCOT Texas Nodal (December 1, 2010) reforms.

- **Market Defect: Scarcity Pricing, Extended LMP**

  Smarter pricing to support operations, infrastructure investment and resource adequacy.



- **Market Failure: Transmission Investment**

  - Regulatory mandates for lumpy transmission mixed with market-based investments.
  - Design principles for cost allocation to support a mixed market (i.e., beneficiary pays).

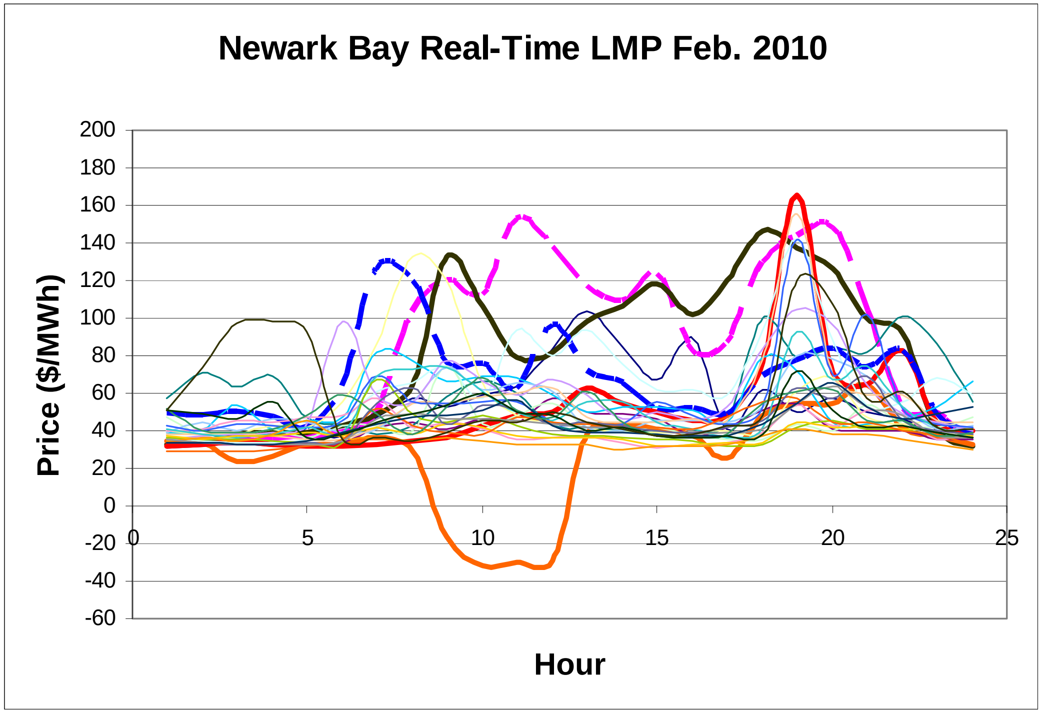
- **Market Challenge: Address Requirements for Climate Change Policy**

1 William W. Hogan, "Electricity Market Structure and Infrastructure," Conference on Acting in Time on Energy Policy, Harvard University, September 18-19, 2008. (available at www.whogan.com).

Smarter pricing provides an opportunity for enhancing efficiency and the range of alternative technologies.

- **Smarter Pricing Challenges**
  - Average energy prices: $50/MWh.
  - Canonical bid baps: $1,000/MWh.
  - MISO average value of lost load: $3,500/MWh.
  - Reliability standard VOLL: $500,000/MWh.

- **Real Time Pricing**
  - Time of Use (TOU) approximations do not track real-time prices: RTP >> CPP > CPR >> PP >> FR.
  - There is substantial geographic and temporal variability of real-time prices.



Early market designs presumed a significant demand response. Absent this demand participation most markets implemented inadequate pricing rules equating prices to marginal costs even when capacity is constrained. This produces a "missing money" problem.

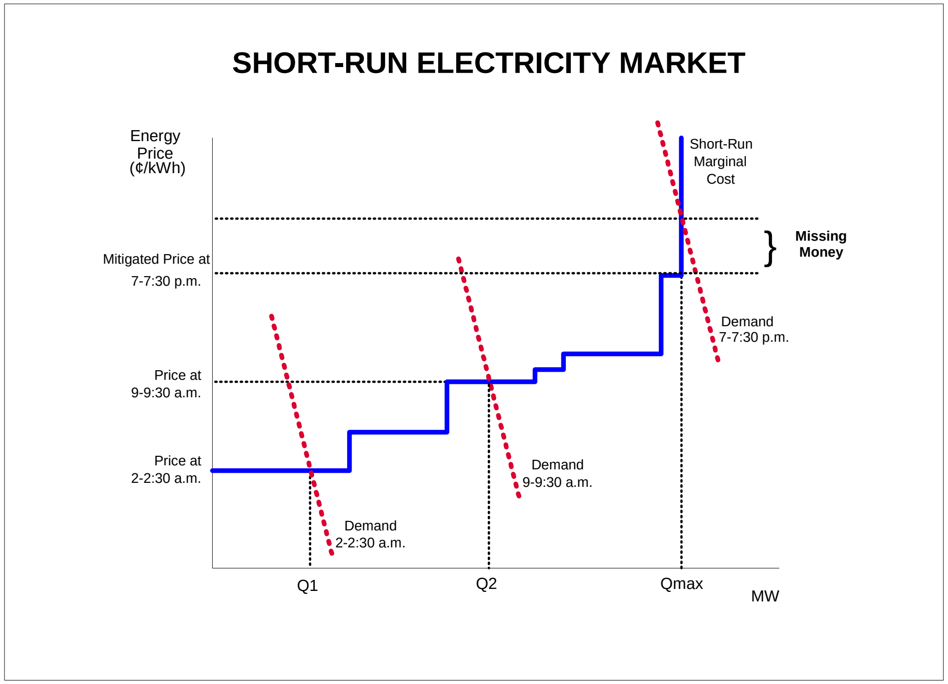
- **PJM, Missing Money, Combustion Turbine (1999-2010, per MW-Year).**

Average Net Energy Revenue = $40,943

Average Levelized Fixed Cost = $88,317

(PJM, State of Market Report, 2010, Vol. 2, p. 176)

- **Capacity Markets.** ISONE, NYISO, PJM.
- **MISO.** Scarcity Pricing and Operating Reserve Demand Curve. (MISO FERC Electric Tariff, Volume No. 1, Schedule 28, January 22, 2009.)[2]



---

[2] "For each cleared Operating Reserve level less than the Market-Wide Operating Reserve Requirement, the Market-Wide Operating Reserve Demand Curve price shall be equal to the product of (i) the Value of Lost Load ("VOLL") and (ii) the estimated conditional probability of a loss of load given that a single forced Resource outage of 100 MW or greater will occur at the cleared Market-Wide Operating Reserve level for which the price is being determined. … The VOLL shall be equal to $3,500 per MWh." MISO, FERC Electric Tariff, Volume No. 1, Schedule 28, January 22, 2009, Sheet 2226.

Scarcity pricing presents one of the important challenges for Regional Transmission Organizations (RTOs) and electricity market design. Simple in principle, but more complicated in practice, inadequate scarcity pricing is implicated in several problems associated with electricity markets.

- **Investment Incentives.** Inadequate scarcity pricing contributes to the “missing money” needed to support new generation investment. The policy response has been to create capacity markets. Better scarcity pricing would reduce the challenges of operating good capacity markets.
- **Demand Response.** Higher prices during critical periods would facilitate demand response and distributed generation when it is most needed. The practice of socializing payments for capacity investments compromises the incentives for demand response and distributed generation.
- **Renewable Energy.** Intermittent energy sources such as solar and wind present complications in providing a level playing field in pricing. Better scarcity pricing would reduce the size and importance of capacity payments and improve incentives for renewable energy.
- **Transmission Pricing.** Scarcity pricing interacts with transmission congestion. Better scarcity pricing would provide better signals for transmission investment.

Improved scarcity pricing would mitigate or substantially remove the problems in all these areas. While long-recognized, only recently has there been renewed interest in developing a better theory and practice of scarcity pricing.[3]

---

[3] FERC, Order 719, October 17, 2008.

The underlying models of operating reserve demand curves differ across RTOs. One need is for a framework that develops operating reserve demand curves from first principles to provide a benchmark for the comparison of different implementations.

- **Operating Reserve Demand Curve Components.** The inputs to the operating reserve demand curve construction can differ and a more general model would help specify the result.
- **Locational Differences and Interactions.** The design of locational operating reserve demand curves presents added complications in accounting for transmission constraints.
- **Economic Dispatch.** The derivation of the locational operating demand curves has implications for the integration with economic dispatch models for simultaneous optimization of energy and reserves.

A series of approximations to a probabilistic unit commitment and economic dispatch models provides a framework for incorporating scarcity pricing and operating reserve demand curves. The resulting model is a workable extension of existing unit commitment and economic dispatch formulations.

Improved pricing through an explicit operating reserve demand curve raises a number of issues.

Demand Response: Better pricing implemented through the operating reserve demand curve would provide an important signal and incentive for flexible demand participation in spot markets.

Price Spikes: A higher price would be part of the solution. Furthermore, the contribution to the "missing money" from better pricing would involve many more hours and smaller price increases.

Practical Implementation: The NYISO, ISONE and MISO implementations dispose of any argument that it would be impractical to implement an operating reserve demand curve. The only issues are the level of the appropriate price and the preferred model of locational reserves.

Operating Procedures: Implementing an operating reserve demand curve does not require changing the practices of system operators. Reserve and energy prices would be determined simultaneously treating decisions by the operators as being consistent with the adopted operating reserve demand curve.

Multiple Reserves: The demand curve would include different kinds of operating reserves, from spinning reserves to standby reserves.

Reliability: Market operating incentives would be better aligned with reliability requirements.

Market Power: Better pricing would remove ambiguity from analyses of high prices and distinguish (inefficient) economic withholding through high offers from (efficient) scarcity pricing derived from the operating reserve demand curve.

Hedging: The Basic Generation Service auction in New Jersey provides a prominent example that would yield an easy means for hedging small customers with better pricing.

Increased Costs: The higher average energy costs from use of an operating reserve demand curve do not automatically translate into higher costs for customers. In the aggregate, there is an argument that costs would be lower.

Better scarcity pricing is an example of smarter pricing to reflect dynamic conditions in electricity systems and better match prices and costs. The alternative includes regulatory mandates and standards that create perverse incentives.

- **Mandates and Standards.** Regulatory mandates often raise average costs but dampen apparent price volatility. For example, capacity payments for the “missing money” induced by inadequate scarcity pricing are typically recovered through socialized and levelized rates.
- **Supply Creates Demand for Mandates.** Socialized costs produce inadequate signals and incentives for distributed generation, variable energy resources, and demand response. The pressure is for more mandates to overcome the poor incentives created by other mandates.
- **Efficient Market Design Competes with Regulatory Rent Seeking.** The principles of workable market design suffer from (constant) collateral attack in the give-and-take of regulatory rent seeking.

A challenge for regulators is to internalize and adhere to the principles of good market design. This often requires making distinctions that are not natural.

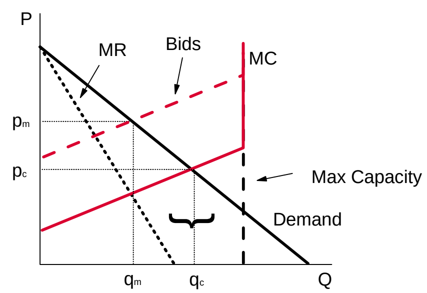
- **Between Costs and Prices.** Minimizing welfare costs is not the same as minimizing consumer prices.
- **Between Short-Run and Long-Run.** A familiar human challenge: “Penny wise and pound foolish.”
- **Between Local and Global Optimization.** Seemingly attractive market design features can be collectively inconsistent. Better design seeks consistency to minimize unintended consequences.

The Federal Energy Regulatory Commission policies confront decisions increasingly inconsistent with basic market design principles.

> "In the face of these diverging opinions, the Commission observes that, as the courts have recognized, 'issues of rate design are fairly technical and, insofar as they are not technical, involve policy judgments that lie at the core of the regulatory mission.' We also observe that, in making such judgments, the Commission is not limited to textbook economic analysis of the markets subject to our jurisdiction, but also may account for the practical realities of how those markets operate. (FERC, "Demand Response Compensation in Organized Wholesale Energy Markets," Order No. 745, ¶ 46, March 15, 2011.)

This rejection of textbook economic analysis is a bad sign: "It won't work in theory, but will it work in practice?" The problem appears in policies to deal with or exploit market power.

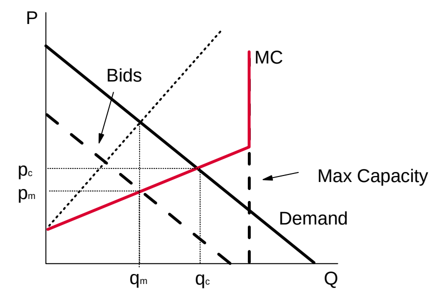
Defining Market Power: Monopoly Withholding



Seller Withholding

$p_m > p_c = MC$

Defining Market Power: Monopsony Withholding



Buyer Withholding

$p_m < p_c = MC$

Recent policy proposals organize buyer market power to reduce market clearing prices and count the transfer from producers to consumers as a benefit captured through government mandates.

Demand Response Payments

"To address this billing unit effect, the Commission in this Final Rule requires the use of the net benefits test described herein to ensure that the overall benefit of the reduced LMP that results from dispatching demand response resources exceeds the cost of dispatching and paying LMP to those resources." (FERC, "Demand Response Compensation in Organized Wholesale Energy Markets," Order No. 745, ¶ 3, March 15, 2011.)

PJM Capacity Markets

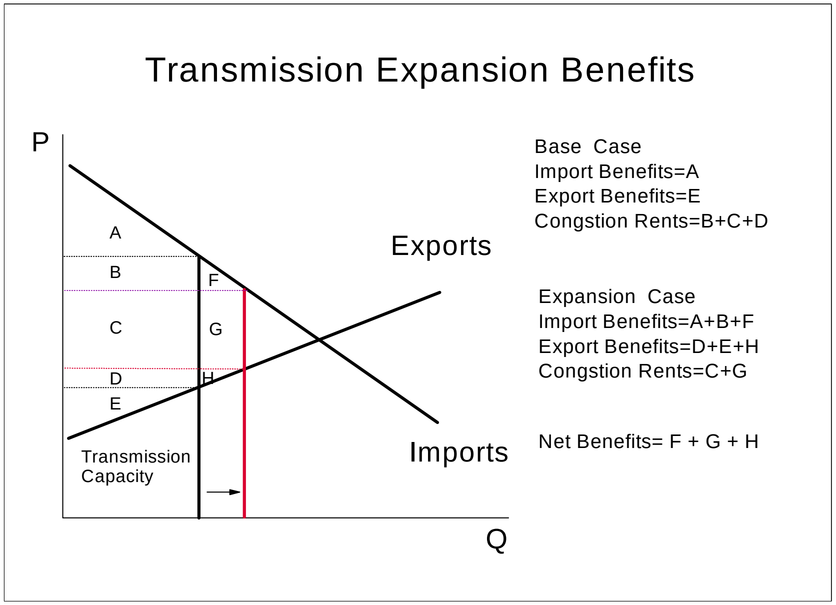
"NJ Rate Counsel provided comments in the June 24, 2010 BPU Technical Conference suggesting new, in-state generation could save NJ ratepayers approximately $465 million/year in capacity payments. The analysis herein only considers the savings realized in the energy market." (LS Power, New In-State Generation LS Power Energy Savings Analysis, Nov. 2010)

"The Bill would require New Jersey to procure 1,000 MW of new capacity when it is not needed for reliability, require the new capacity to clear in the auction through an offer price below its costs and provide subsidies to the new capacity in the form of additional out of market revenue. These features of the Bill are not consistent with the PJM market design. If implemented, the market results would not be consistent with a competitive outcome. … The result of such a subsidy by New Jersey ratepayers would be to artificially depress the Reliability Pricing Model (RPM) auction prices below the competitive level, with the result that the revenues to generators both inside and outside of New Jersey would be reduced as would the incentives to customers to manage load and to invest in cost effective demand side management technologies." (PJM Market Monitor, "Impact of New Jersey Assembly Bill 3442 on the PJM Capacity Market," January 6, 2011.)

Transmission infrastructure benefits include conflicting definitions that are inconsistent with basic market principles and will create cost allocation problems.

Transmission Benefits

"The Energy Market Benefit component of the Benefit/Cost Ratio is expressed as: Energy Market Benefit = [.70] * [Change in Total Energy Production Cost] + [.30] * [Change in Load Energy Payment]. … Reliability Pricing Benefit = [.70] * [Change in Total System Capacity Cost] + [.30] * Change in Load Capacity Payment]." (PJM, "PJM Region Transmission Planning Process," Revision: 16, Manual 14b, Effective Date: November 18, 2010, p. 75.)



"Market Congestion Benefit: 70% * Adjusted Production Cost Savings + 30% * Load Cost Savings." (MISO, "2010 Transmission Expansion Plan," Nov. 30, 2010, p. 31.)

"Load Cost Savings where load cost represents the annual load payments, measured by projections in hourly load weighted LMP: Load cost savings and Adjusted Production Cost savings are essentially two alternative benefit measures to address a single type of economic value and are not additive measures. Load cost savings were not used to calculate the total value of the RGOS plans in MTEP10. … Value of transmission plan (per future) = Sum of values of financially quantifiable measures = Adjusted Production Cost savings + Capacity loss savings + Carbon emission reductions." (MISO, "2010 Transmission Expansion Plan," Nov. 30, 2010, p. 153-154.)

Efficient pricing presents one of the important challenges for Regional Transmission Organizations (RTOs) and electricity market design. Simple in principle, but more complicated in practice, inadequate scarcity pricing is implicated in several problems associated with electricity markets.

- **Investment Incentives.** Inadequate scarcity pricing contributes to the "missing money" needed to support new generation investment. The policy response has been to create capacity markets. Better scarcity pricing would reduce the challenges of operating good capacity markets.

- **Demand Response.** Higher prices during critical periods would facilitate demand response and distributed generation when it is most needed. The practice of socializing payments for capacity investments compromises the incentives for demand response and distributed generation.

- **Renewable Energy.** Intermittent energy sources such as solar and wind present complications in providing a level playing field in pricing. Better scarcity pricing would reduce the size and importance of capacity payments and improve incentives for renewable energy.

- **Transmission Pricing.** Scarcity pricing interacts with transmission congestion. Better scarcity pricing would provide better signals for transmission investment.

Improved pricing would mitigate or substantially remove the problems in all these areas.[4]

Smart Grids Need Smart Prices.

4 FERC, Order 719, October 17, 2008.

William W. Hogan is the Raymond Plank Professor of Global Energy Policy, John F. Kennedy School of Government, Harvard University. This paper draws on work for the Harvard Electricity Policy Group and the Harvard-Japan Project on Energy and the Environment. The author is or has been a consultant on electric market reform and transmission issues for Allegheny Electric Global Market, American Electric Power, American National Power, Aquila, Australian Gas Light Company, Avista Energy, Barclays, Brazil Power Exchange Administrator (ASMAE), British National Grid Company, California Independent Energy Producers Association, California Independent System Operator, Calpine Corporation, Canadian Imperial Bank of Commerce, Centerpoint Energy, Central Maine Power Company, Chubu Electric Power Company, Citigroup, Comision Reguladora De Energia (CRE, Mexico), Commonwealth Edison Company, COMPETE Coalition, Conectiv, Constellation Power Source, Coral Power, Credit First Suisse Boston, DC Energy, Detroit Edison Company, Deutsche Bank, Duquesne Light Company, Dynegy, Edison Electric Institute, Edison Mission Energy, Electricity Corporation of New Zealand, Electric Power Supply Association, El Paso Electric, GPU Inc. (and the Supporting Companies of PJM), Exelon, GPU PowerNet Pty Ltd., GWF Energy, Independent Energy Producers Assn, ISO New England, LECG LLC, Luz del Sur, Maine Public Advocate, Maine Public Utilities Commission, Merrill Lynch, Midwest ISO, Mirant Corporation, MIT Grid Study, JP Morgan, Morgan Stanley Capital Group, National Independent Energy Producers, New England Power Company, New York Independent System Operator, New York Power Pool, New York Utilities Collaborative, Niagara Mohawk Corporation, NRG Energy, Inc., Ontario IMO, Pepco, Pinpoint Power, PJM Office of Interconnection, PJM Power Provider (P3) Group, PPL Corporation, Public Service Electric & Gas Company, Public Service New Mexico, PSEG Companies, Reliant Energy, Rhode Island Public Utilities Commission, San Diego Gas & Electric Corporation, Sempra Energy, SPP, Texas Genco, Texas Utilities Co, Tokyo Electric Power Company, Toronto Dominion Bank, Transalta, Transcanada, TransÉnergie, Transpower of New Zealand, Tucson Electric Power, Westbrook Power, Western Power Trading Forum, Williams Energy Group, and Wisconsin Electric Power Company. The views presented here are not necessarily attributable to any of those mentioned, and any remaining errors are solely the responsibility of the author. (Related papers can be found on the web at www.whogan.com).