

**DESIGNING MARKET INSTITUTIONS  
FOR ELECTRIC NETWORK SYSTEMS:  
REFORMING THE REFORMS  
IN NEW ZEALAND AND THE U.S.**

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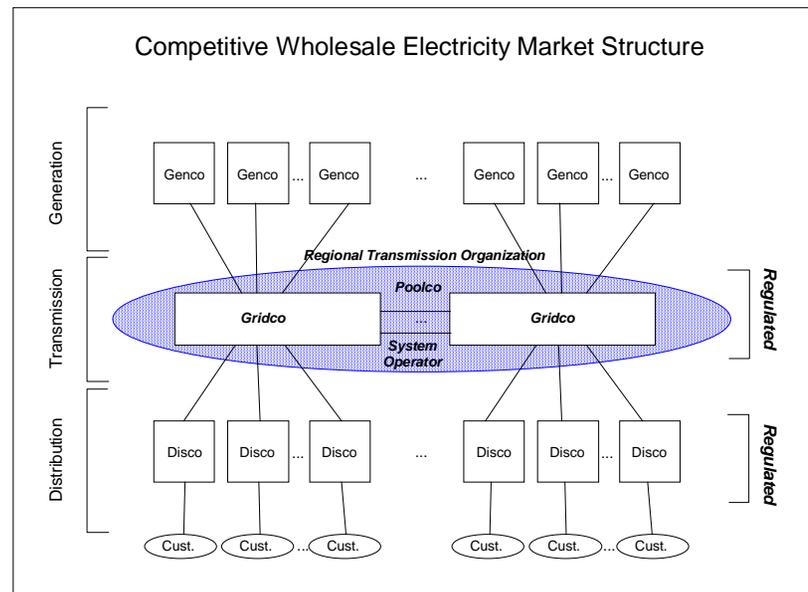
**UTILICON Conference  
Auckland, NZ**

**March 13, 2001**

# ELECTRICITY MARKET

# Competitive Structure

The usual separation into generation, transmission, and distribution is insufficient. In an electricity market, the transmission wires and the pool dispatch are distinct essential facilities.



The special conditions in the electricity system stand as barriers to an efficient, large-scale bilateral market in electricity. A pool-based market model for regional coordination helps overcome these barriers.

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The independent system operator provides a dispatch function. Three questions remain. Just say yes, and the market can decide on the split between bilateral and coordinated exchange.

- **Should the system operator be allowed to offer an economic dispatch service for some plants?**

The alternative would be to define a set of administrative procedures and rules for system balancing that purposely ignore the information about the costs of running particular plants. It seems more natural that the operator consider customer bids and provide economic dispatch for some plants.

- **Should the system operator apply marginal cost prices for power provided through the dispatch?**

Under an economic dispatch for the flexible plants and loads, it is a straightforward matter to determine the locational marginal costs of additional power. These marginal costs are also the prices that would apply in the case of a perfect competitive market at equilibrium. In addition, these locational marginal cost prices provide the consistent foundation for the design of a comparable transmission tariff.

- **Should generators and customers be allowed to participate in the economic dispatch offered by the system operator?**

The natural extension of open access and the principles of choice would suggest that participation should be voluntary. Market participants can evaluate their own economic situation and make their own choice about participating in the operator's economic dispatch or finding similar services elsewhere.

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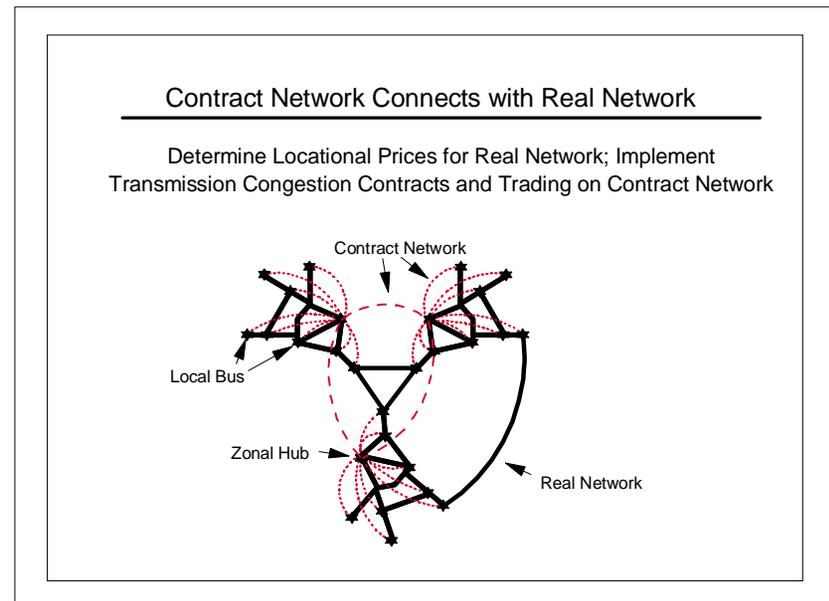
**Just say yes.** The basic lessons from both theory and practice identify the importance of the coordinated wholesale spot market and efficient pricing to handle the complexities of the electricity system. The Independent System Operator (ISO), whether separate from or combined with the grid owner, provides an essential service.

- **Choose Efficient Coordination:** The choice is not between centralized and decentralized spot markets. The choice is between good and bad coordination.
- **Use the Least-Cost Approach:** Economic (re)dispatch for energy and ancillary services is the solution, not the problem.
- **Get the Prices Right:** Market participants will respond to the price incentives, for good or for ill. That, after all, is a fundamental premise of electricity market restructuring. Efficient outcomes include locational prices.
- **Monitor Market Performance:** Good design does not eliminate market power. Market power mitigation measures should be fashioned to support a transition to competition.
- **Offer Financial Transmission Rights:** Provide hedging for transmission congestion using financial rights. It is simple for the ISO to support, but virtually impossible for anyone else.

**Locational pricing provides a sound foundation for a competitive electricity market. However, different prices at every location appears complex. Can the market operate with a simpler system? Yes, the hub and spoke model works in theory and in practice.**

Locational marginal cost pricing lends itself to a natural decomposition. For example, even with loops in a network, market information could be transformed easily into a hub-and-spoke framework with locational price differences on a spoke defining the cost of moving to and from the local hub, and then between hubs.

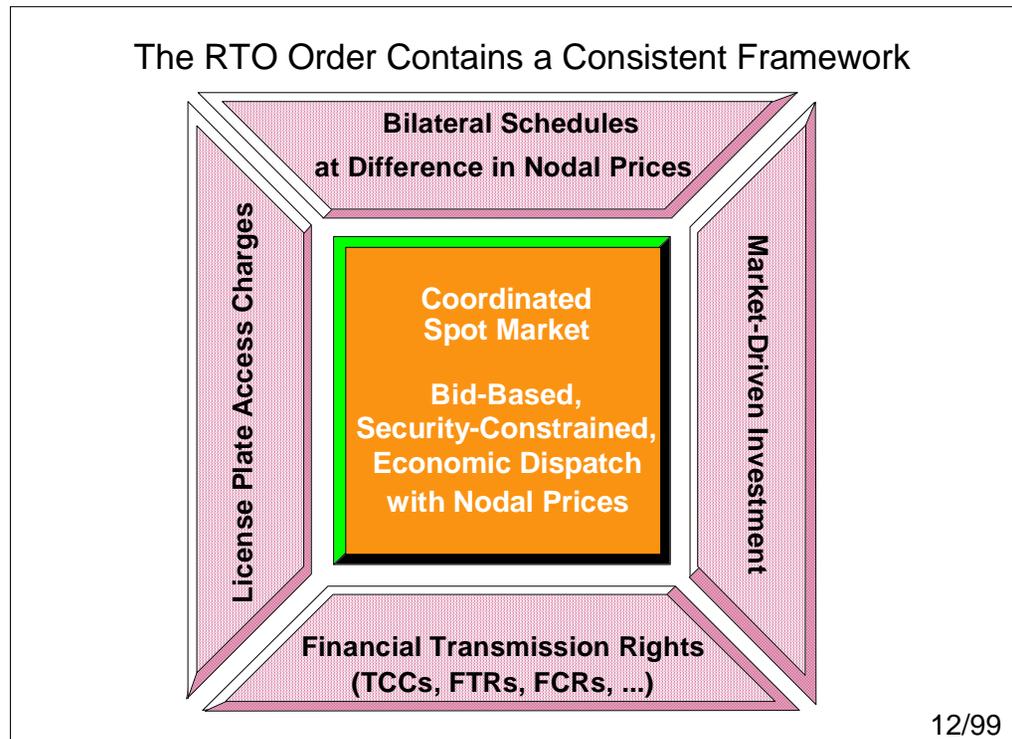
Creation or elimination of hubs would require no intervention by regulators or the ISO. New hubs could arise as the market requires, or disappear when not important. A hub is simply a special node within a zone. The ISO still would work with the locational prices, but the market would decide on the degree of simplification needed. However, everyone would still be responsible for the opportunity cost of moving power to and from the local hub. There would be locational prices and this would avoid the substantial incentive problems of averaging prices. This system works in PJM for congestion pricing, and is used in Australia for loss pricing--simplifying without distorting locational prices.



# ELECTRICITY MARKET

# A Market Framework

The Regional Transmission Organization (RTO) Millennium Order (Order 2000) contains a workable market framework that is working in places like the Pennsylvania-New Jersey-Maryland Interconnection (PJM).



Poolco...ISO...IMO...GO/SO...Transco...RTO...: "A rose by any other name ..."

**The core feature of a bid-based, security constrained economic dispatch with locational prices can be found in many existing or announced market designs.**

- Argentina.
- Bolivia.
- Chile.
- Mexico (proposed).
- New England (proposed).
- New York.
- New Zealand.
- Norway (dynamic zones).
- PJM.
- Peru.
- and more ....

The breadth of application and success of the framework dispel the notion that the model is too complex to be implemented. We now have both the theory and substantial operating experience.

Electricity systems are not simple. The reality of electricity systems creates an interest in simplifying market design to provide better support for commercial transactions. The benefits of simplification are clear, other things being equal. However, other things are usually not equal, and the law of unintended consequences often dictates that what appears simple may turn out to be complex in the end. What may appear complex can be simple in the end if it is consistent with the reality of the electric system and does not require substantial non-market interventions to make the market work.

- **Congestion Zones.** Full locational pricing at every node in the network is a natural consequence of the basic economics of a competitive electricity market. However, it has been common around the world to assert, usually without apparent need for much further justification, that nodal pricing would be too complicated and aggregation into single price zones, with socialization of the attendant costs, would be simpler and solve all manner of problems.
- **Flowgates and Decentralized Congestion Management.** If a single contract path is not good enough, perhaps many paths would be better. Since power flows along many parallel paths, there is a natural inclination to develop an approach to transmission services that would identify the key links or "flowgates" over which the power may actually flow, and to define transmission rights according to the capacities at these flowgates.

The debate over alternative electricity market institutions often confuses two design issues: what is appropriate as a basis for design of the system operator, and what would be appropriate as the design of a stand alone business offering a service within the framework of the market design.

**Aggregation of many locations into a few congestion zones creates problems when market participants have choices. In general, zonal pricing is not consistent with market opportunity costs. The costs of transmission congestion can be very high, and failure to internalize these costs can disrupt the energy market. This is not a mere technical detail. From the perspective of designing market institutions, response to prices is the most important phenomenon.**

**Fact:** A single transmission constraint in an electric network can produce different prices at every node. Simply put, the different nodal prices arise because every location has a different effect on the constraint. This feature of electric networks is caused by the physics of parallel flows. Unfortunately, if you are not an electrical engineer, you probably have very bad intuition about the implications of this fact. You are not alone.

**Fiction:** We could avoid the complications of dealing directly with nodal pricing by aggregating nodes with similar prices into a few zones. The result would provide a foundation for a simpler competitive market structure.

If prices closely reflect operating conditions and marginal costs, then market participants can have numerous choices in the way they use the transmission system. However, if pricing does not conform to the operating conditions, then substantial operating restrictions must be imposed to preserve system reliability. Customer flexibility and choice require efficient pricing; inefficient pricing necessarily limits market flexibility.

## Complex problems have been created by the simplification of zonal congestion pricing:

- The first region in the United States to abandon a zonal pricing model after it failed in practice was PJM, from its experience in 1997 when its zonal pricing system prompted actions which caused severe reliability problems. Given this experience, PJM adopted a nodal pricing system that has worked well since March 1998.<sup>1</sup>
- Subsequently, the original one-zone congestion pricing system adopted for the New England independent system operator (ISONE) created inefficient incentives for locating new generation.<sup>2</sup> To counter these price incentives, New England proposed a number of limitations and conditions on new generation construction. Following the Commission's rejection of the resulting barriers to entry for new generation in New England, there developed a debate over the preferred model for managing and pricing transmission congestion.<sup>3</sup> In the end, New England proposed go all the way to a nodal pricing system.<sup>4</sup>

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<sup>1</sup> William W. Hogan, "Restructuring the Electricity Market: Institutions for Network Systems," Harvard-Japan Project on Energy and the Environment, Center for Business and Government, Harvard University, April 1999, pp. 37-44.

<sup>2</sup> The use of zones for collecting transmission fixed charges is not the issue here. The focus is on managing transmission congestion. For a critique of the previously proposed one-zone congestion pricing system, see Peter Cramton and Robert Wilson, "A Review of ISO New England's Proposed Market Rules," Market Design, Inc., September 9, 1998.

<sup>3</sup> Federal Energy Regulatory Commission, New England Power Pool Ruling, Docket No. ER98-3853-000, October 29, 1998.

<sup>4</sup> ISO New England, "Congestion Management System and a Multi-Settlement System for the New England Power Pool," FERC Docket EL00-62-000, ER00-2052-000, Washington DC, March 31, 2000. The proposal includes full nodal pricing for generation and, for a transition period, zonal aggregation for loads.

### Complex problems have been created by the simplification of zonal congestion pricing (cont.):

- A similar zonal congestion management market design created similar problems in California, which prompted the FERC to reject a number of ad hoc market adjustments and call for fundamental reform of the zonal congestion management system. "The problem facing the [California] ISO is that the existing congestion management approach is fundamentally flawed and needs to be overhauled or replaced."<sup>5</sup>
- The zonal pricing system in Alberta, Canada, apparently produced a related set of incentives that failed to give generators the price signal to locate consistent with the needs of reliability: "Most of the electricity generation sources are located in the northern part of the province and ever-increasing amounts of electricity are being transported to southern Alberta to meet growth, ... [t]his is causing a constraint in getting electricity into southern Alberta and impacting overall security of the high-voltage transmission system."<sup>6</sup> As a result, Alberta has proposed a central generation procurement process under the transmission operator to provide a means to get generation built in the right place. This is hardly a true simplification, nor is it consistent with the original intent to move towards a competitive market and away from monopoly procurement.

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<sup>5</sup> Federal Energy Regulatory Commission, "Order Accepting for Filing in Part and Rejecting in Part Proposed Tariff Amendment and Directing Reevaluation of Approach to Addressing Intrazonal Congestion," Docket ER00-555-000, 90 FERC 61, 000, Washington DC, January 7, 2000, p. 9. See also Federal Energy Regulatory Commission, "Order Denying Requests for Clarifications and Rehearing," 91 FERC 61, 026, Docket ER00-555-001, Washington DC, April 12, 2000, p. 4.

<sup>6</sup> "Alberta Transmission Czar Wants More Generation," Electricity Daily, Vol. 14, No. 77, April 21, 2000, p. 3.

Since power flows along many parallel paths, there is a natural inclination to develop transmission services that would identify the key links or "flowgates" over which the power may actually flow, and to define transmission rights according to the capacities at these flowgates. The assertion is that the commercially significant congestion can be represented by a system with:

- Few flowgates or constraints.
- Known capacity limits at the flowgates.
- Known power transfer distribution factors (PTDF) that decompose a transaction into the flows over the flowgates.

Under these simplifying assumptions, the decentralized model might work in practice. However, There is some experience with this flowgate model applied as part of the NERC Pilot Project for Market Redispatch in 1999. Despite substantial market need for congestion management, there were *no* successful applications of any decentralized trades under this approach.<sup>7</sup>

**The simplified assumptions are not true.**<sup>8</sup>

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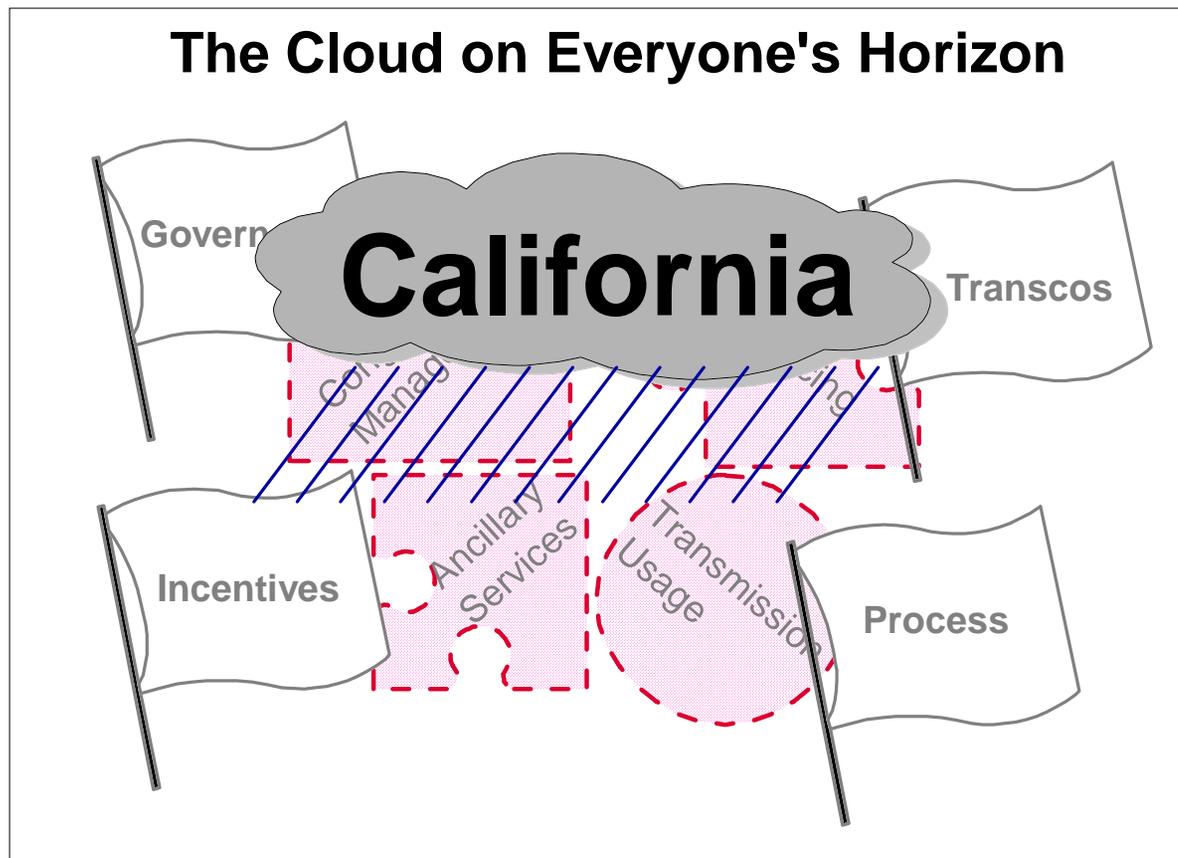
<sup>7</sup> Congestion Management Working Group of the NERC Market Interface Committee, "Final Report on the NERC Market Redispatch Pilot," November 29, 1999, filed with FERC on December 1, 1999.

<sup>8</sup> William W. Hogan, "Flowgate Rights and Wrongs," Center for Business and Government, Harvard University, August 2000.

# ELECTRICITY MARKET

# California Developments

The crisis in California has become the cloud on everyone's horizon. The problems are serious and surprising. The precedents will affect the speed and content of electricity restructuring developments everywhere.

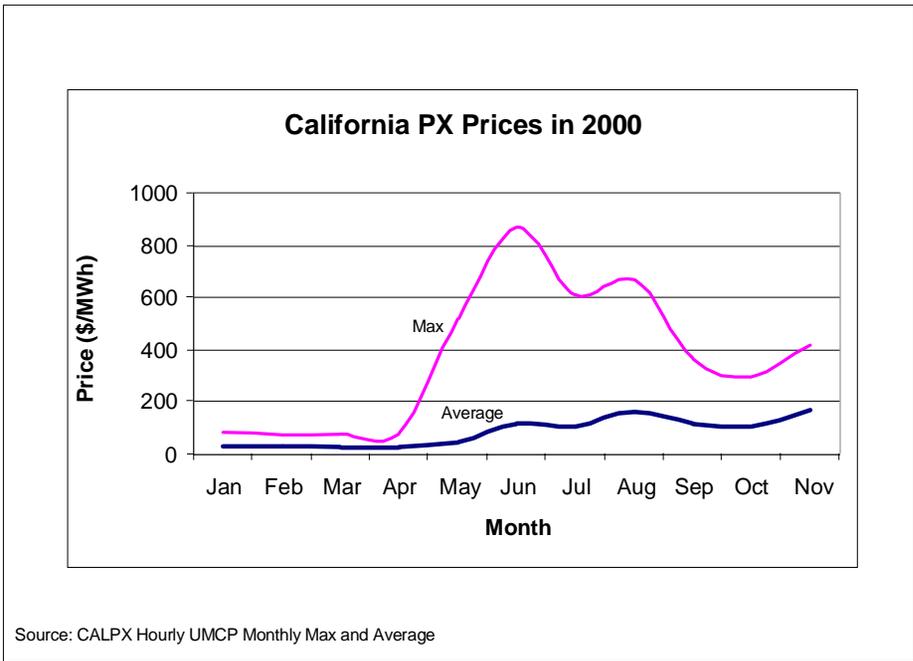


# ELECTRICITY MARKET

# California Developments

The California crisis erupted in the Summer of 2000. Bad policy combined with bad luck to create an unexpected and unprecedented price explosion.

- **Bad Policy:** Divestiture of thermal generation without vesting contracts left utilities on spot market.
- Rate caps for load at \$65 per MWh eliminated demand response.
- Separation of ISO and PX and the myriad associated market design flaws that followed.
- **Bad Luck:** Low water year and unexpected growth in demand throughout the western system.
- Binding environmental constraints and eventually a shortage of gas.
- **Bad News:** In the Spring of 2000, forward prices were under \$80, and viewed as too high.
- From June through November of 2000 prices in the Western Hubs were \$100-\$800 .
- Panic ensued. Villains were sought. Bankruptcy loomed.
- Restructuring will slow, or stop, or maybe even reverse.



**That the California crisis is man made makes it no less serious.**

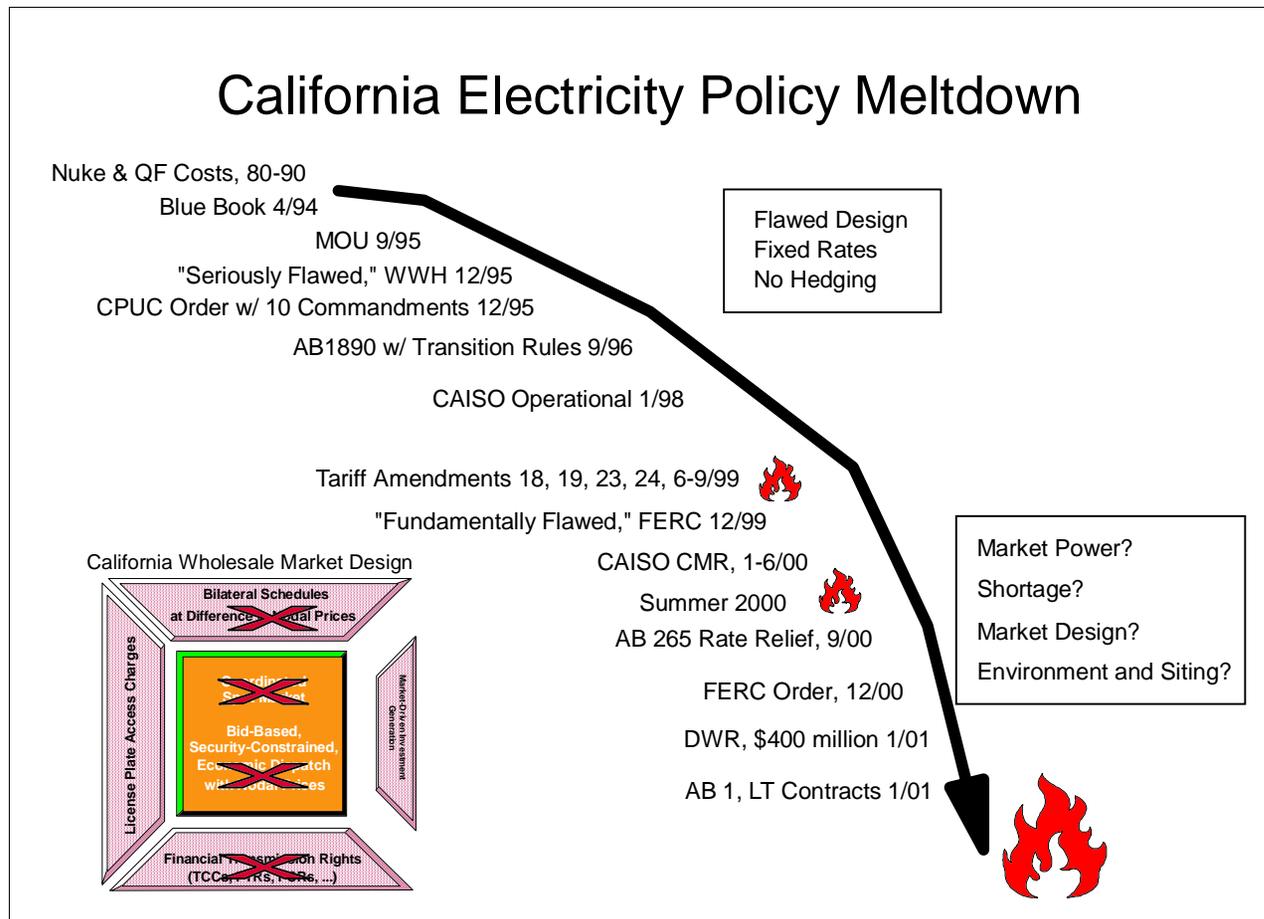
- California electric power bills: 1999 \$7.5 B; 2000 \$28 B; 2001 \$80(?) B.
- Two major utilities, PG&E and SCE, accumulate \$12 B in losses and stop paying their bills.
- Federal Government points to Sacramento as the responsible party.
- U.S. Department of Energy issued emergency orders to sell to California.
- Governor and others condemn criminal profiteers from outside the state.
- Governor draws line in sand, promising not to raise retail prices.
- Wholesale prices increase further from fear of default under bankruptcy.
- Company credit ratings drop to junk bond status.
- Intel announces intent to stop building in California.
- California burns through \$400 million in state general funds in two weeks.
- State experiences stage 3 emergencies and rolling blackouts.
- Problem spreads to danger of curtailment of natural gas supplies.
- Wholesale price increases and shortages a problem throughout the western system.
- Water reserves drawn down and retail prices up in many western states.
- California Power Exchange goes out of business.
- California legislates a panic takeover of electricity industry.
- ...

"...California seems to be living in some surreal version of 'The Wizard of Oz,' trapped among the brainless, the heartless and the gutless." (Peter Schrag, editorial, Sacramento Bee, Feb. 7, 2001)

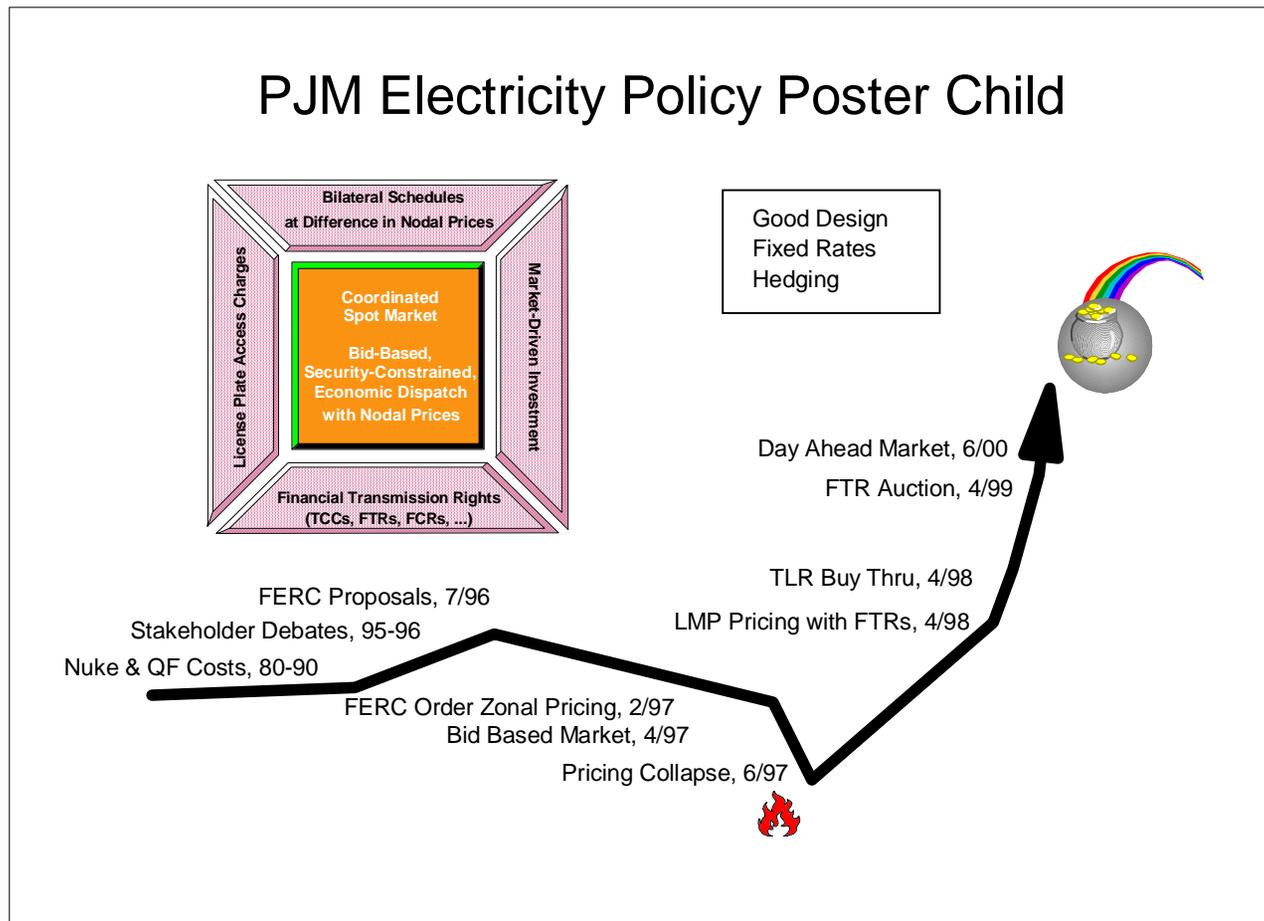
# ELECTRICITY MARKET

# California Developments

The California meltdown had been expected, but not expected to be as bad as it has been.



The PJM ( and NY, soon NE) success stands in sharp contrast to the California meltdown.



**The immediate California emergency needs to be addressed, and then we can turn attention to the fundamental problems in the development of electricity restructuring.**

*Ad Hoc "Manifesto," from Solow , McFadden, et al. , January 26, 2001:*

- **Pay your bills.**

This is fundamental. Electricity is not yet a cash-and-carry market.

- **Raise retail prices.**

Without raising retail prices, there is not enough money to pay the bills. And the incentives to reduce demand are crucial in resolving the short run problem.

- **Look to the long run.**

The summer of 2001 is not far away. The fundamentals of electricity restructuring need urgent attention in California and elsewhere.

"Didn't make a dent." (anonymous California legislator)

**The FERC proposals are too little and it is too late for such spare direction.<sup>9</sup>**

The initial actions include:

- the elimination of the requirement that the three investor-owned utilities (IOUs) ... must sell into and buy from the PX;
- the addition of a penalty charge for deviations in scheduling in excess of five percent of an entity's hourly load requirements and the disbursement of penalty revenues to the loads that scheduled accurately;
- the establishment of independent, non-stakeholder Governing Boards for the PX and the ISO;
- the establishment of generation interconnection procedures; and
- a new form of "soft" price cap at \$150.

Further, the Commission identified a number of structural reforms that must be addressed, including:

- the submission of a congestion management redesign proposal;
- possible changes to the auction mechanisms;
- improved market monitoring and market mitigation strategies;
- demand response programs by the ISO and Scheduling Coordinators;
- elimination of the requirement for balanced schedules; and
- new approach to reserve requirements.

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<sup>9</sup> Federal Energy Regulatory Commission, "Order Proposing Remedies for California Wholesale Electric Markets," Docket No. EL00-95-000, Washington, DC, November 1, 2000, p. 5.

**The FERC needs to take a proactive role if anything is going to be accomplished in electricity restructuring. Consider the comments from the Federal Trade Commission staff:**

"In our view, the ISO/RTO reformation process in California and elsewhere is sufficiently advanced to benefit from more positive guidance from FERC in the form of benchmark examples of successful RTO design elements. For instance, in our August 1999 comment in FERC's RTO rulemaking proceeding, we identified locational marginal pricing (LMP) as a potential benchmark for how to price transmission congestion effectively. ...

Providing positive benchmark examples also may avoid diversion of public attention to proposals that are highly unlikely to facilitate effective competition. By putting forward benchmark examples, FERC would encourage proposals in California that start from an acceptable base, not from the lowest common denominator among stakeholders."<sup>10</sup>

**[understate, v.t. and v.i.; understated, pt., pp.; understating, ppr. to make a weaker statement (of) than is warranted by truth, accuracy, or importance; to state (something) too weakly or moderately.]**

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<sup>10</sup> Federal Trade Commission, "Comment of the Staff of the Bureau of Economics and of Policy Planning of the Federal Trade Commission," FERC, Docket nos. EL00-95-000, Washington DC, November 22, 2000, pp. 7-8.

**The list of necessary reforms for the California market is long, and the difficulty of identifying and fixing all of the problems has been exacerbated by repeated ad hoc reforms that have dismissed theoretically sound and proven design principles. These principles include:<sup>11</sup>**

- The ISO must operate, and provide open access to, short-run markets to maintain short-run reliability and to provide a foundation for a workable market.
- An ISO should be allowed to operate integrated short-run forward markets for energy and transmission.
- An ISO should use locational marginal pricing to price and settle all purchases and sales of energy in its forward and real-time markets and to define comparable congestion (transmission usage) charges for bilateral transactions between locations.
- An ISO should offer tradable point-to-point financial transmission rights that allow market participants to hedge the locational differences in energy prices.
- An ISO should simultaneously optimize its ancillary service markets and energy markets.
- The ISO should collaborate in rapidly expanding the capability to include demand side response for energy and ancillary services.

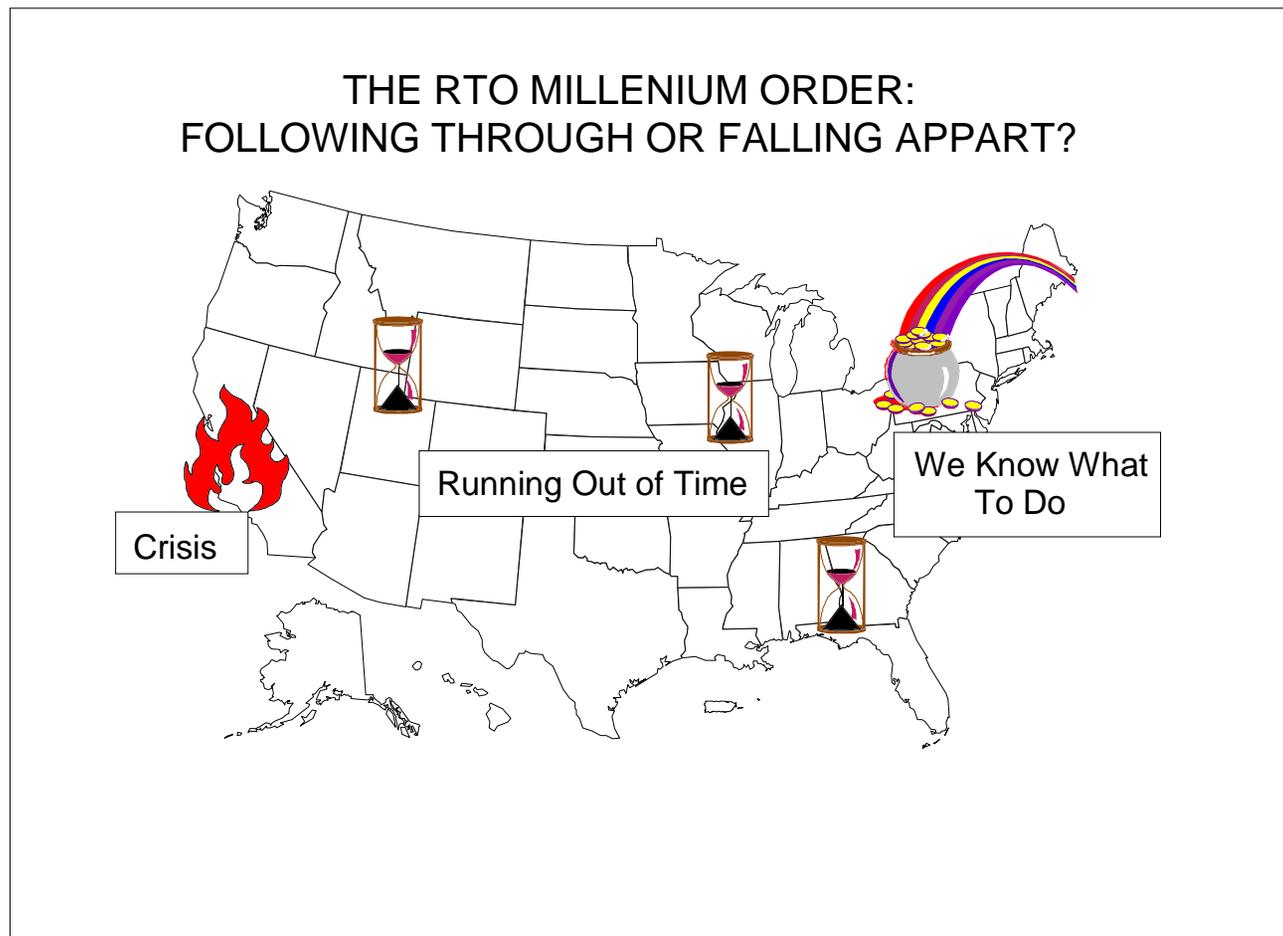
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<sup>11</sup> John D. Chandley, Scott M. Harvey, William W. Hogan, "Electricity Market Reform in California," Comments in FERC Docket EL00-95-000, Center for Business and Government, Harvard University, November 22, 2000. pp. 15-25.

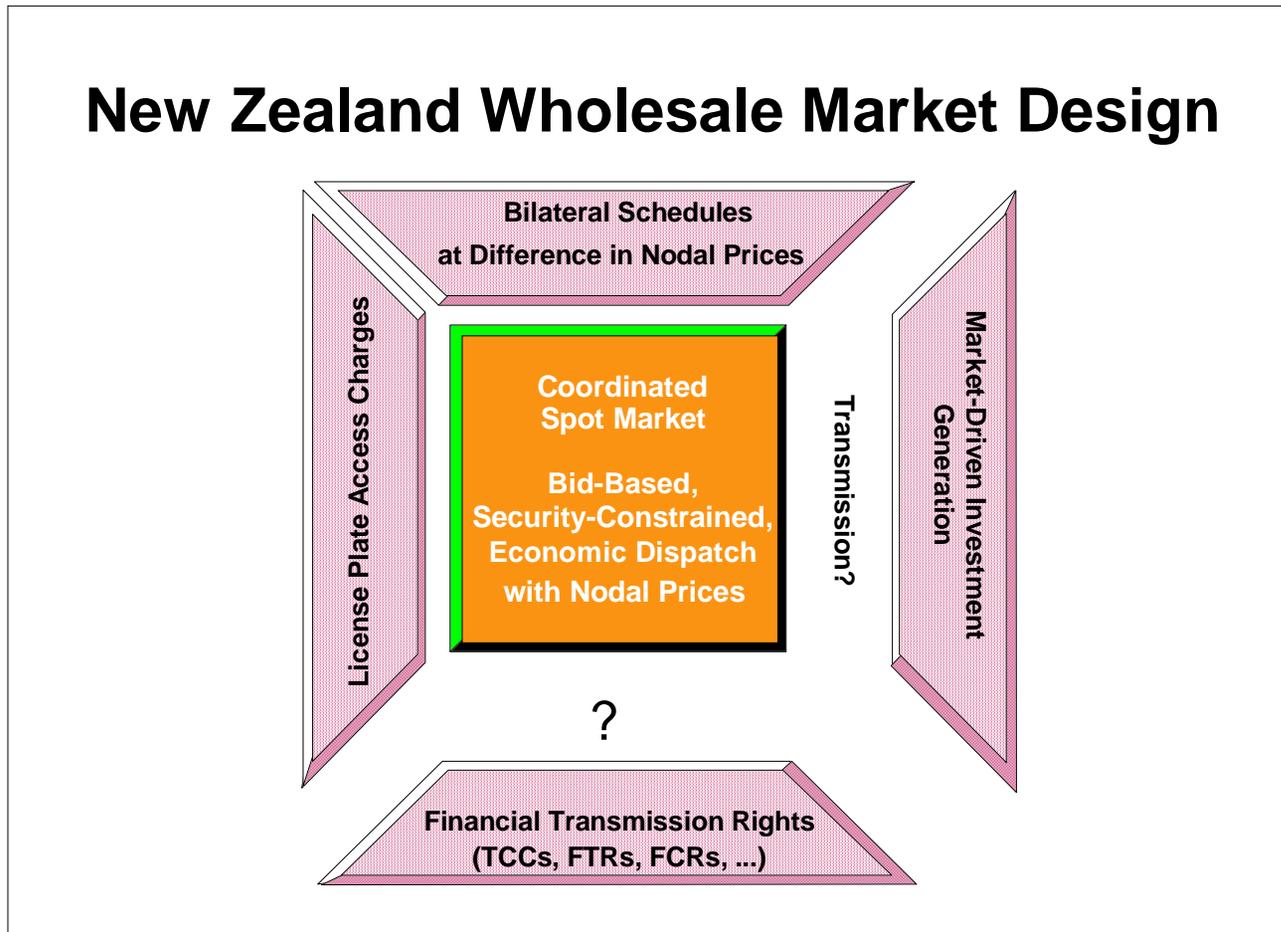
# ELECTRICITY MARKET

# California Developments

National progress in implementing the advance of regional transmission organizations under the Millennium Order (Order 2000) hangs in the balance. Time is running out.



An overview of the New Zealand wholesale electricity market design suggests both good fundamentals and plausible next steps.



**The Government Policy Statement of December 2000 could serve as a model for other countries. It echoes the objectives of the Millennium Order in the U.S.**

### **Guiding Principles for the electricity industry**

"The Government's overall objective is to ensure that electricity is delivered in an efficient, fair, reliable and environmentally sustainable manner to all classes of consumer. Industry arrangements should promote the satisfaction of consumers' electricity requirements in a manner which is least-cost to the economy as a whole and is consistent with sustainable development." (p.1)

- "Energy and other resources are used efficiently...
- the full costs of producing and transporting each additional unit of electricity are signalled so that investors and consumers can make decisions ...
- the quality of electricity services, and in particular trade-offs between quality and price, should as far as possible reflect customers' preferences ...
- transmission losses and constraints are signalled to ensure that overall costs to the economy, including the costs of insufficient competition in local regions, are minimised ...
- greenhouse gas emissions are minimised." (p. 2)

**In short, the principles establish the primacy of the public interest. Markets are means, not ends.**

**The details matter. Good principles cannot overcome bad implementation.**

- **Good statements of principle are necessary.** If the government does not stand for the public interest, who will? However, most market designs start with a reasonable statement of good principles. California's "fundamentally flawed" foundation is the exception, not the rule.
- **Electricity markets are complex.** Introducing markets means disassembling the largest machine in the world. The gears must still mesh as well as turn.
  - Dispatch, locational pricing, congestion management, scheduling, settlements, access pricing, transmission rights, investment, etc. are all of a piece. The pieces must be considered and designed together, in order to maintain the essential compatibility.
  - Don't break what isn't broken. New Zealand already has the most essential core ingredients in its coordinated spot market using a bid-based, security-constrained, economic dispatch with nodal prices. Keep it, and improve on it. Make other things compatible with it.
- **Stakeholders will agree to shoot themselves in the foot.** There is no magic in voluntary industry agreements when it comes to setting the market rules. The FERC has tried to defer to market participants, but there have been many examples of the bad effect of a tyranny of the majority or sinking to the least common denominator. Setting the market rules is more like designing a bridge than dividing a pie. In the end, the FERC has been forced to be prescriptive, often after incurring great costs.
- **We know what to do.** The basic framework of the Millennium Order is working.

**An obvious challenge for New Zealand is in the development of tradable transmission rights. With spot market prices set equal to locational marginal costs, market participants have an incentive to initiate and pay for transmission investments.**

"To ensure investment efficiency, it should be left to industry participants, wherever possible, to make [transmission] investment decisions that benefit grid users..." (GPS, p. 13)

- **Transmission Benefits Along with Transmission Costs.** Point-to-point Financial Transmission Rights (FTRs) provide a mechanism to award the transmission benefits along with the transmission investment costs. The FTRs protect the holders from future changes in congestion and losses. This supports both current trading and future investment.
- **Imperfect Markets versus Imperfect Regulation.** Most markets have only imperfect incentives, and we should set a reasonable goal for transmission investment. Under what circumstances would tradable point-to-point rights and congestion pricing provide the right incentives for investment?
- **Free Riders May Force a Residual Role for Monopoly Investment.** Due to economies of scale and network effects, there may be situations where many would benefit from a transmission expansion but no coalition is prepared to make the investment. In this case, a regulatory decision to approve the investment and allocate the costs may be required.
- **Incentives for Grid Owners.** There need to be incentives for maintenance of the existing capacity over the life of contracted service, and to cooperate with merchant transmission investments.

In summary:

- **Focus on the public interest in efficient market design. Follow market preferences in trading within the rules. But charge the governance institutions with ensuring the primacy of the principles in the GPS.**
- **Get the prices right. The whole point is that market participants will respond to incentives, fast.**
- **Keep the coordinated spot market with bid-based, security-constrained, economic dispatch and nodal prices. It works.**
- **Develop market power mitigation protocols that support transition to a competitive market.**
- **Develop financial transmission rights as the means for hedging and supporting transmission investment.**
- **Keep transmission access pricing as fixed charges to the extent possible.**
- **Design transmission standards, incentives, and procedures to support the use of FTRs and merchant investment.**
- **Preserve the option of a regulatory backstop for transmission investment in cases of market failure.**

Supporting papers and additional detail can be obtained from the author. William W. Hogan is the Lucius N. Littauer Professor of Public Policy and Administration, John F. Kennedy School of Government, Harvard University and a Director of LECG, LLC. 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 American National Power, Brazil Power Exchange Administrator (ASMAE), British National Grid Company, Calpine Corporation, Commonwealth Edison Company, Detroit Edison Company, Duquesne Light Company, Electricity Corporation of New Zealand, GPU Inc. (and the Supporting Companies of PJM), GPU PowerNet Pty Ltd., Mirant Corp, National Independent Energy Producers, New England Independent System Operator, New England Power Company, New York Independent System Operator, New York Power Pool, New York Utilities Collaborative, Niagara Mohawk Corporation, PJM Office of Interconnection, San Diego Gas & Electric Corporation, Sempra Energy, TransÉnergie, Transpower of New Zealand, Westbrook Power, 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 <http://ksgwww.harvard.edu/people/whogan>)