INTERREGIONAL COORDINATION OF ELECTRICITY MARKETS

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ELECTRICITY MARKET Interregional Coordination

Interregional coordination of electricity markets is necessary in the large networks in the United States. There will be many regional interconnected markets.

- **Regional Market Design.** The Regional Transmission Organization (RTO) process provides the opportunity to establish a workable market design. What happens within a region is at least as important as what transpires between regions.

- **Seams and Common Protocols.** Common definitions and protocols at the seams can avoid unnecessary complexities that hinder interregional trade.

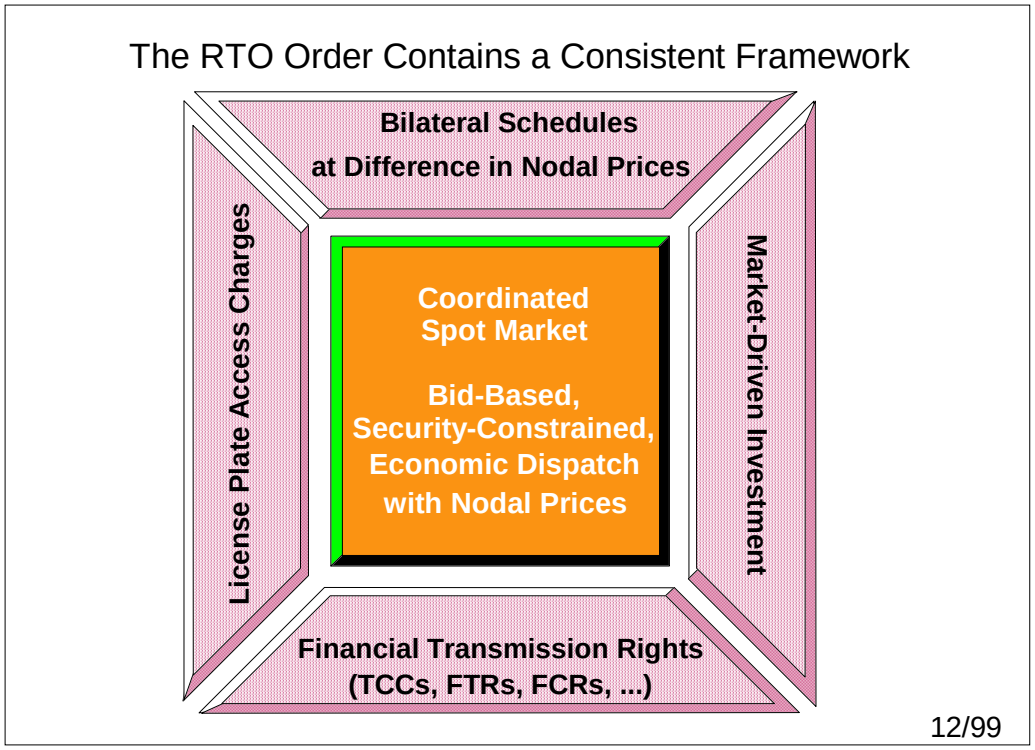
- **Day-Ahead Unit Commitment and Scheduling.** Common unit commitment decisions and associated day-ahead scheduling offer many further benefits for improved trading, reliability and development of consistent transmission rights.

- **Real-Time Congestion Management.** Coordination of congestion management and real-time pricing would provide improved market tools for managing transmission use and one-stop shopping for market participants.

Good coordination cannot overcome bad market design. Markets in power, more than most markets, are made; they don't just happen.

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) and New York.



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

ELECTRICITY MARKET A Market Framework

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.[1]

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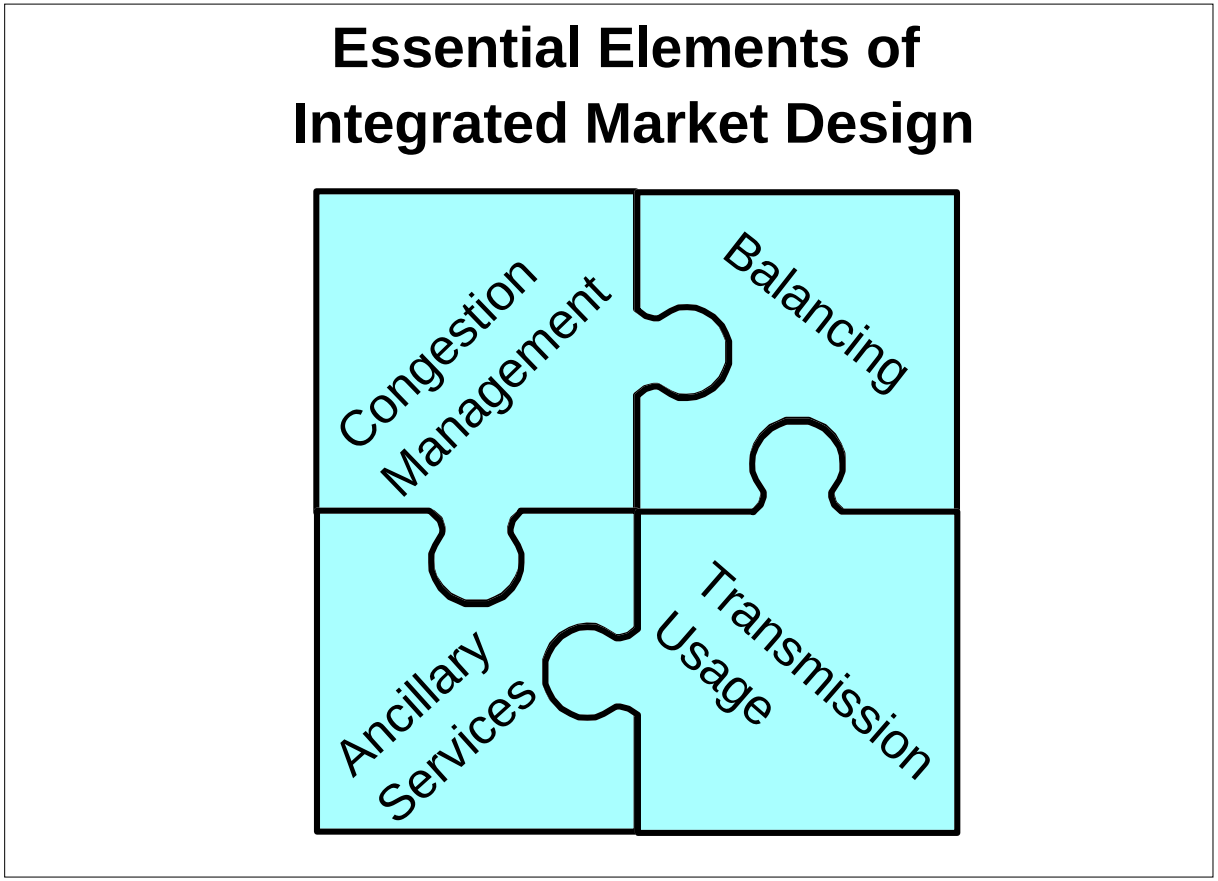
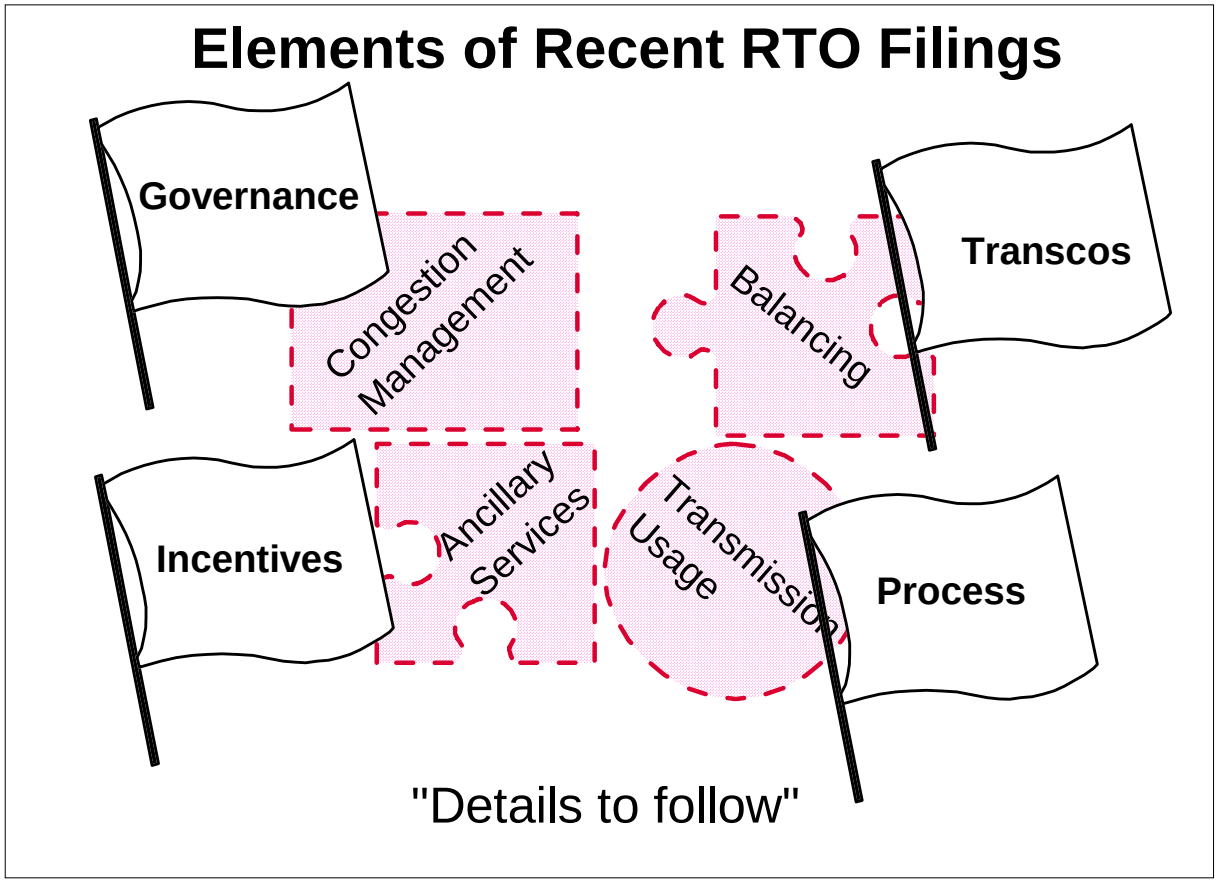
[1] William W. Hogan, "Electricity Market Restructuring: Reforms of Reforms," CRRI Conference, Rutgers University, May 25, 2001. http://ksghome.harvard.edu/~.whogan.cbg.ksg/rut052501.pdf

The critical features for a successful electricity market include close coordination of the elements that determine bid-based security constrained economic dispatch. We know how to make the pieces fit together. And we know that the pieces must fit together.



The RTO filings display a great diversity of approaches, but there are some common themes. Most importantly, the emphasis is not on the essential elements that seem difficult and controversial. The focus is on governance and issues that seem easier to discuss.



ELECTRICITY MARKET Reforms of Reforms

Market design problems have resulted in reforms of reforms in electricity restructuring:

- The first region in the United States to abandon a too simplified market 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.[2]

- Subsequently, the original one-zone congestion pricing system adopted for the New England independent system operator (ISONE) created inefficient incentives for locating new generation. To counter these price incentives, New England proposed a number of limitations and conditions on new generation construction. Following the FERC'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.[3] In the end, New England proposed go all the way to a nodal pricing system.[4]

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[2] 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.

[3] Federal Energy Regulatory Commission, New England Power Pool Ruling, Docket No. ER98-3853-000, October 29, 1998.

[4] 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.

(cont.):

- New Zealand has reconsidered its reforms and revisited the issues of electricity market design.[5] The Government of New Zealand set down principles for reform of the electricity market.[6] The foremost missing ingredient in the New Zealand wholesale market design is a system of long-term transmission rights. At the end of 2000, there was common agreement that extending the model to include FTRs would provide an added tool that would provide mechanisms for hedging transmission congestion costs and incentives for long-term investment.[7]

- The California market was in trouble well before it spun out of control in the summer of 2000. In California, the approach of a coordinated spot market was explicitly rejected in preference to a complicated trading regime as embodied in the Memorandum of Understanding of 1995. In December 1999, the FERC rejected the 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."[8]

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[5] Ministry of Economic Development of New Zealand, "Inquiry into the Electricity Industry," Report to the Minister of New Zealand, Wellington, New Zealand, June 2000.

[6] Pete Hodgson, Minister of Energy, "Government Policy Statement: Further Development of New Zealand's Electricity Industry," Wellington, New Zealand, December 2000.

[7] Ministry of Economic Development of New Zealand, "Inquiry into the Electricity Industry," Report to the Minister of New Zealand, Wellington, New Zealand, June 2000, p. 61.

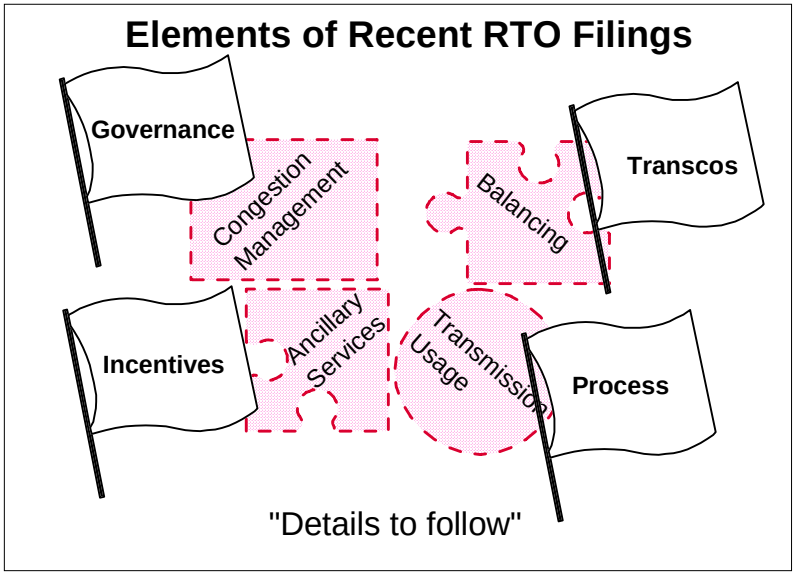
[8] Federal Energy Regulatory Commission, "Order Accepting for Filing in Part and Rejecting in Part Proposed Tariff Amendment and Directing Reevaluation of Approach to Addressing Intrazonal Congestion," Docket ER00-555-000, 90 FERC 61, 000, Washington DC, January 7, 2000, p. 9. See also Federal Energy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

ELECTRICITY MARKET — RTO Developments

The same problems reappear in the RTO proposals. In California the case has become acute. Time is running out. The same medicine would work for the acute case and the chronic sufferers. The FERC is on target. However, the success of the RTO Millenium Order depends on two big "ifs." Market reform can work …

- **If FERC means what it says. …**
- **If FERC follow through. …**

PLACEBOS



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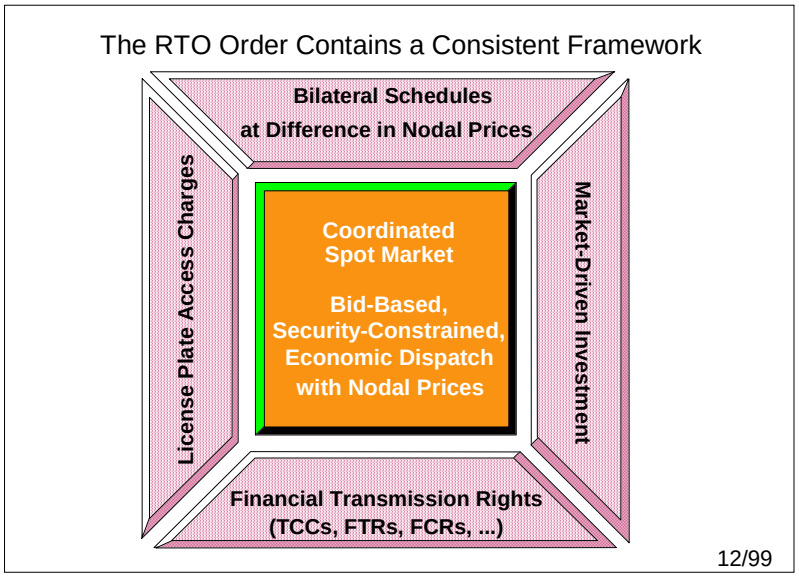

ELECTRICITY MARKET — Interregional Coordination

The many regional interconnected markets create seams issues that call out for common definitions and protocols. In the eastern grid, there are formal efforts underway to create a system with one stop shopping.

> "The NYISO; the Independent System Operator of New England (ISO-NE); the Independent Electricity Market Operator (IMO) of Ontario; the NPCC; the Pennsylvania-New Jersey-Maryland Interconnection (PJM); TransÉnergie of Quebec, New Brunswick Power of the Maritimes and Detroit Edison, … will participate in a process to develop the blueprint for a system that will allow energy companies to easily buy and sell wholesale energy inter-regionally by going to a single website tied to each of the companies' market scheduling systems. … The target technology, generically referred to as a "Collaborative Scheduling System" (CSS), will be designed to permit a buyer or seller of wholesale electricity to go to any one market's website and schedule all of their wholesale energy transactions throughout the entire Northeast.[9]

The Golden Rule of Interregional Coordination is the Golden Rule: ***Do unto others as you would have others do unto you.***

The Silver Rule of Interregional Coordination: ***Do unto others as would be done if there were only one region.***

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[9] New York ISO, Press Release, June 5, 2001, (http://www.nyiso.com/topics/articles/index.html).

ELECTRICITY MARKET Day-Ahead Interregional Coordination

Day-ahead unit commitment and scheduling would provide a number of benefits. A feasibility study examined seven alternatives for coordinating day-ahead markets.

> **"A. Benefits and Costs of a Combined Market**
>
> The development of a combined day-ahead market in the Northeast is intended to address seven broad areas for improvement. First, the combined market is intended to facilitate electricity trading across a broad region of the Northeast, and in particular to enable more consistent scheduling of interchange transactions within the Northeast, in turn leading to a more efficient and less volatile regional electricity market. Second, the combined market is intended to facilitate inter-ISO congestion management. Third, the combined market is intended to support reserve sharing mechanisms across the Northeast ISOs that will lead to a more efficient (lower cost) and reliable market. Fourth, the combined market is expected to broaden the relevant market within which generators compete to supply power, easing market power concerns. Fifth, the combined market is intended to reduce transaction costs for market participants that participate in multiple markets. Sixth, the combined market is intended to provide improved mechanisms for hedging transmission congestion in day-ahead markets. Seventh, the combined market could provide a mechanism for reducing future software costs."[10]

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[10] Scott M. Harvey, Susan L. Pope, John P. Buechler, and Robert M. Thompson, "Feasibility Study for a Combined Day-Ahead Market in the Northeast," LECG, LLC and KEMA Consulting, Inc. for the ISO-New England, New York ISO, and Ontario IMO, May 4, 2001, p. 93. (http://www.nyiso.com/markets/index.html#regdam)

TRANSMISSION COORDINATION Real-Time Market Coordination

A market-oriented system would require information on scheduled loads, bids and prices to determine an economic redispatch of the system.

The basic outline involves a communication between system operators and market participants to obtain market information, and among system operators to achieve coordinated congestion relief:

1. Market Participants Submit Schedules and Bids for Dispatch Hour.

2. System Operators Interact to Achieve Coordinated Congestion Relief.

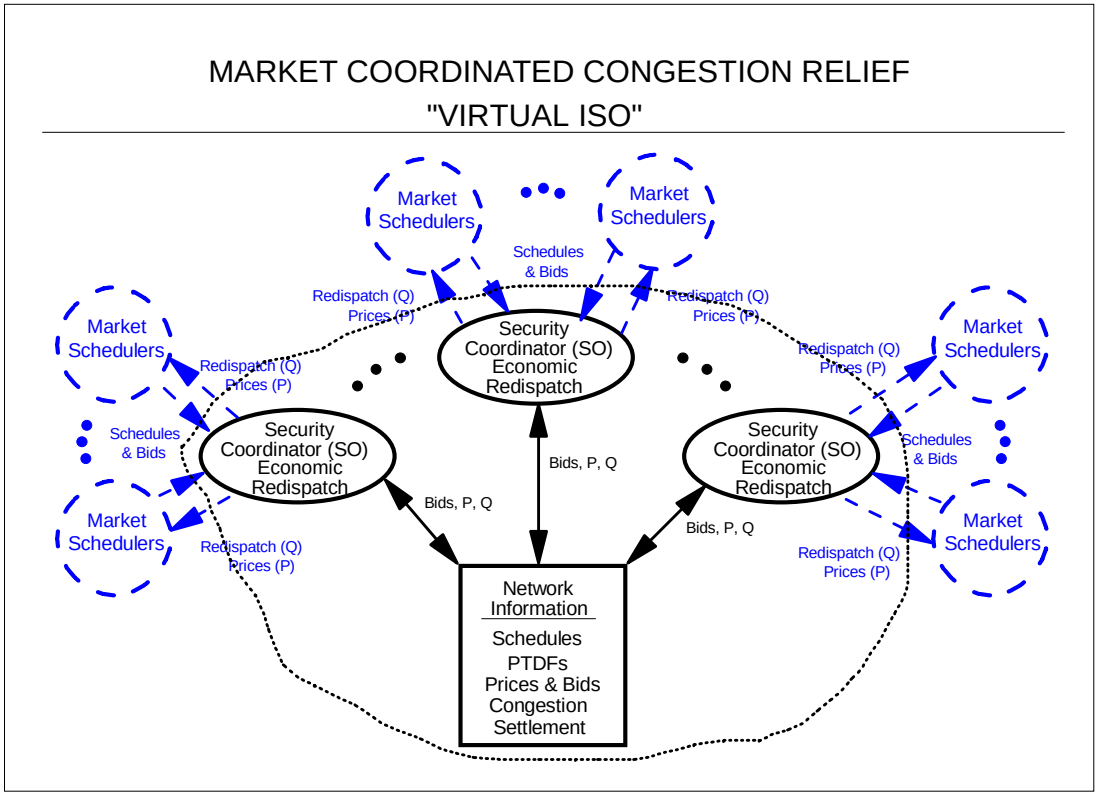
3. System Operators Publish (Re)Dispatch and Prices.

Further details of the redispatch protocol can be found in:

Michael Cadwalader, Scott Harvey, William Hogan, and Susan Pope, "Coordination of Congestion Relief Across Multiple Regions," Center for Business and Government, Harvard University, October 7, 1999.
http://ksghome.harvard.edu/~.whogan.cbg.ksg/isoc1099r.pdf

TRANSMISSION COORDINATION — Virtual ISO

Through repeated exchange of information in a common data base, the regional system operators would solve their local problems to update the schedules and price estimates. A consistent solution would be an overall market equilibrium as though obtained by a "virtual ISO."



TRANSMISSION COORDINATION MAPS Approximation

A model of a realistic network provides a tool for testing the procedures for regional coordination. The price coordination algorithm tested is an approach with minimal information. There is no attempt to exploit the expertise of system operators.[11]

- **GE MAPS.** The GE MAPS model provides an available tool for defining realistic networks with many constraints.
- **GE Mini- MAPS.** The MAPS model linearizes the network representation around a solved load flow. The full model contains more detail, but for our purposes it is useful to have a simplified version of the MAPS model. The important information extracted from the detailed MAPS runs includes:
  - **Network Constraints.** The shift factors for the binding constraints and the MAPS solution can be used to create a linear representation of the binding constraints in the MAPS solution.
  - **Bid Curves.** Interpolation between the unconstrained and constrained MAPS solutions provides an approximate representation of the bid curves.
  - **Regional Coordination.** Given the mini-MAPS model for each region, simulation of the coordination algorithm is simplified without much loss in reality. Non-binding constraints are ignored, and the shape of the bid curves is not realistic. But the network representation is faithful to GE MAPS.

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[11] For further details, see Michael D. Cadwalader, Andrew P. Hartshorn, Scott M. Harvey, Susan L. Pope, William W. Hogan, "Coordinating Congestion Relief Across Multiple Regions: Computational Testing," Presentation to ISO MOU Business Practices Group, October 19, 2000. http://www.isomou.com/working_groups/business_practices/documents/general/cong_mt.pdf

TRANSMISSION COORDINATION MAPS Approximation

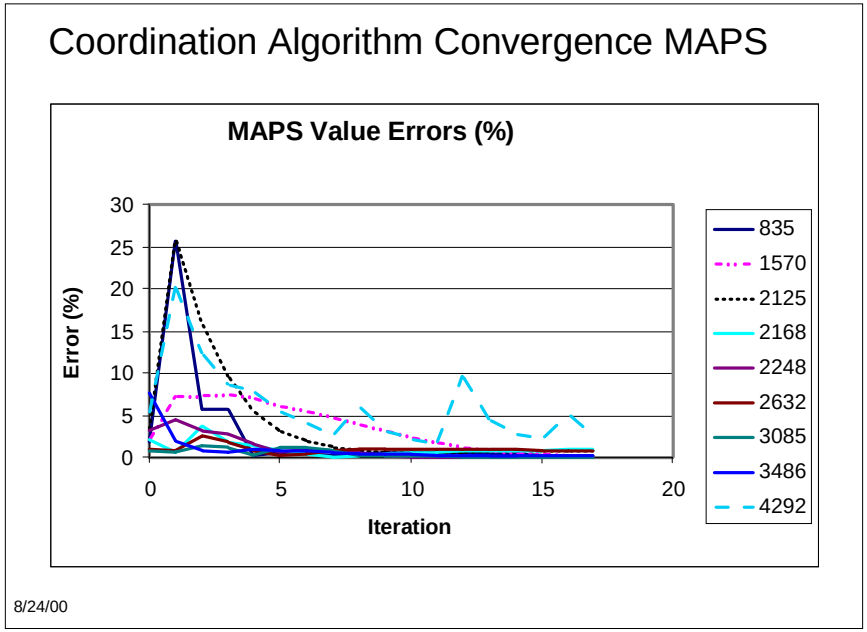
For the simulation purposes, the test used a readily available model for two sets of data. Four constrained hours were uses to try various versions of the algorithms. The final five hours were tested in the best algorithm.

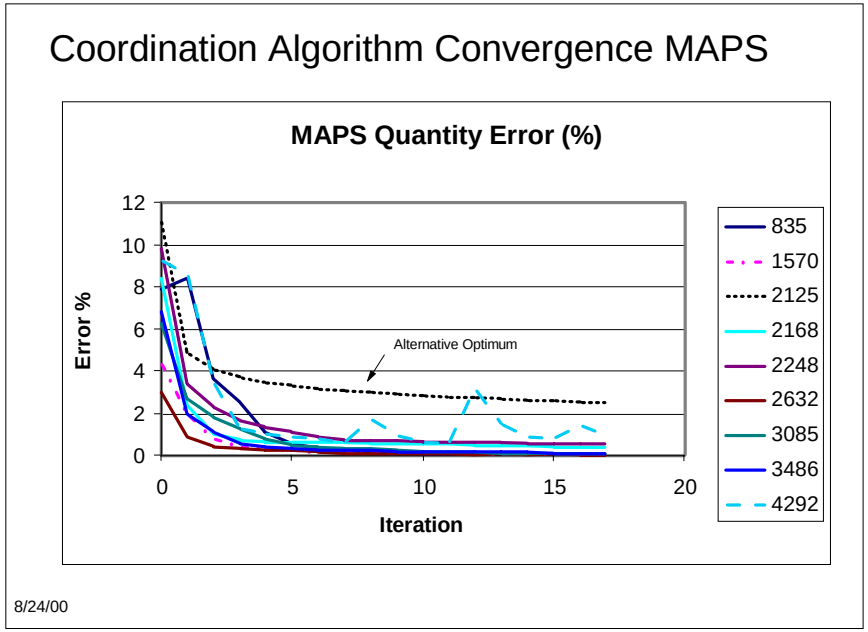
	MAPS Hour								
	835	***1570***	***2125***	***2168***	***2248***	***2632***	***3085***	***3486***	***4292***
Locations	1103	1103	1103	1103	1103	1103	1103	1103	1103
Constraints	33	37	30	37	41	31	27	29	33
Flexible Generators	54	39	38	61	62	32	22	32	66
Hi Price	41.25	79.42	27.20	114.64	116.50	43.94	23.58	40.03	70.26
Lo Price	-0.97	-0.97	4.64	-0.99	-15.15	15.18	18.15	20.68	-79.29

The selected MAPS representation had no detail for Ontario, which was combined with New York as a single region. There were relatively few binding constraints in PJM compared to what would be expected. However, the problems provided enough complexity in the network representation to serve as a reasonable test of how the mechanism might work on a real system.

TRANSMISSION COORDINATION MAPS Approximation

For the results reported here, the two measures of solution error are the value error as a percent of total and the dispatch quantity error as a percent of total generation.





The results confirm that even a simple coordination algorithm can achieve convergence for constrained problems on a realistic network.

TRANSMISSION COORDINATION MAPS Approximation

The lessons from these simulations test include:

- The redispatch quantities converge rapidly.

- The prices at the flexible buses converge rapidly, but computing prices at buses with fixed quantities may require further iteration.

- Calculation of all prices could be simplified by reporting the shift factor data once the redispatch is determined and allowing for a joint estimation of prices in all regions. This would be much simpler than joint optimization of prices and quantities.

- The mini-MAPS approach provides a great deal of what is needed in the computer simulations, and there would not be much advantage in trying for more realistic computer simulations.

The challenge would be to identify how these results might be translated into a working system.

- Information exchange to include more than just congestion costs and net loads.
- Representation of networks using approximations of external systems.
- Settlement system for interregional redispatch costs.
- Design of regionally coordinated financial transmission right systems.
- Special algorithms that would exploit operator insight and experience.

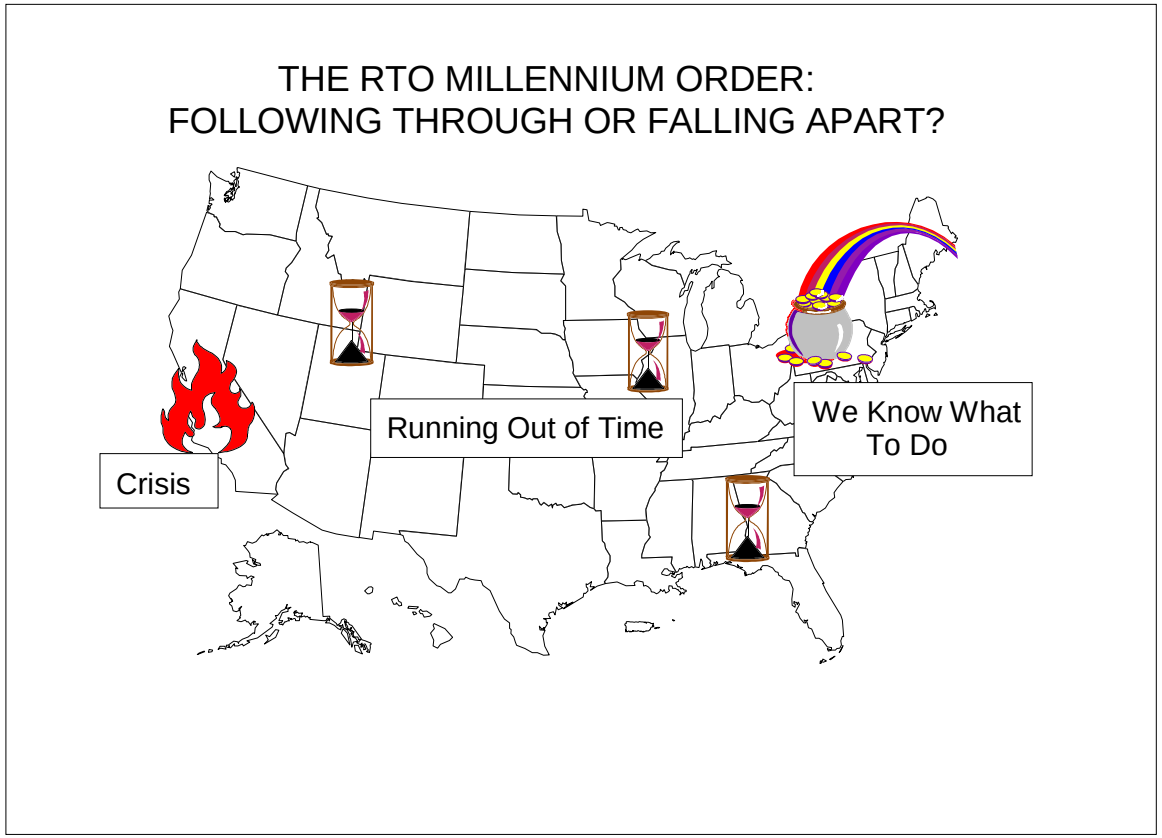
The result of the testing on large networks includes agreement to proceed with a pilot program for improving management during conditions of significant congestion:

> "The objective of this pilot program is to develop an interregional operational protocol to facilitate the management of transmission congestion between the Northeast ISO regions during periods when inter-regional transmission congestion is causing extreme or emergency operating conditions to exist in one or more region. It is generally recognized that a market-based mechanism is required to facilitate energy transfers and to mitigate inter-regional congestion between the existing northeast ISO markets."[12]

[12] ISOMOU, Business Practices Group, "Interregional Congestion Management Pilot Program," draft, March 13, 2001, p. 1. (http://www.isomou.com/working_groups/business_practices/documents/general/interregional_tx_pilot.pdf)

ELECTRICITY MARKET — Reforms of Reforms

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



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, Comision Reguladora De Energia (CRE, Mexico), 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 Corporation, 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://www.ksg.harvard.edu/whogan)