ELECTRICITY MARKET REFORM:
Market Design and Resource Adequacy

William W. Hogan

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

The Economics of Energy Markets

Toulouse School of Economics

Toulouse, France

June 15, 2011

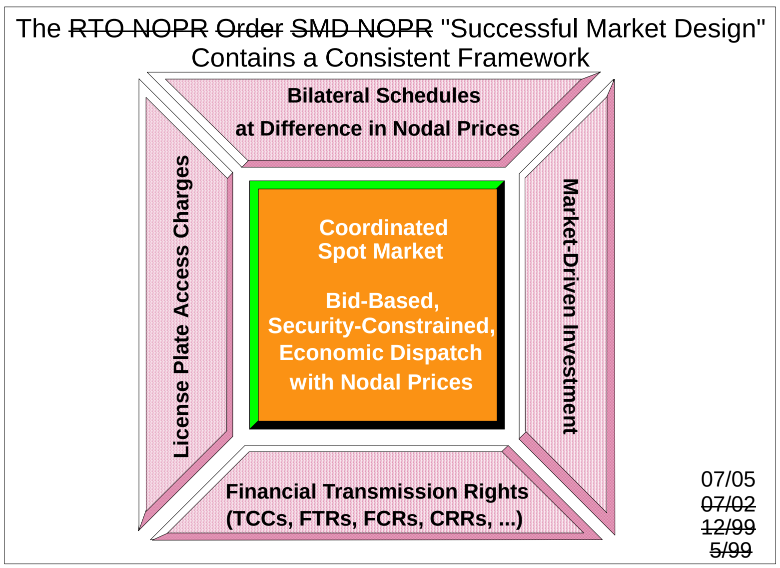
The focus on the electricity sector's role in addressing climate change through improved efficiency, development of renewable energy, and use of low carbon fuels creates expanded demands for and of electricity restructuring.

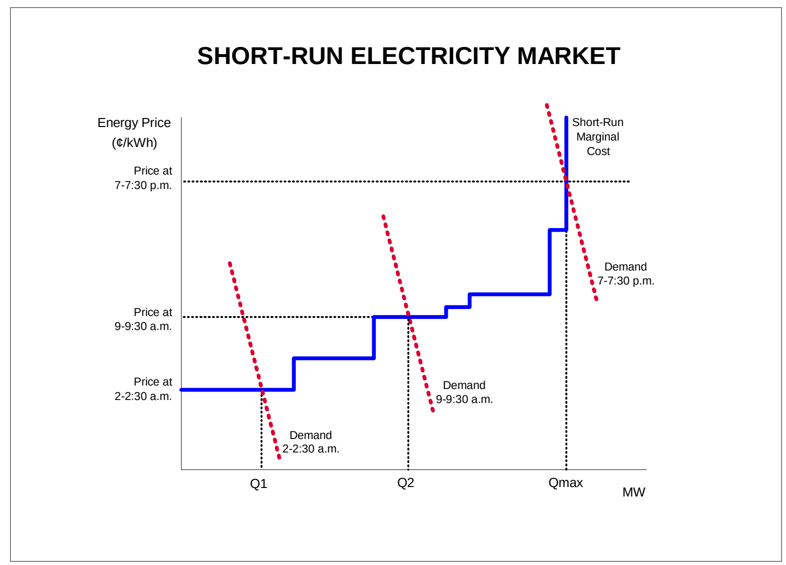
The transformation envisioned is massive, long term, and affects every aspect of electricity production and use.

- 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]

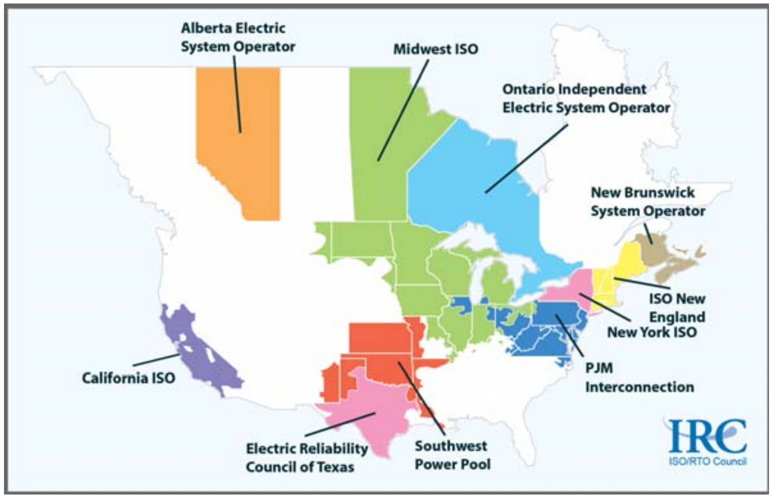
- **Regional Markets Not Fully Deployed**

- **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).

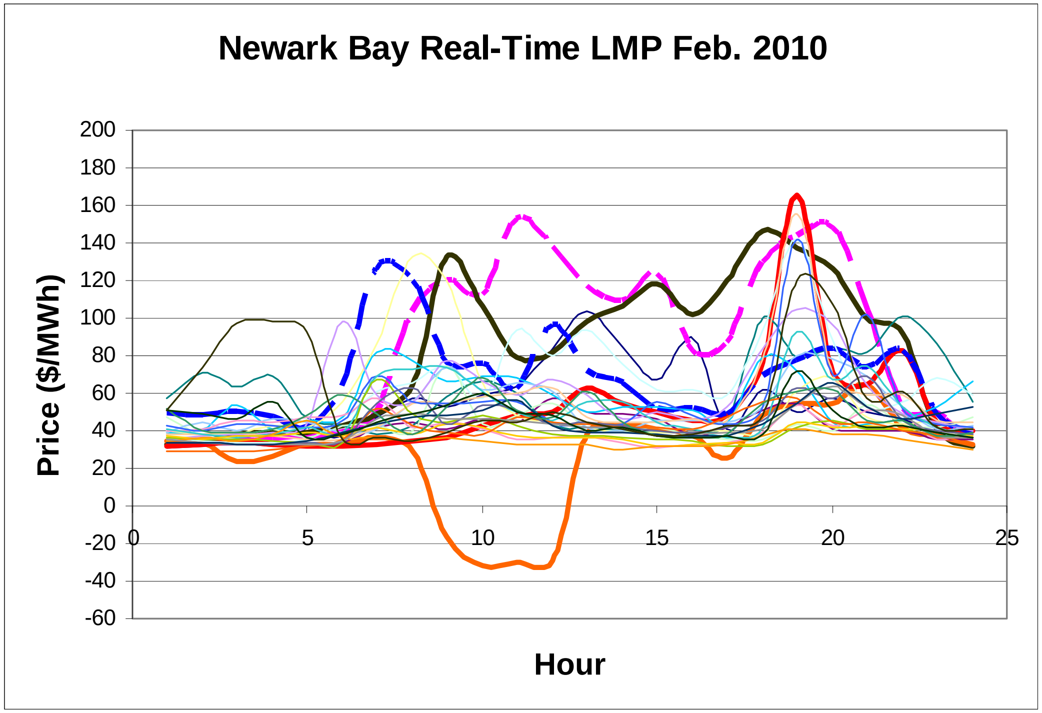
- **Market Challenge: Address Requirements for Climate Change Policy**

[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).

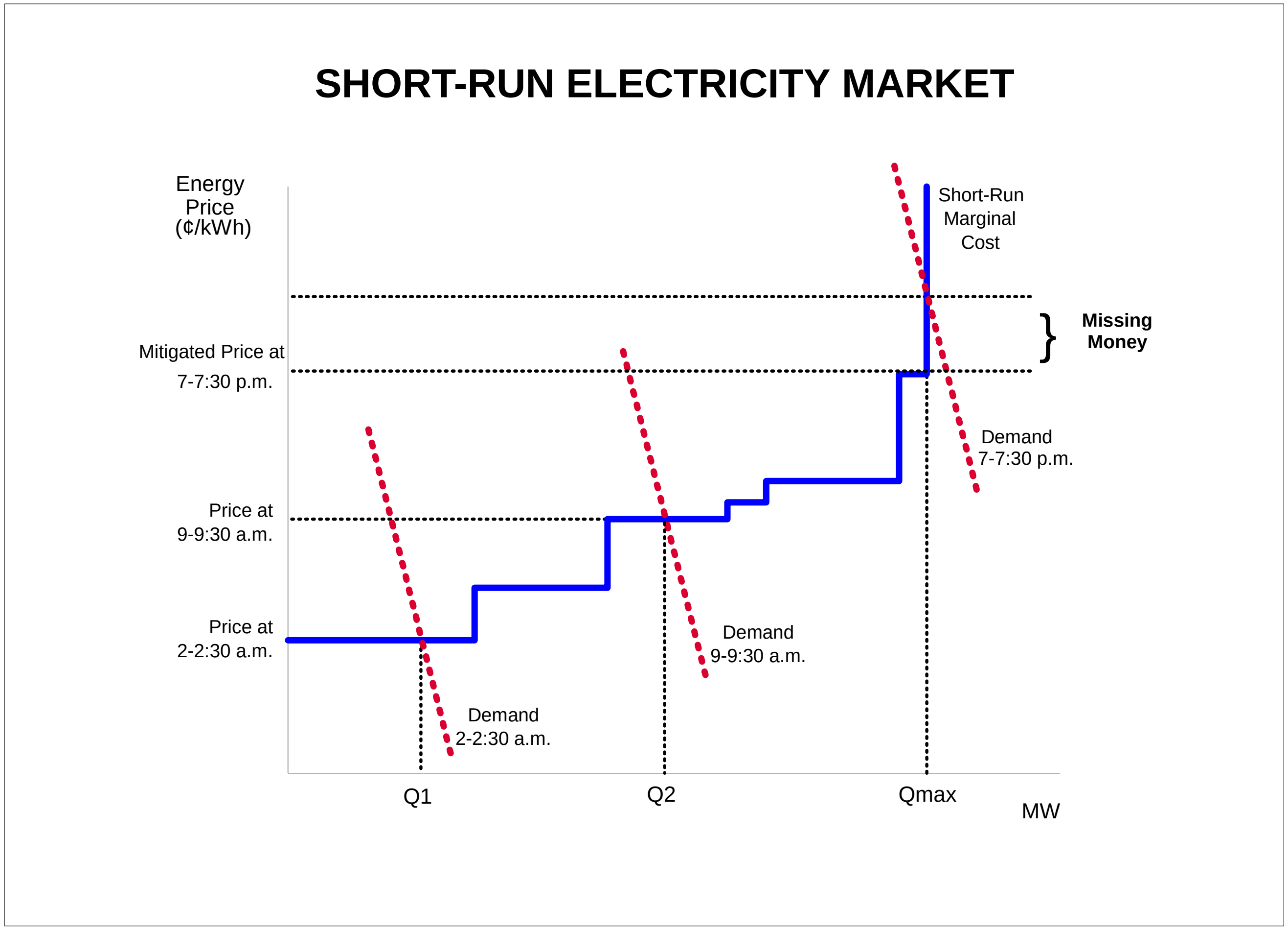
Smarter pricing provides an opportunity for enhancing efficiency and the range of alternative technologies.

- **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.

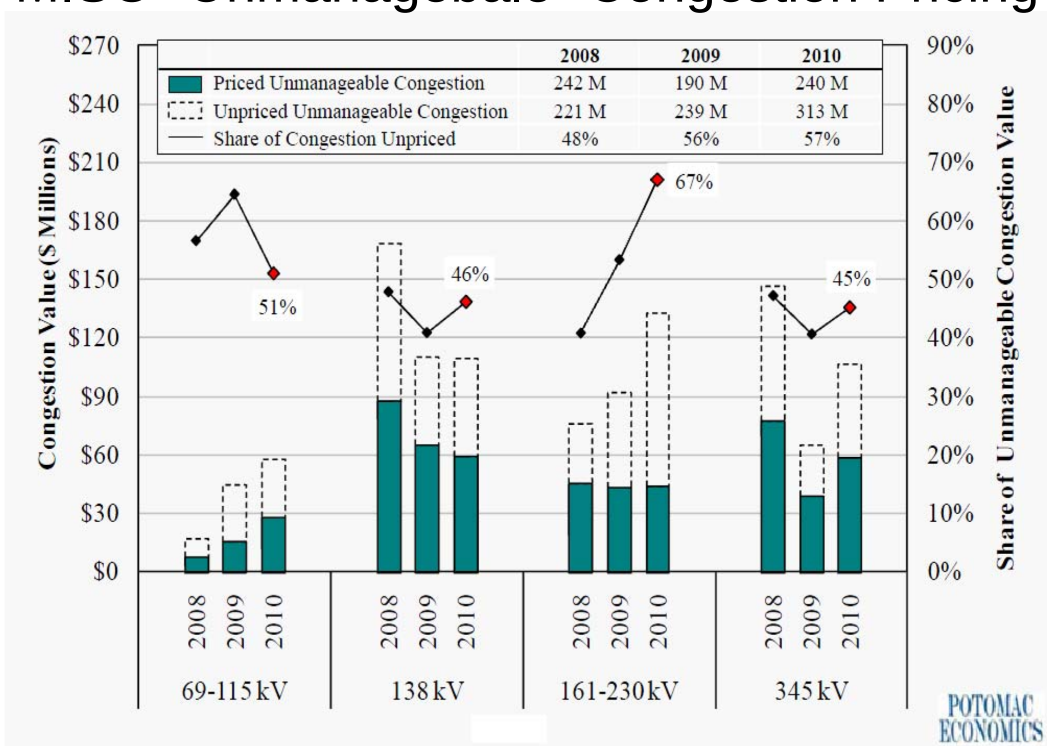


Early market designs presumed a significant demand response. Absent this demand participation most markets implemented inadequate pricing rules equating prices to marginal costs even when capacity is constrained. This produces a "missing money" problem.



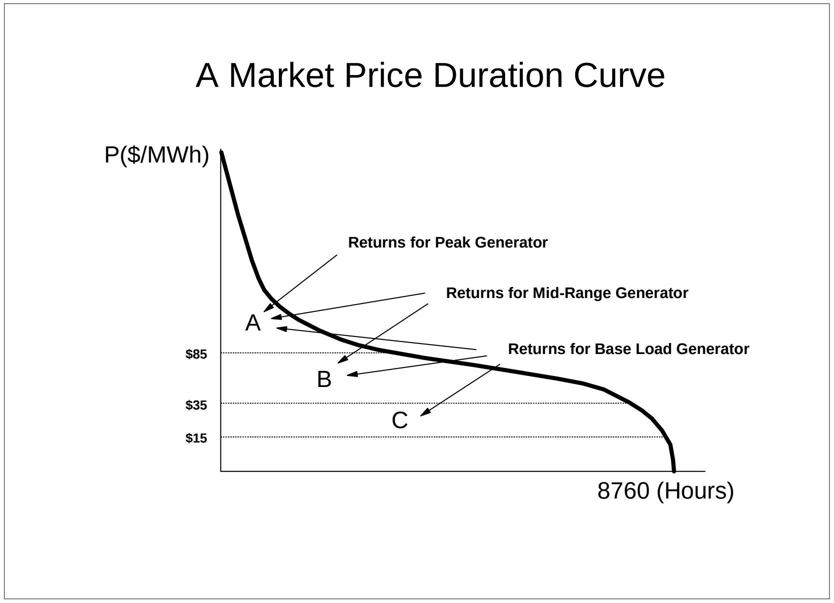
Congestion management practices can contribute to the missing money problem. For example, the Midwest Independent System Operator (MISO) frequently modifies transmission constraint representations and materially reduces congestion rents and constrained locational prices.

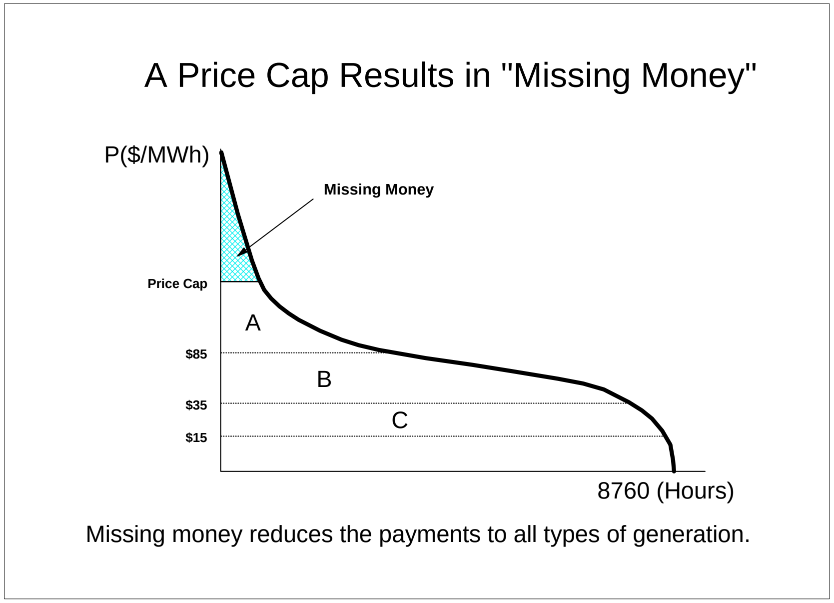
MISO "Unmanagebale" Congestion Pricing



Source: David Patton, *2010 State of the Market Report, Midwest ISO*, Potomac Economics, May 2011, p. 171.

A variety of market rules for spot markets interact to create *de jure* or *de facto* price caps. The resulting "missing money" reduces payments to all types of generation.

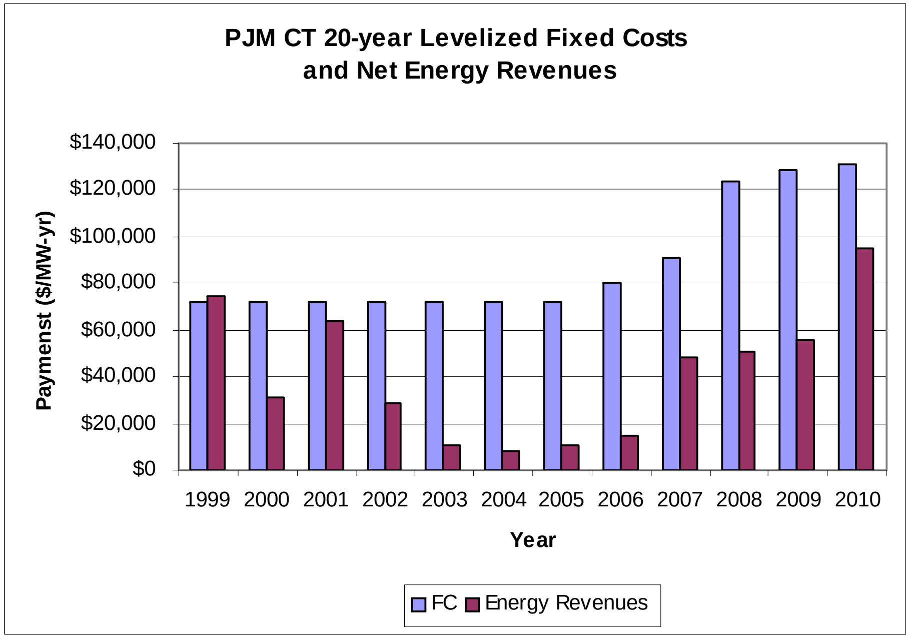




If market prices do not provide adequate incentives for generation investment, the result is a market failure. The market design defect creates the pressure for regulators to intervene to mandate generation investment.

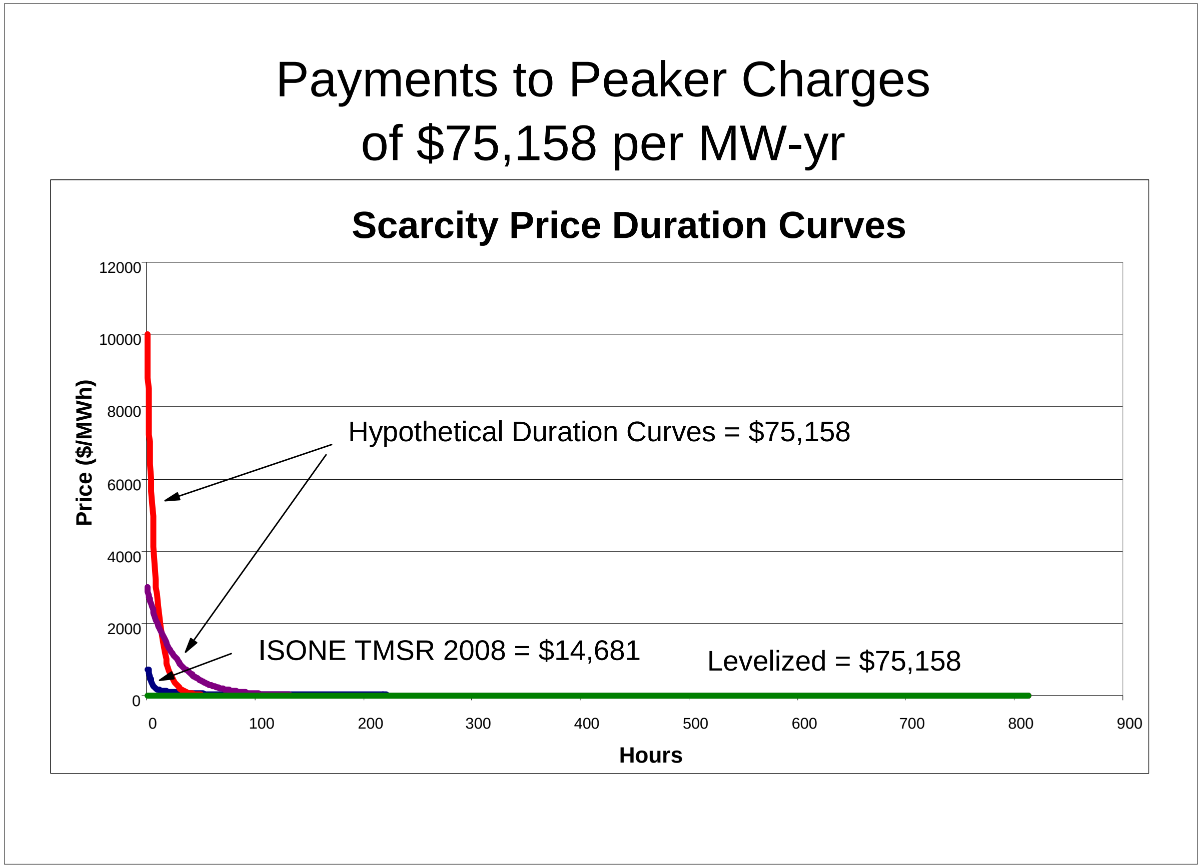
Existing energy prices have not been sufficient to support new entry. The case of an efficiently dispatched combustion turbine in PJM illustrates the magnitude of the problem.

Payments for CT Peaker
PJM Economic Dispatch



Source: Monitoring Analytics, State of the Market Report, 2010, Table 3-21, Vol. 2, p. 171.

Different scarcity pricing duration curves will determine the contribution of scarcity prices to total payments for energy and reserves. For example, consider the PJM estimate of a fixed charge for a peaker at $75,158 per MW-yr. The hypotheticals illustrate consistent alternative duration curves. These are compared with the actual 2008 price duration curve in ISONE for ten minute spinning reserves (TMSR) for location ID 7000.



Regulated investment and capacity markets make central planners and regulators the decision makers. High bid caps present a solution that will create more unintended consequences.

- **Installed Capacity**. Assuming it is impossible to provide adequate scarcity pricing, interventions focus on regulation and installed capacity requirements.
  - Emphasis on physical capacity and planning targets. This seems natural and innocuous, but the physical perspective leads to a host of market design problems.
  - Requirement for longer-term regulatory commitments and decisions. Substantial payments must come through the regulatory decision, investment requires the commitment.
  - Assumes there is some method for defining and ensuring transmission deliverability. If we knew how to do this, everything would be easier. But the electricity network makes this difficult.
  - Experience reveals unintended consequences and renews interest in better scarcity pricing.
- **High Bid Caps.** Making the market safe for market power.
  - Requires a relaxation of market power mitigation policies during times of scarcity.
  - Requires regulators to deliver on promises not to intervene when the crisis occurs.
- **Scarcity Pricing**. Suspending disbelief, consider better scarcity pricing through operating reserve demand curves.
  - An "energy only" market without an installed capacity requirement, but with alternative regulatory requirements.
  - Or "belts and suspenders" with better scarcity pricing that supports an installed capacity system.

The "missing money" problem results in too little generation and infrastructure investment. The policy responses illustrate the tension between market design and regulation.

- **Regulated investment in new generation.**
  - SPP and balanced scheduling requirements.
  - State procurement initiatives for renewables and other new capacity.
- **Capacity Markets.**
  - PJM and the Reliability Pricing Model (RPM).
  - New England and the Forward Capacity Market (FCM).
  - NYISO and the Installed Capacity Market (ICAP).
  - SWIS and Reserve Capacity Mechanism (RCM) in Australia.
- **Energy pricing reforms.**
  - High bid caps as in Australia ($10,000/MWh), Texas ($2,250/MWh) and PJM ($1,000/MWh).
  - Operating reserve demand curves in New York, New England and the Midwest. (MISO FERC Electric Tariff, Volume No. 1, Schedule 28, January 22, 2009.)[2]

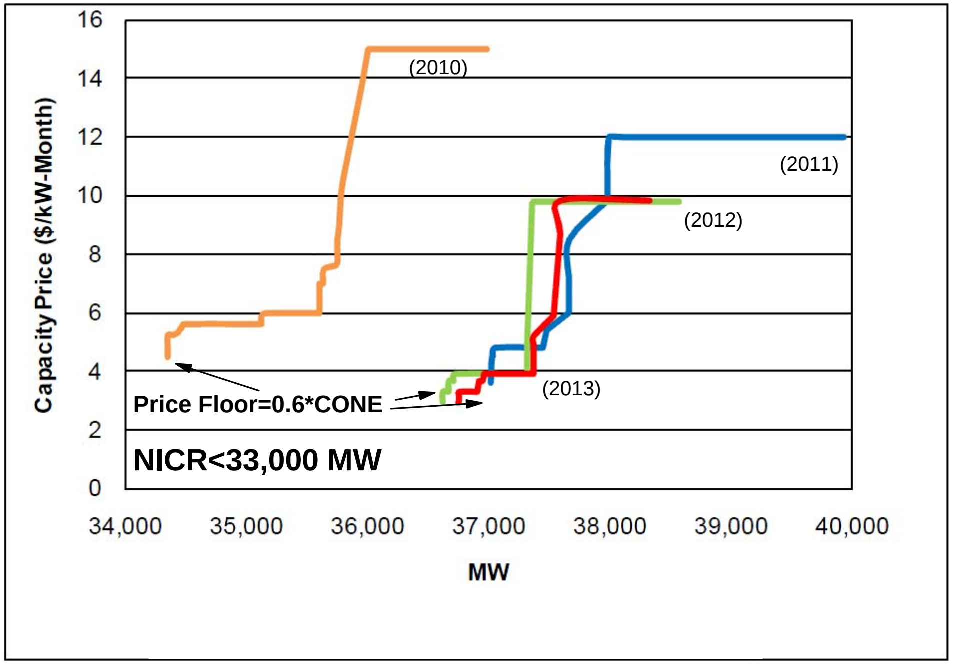
[2] "For each cleared Operating Reserve level less than the Market-Wide Operating Reserve Requirement, the Market-Wide Operating Reserve Demand Curve price shall be equal to the product of (i) the Value of Lost Load ("VOLL") and (ii) the estimated conditional probability of a loss of load given that 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.

Capacity market design presents many challenges and difficult questions. In essence, a good forward capacity market design for months to years ahead requires addressing issues that are difficult to consider when looking only a few hours or days ahead.

- **Capacity Definition(s).** Traditional dispatchable plants, intermittent resources, demand response.
- **Horizon and Duration.** Annual to multiple years, with short term adjustments and trueups.
- **Capacity Requirements.** Uncertain conditions and complicated reliability standards.
- **Transmission Constraints.**
  - **Locational requirements.** Difficult to define and model locational requirements.
  - **Integrated expansion plans.** Timing and accountability for transmission expansion.
- **Cost of New Entry.** Marginal source of capacity depends on existing mix.
- **Energy Revenues.** Ex ante (PJM) or ex post (ISONE) determination.
- **Demand Curves.** Fixed capacity requirements, price collars, variable demand slope.
- **Capacity Cost Recovery.** Locational, socialized payments.
- **Performance and Penalties.** Outages rates, exemptions, transition payments, penalties.

The ISONE Forward Capacity Market Auctions have seen supply curve offers well in excess of Net Installed Capacity Requirement (NICR). This has triggered the floor price constraints at 60% of the Cost of New Entry (CONE).

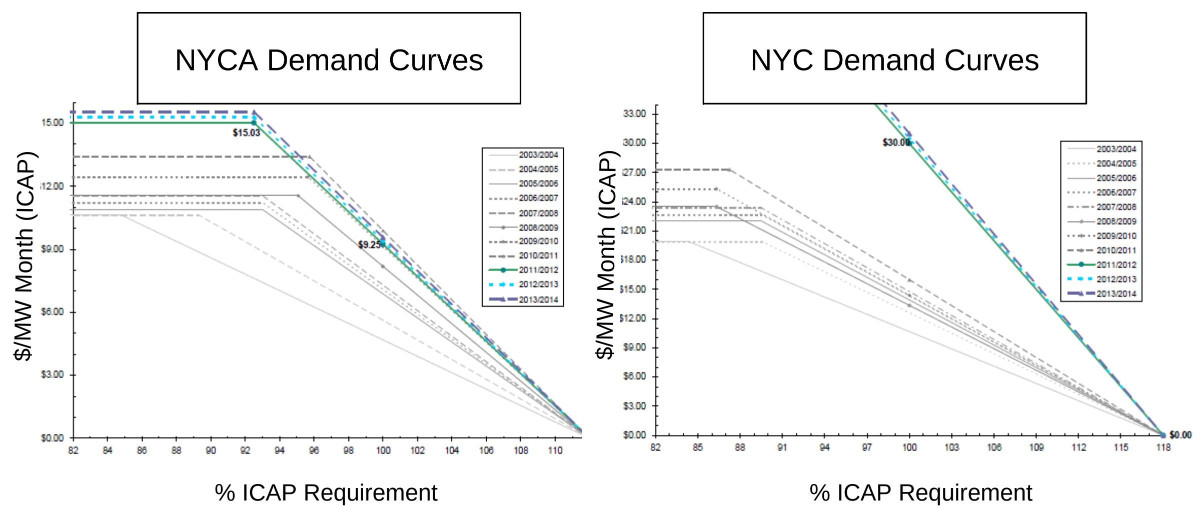
ISONE Forward Capacity Auction Supply Curves



Source: ISONE, *2010 Annual Market Report*, June 3, 2011, p. 117.

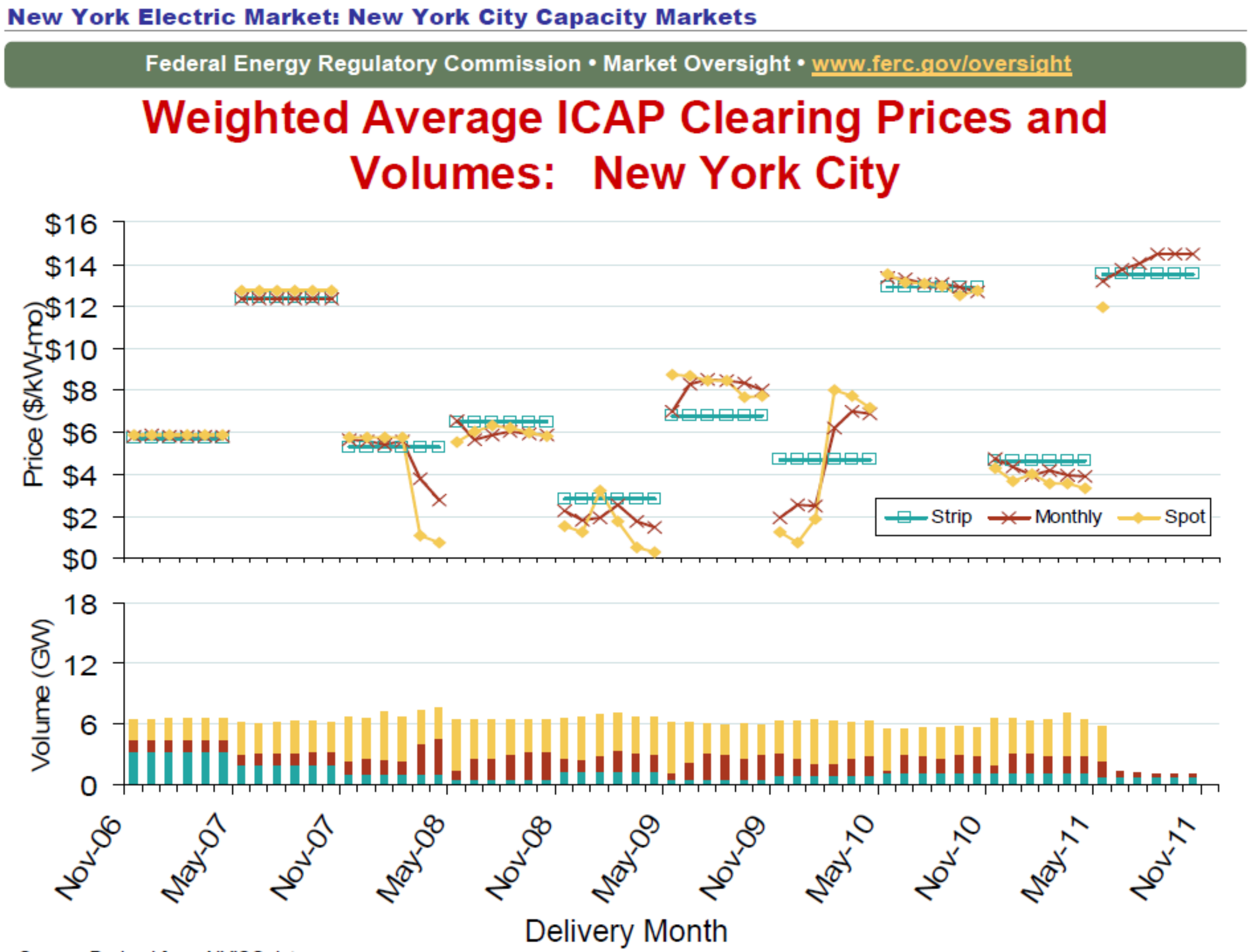
New York's locational ICAP demand curves reflect higher cost of new entry in New York City (NYC) zone compared to the rest of the state (NYCA).

NYISO Capacity Market Demand Curves



Source: David Lawrence, *NYISO FERC Affidavit,* Docket No. ER11-2224-00, March 29, 2011.

New York's locational ICAP market has produced high clearing prices in the constrained New York City location.



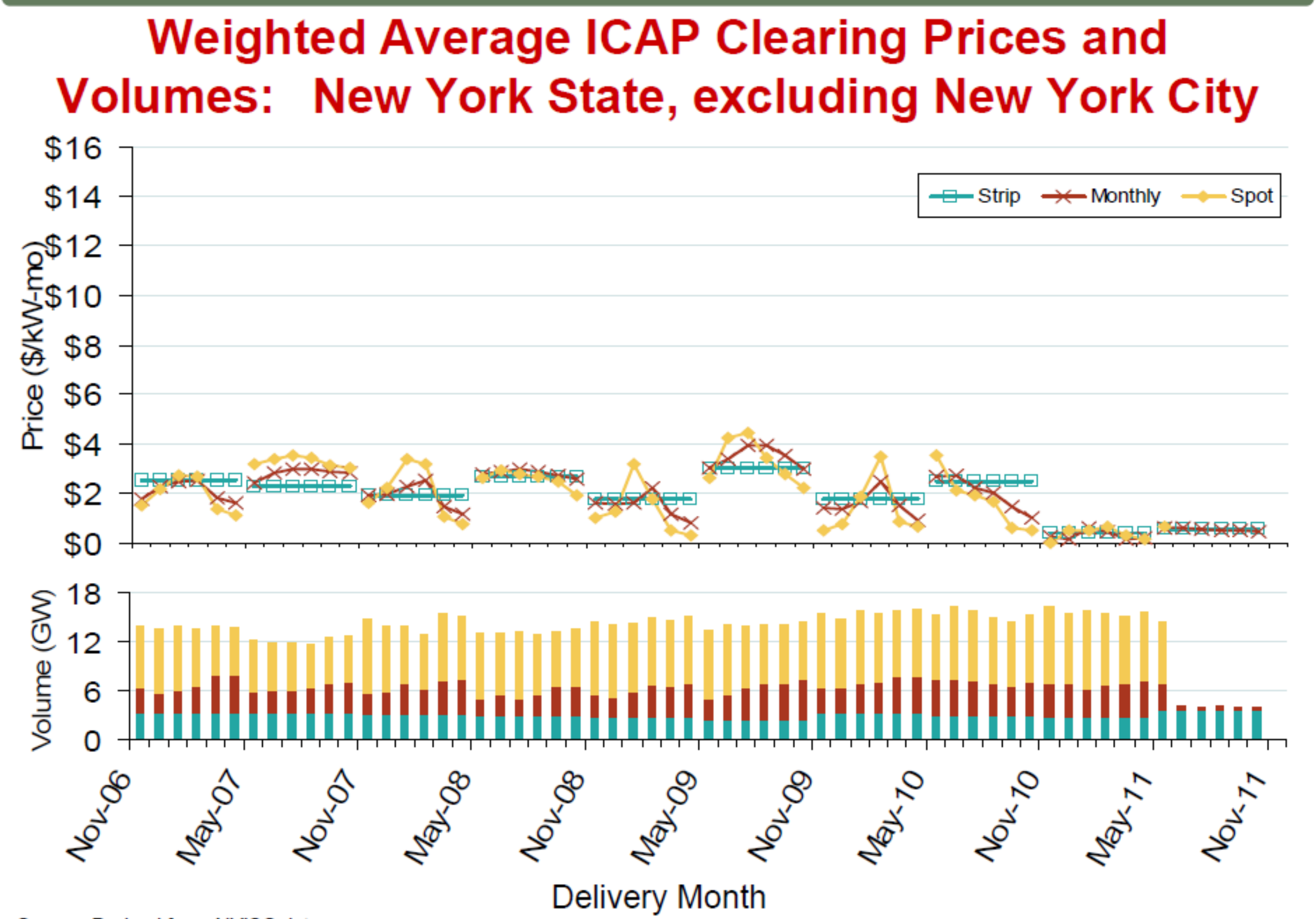
Source: Derived from *NYISO* data.

Updated May 6, 2011

NYISO ICAP prices for the rest of the state are much lower, and indicated excess capacity.

New York Electric Market: New York Capacity Markets

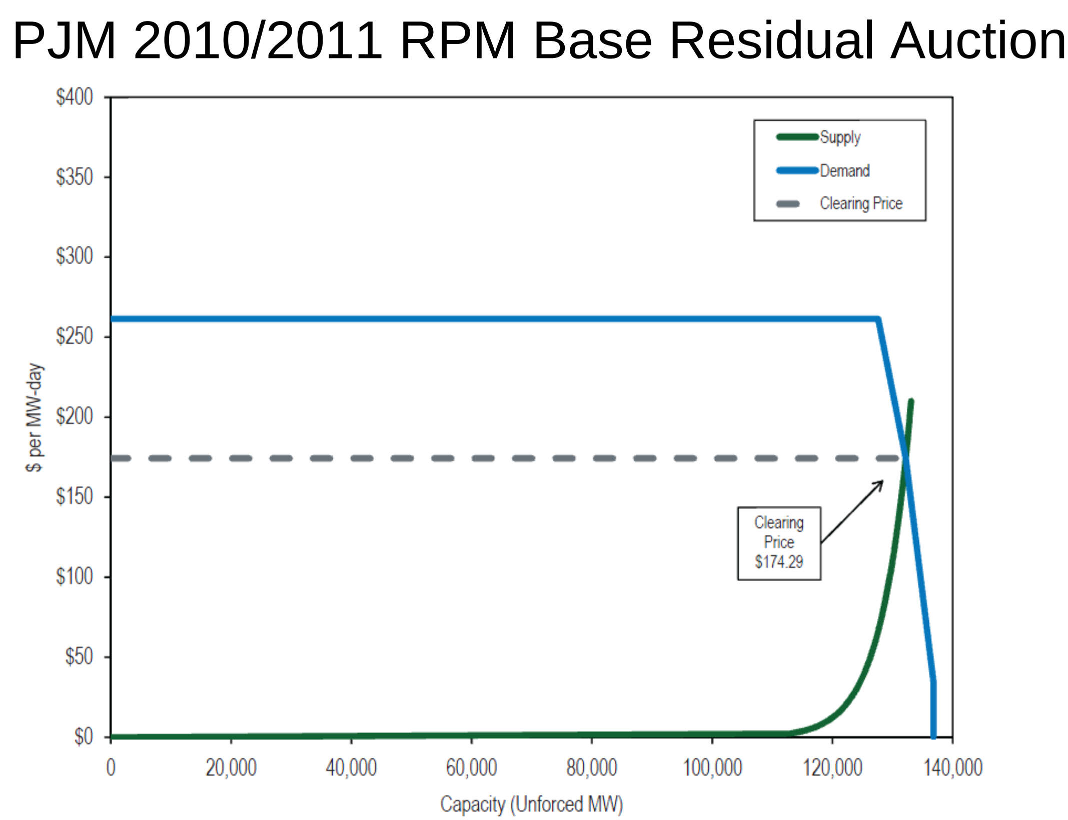
Federal Energy Regulatory Commission • Market Oversight • www.ferc.gov/oversight



Source: Derived from *NYISO* data.

Updated May 6, 2011

PJM's Reliability Pricing Model Variable Resource Requirement (VRR) "Demand" curve illustrates a steep demand curve above minimum requirements.

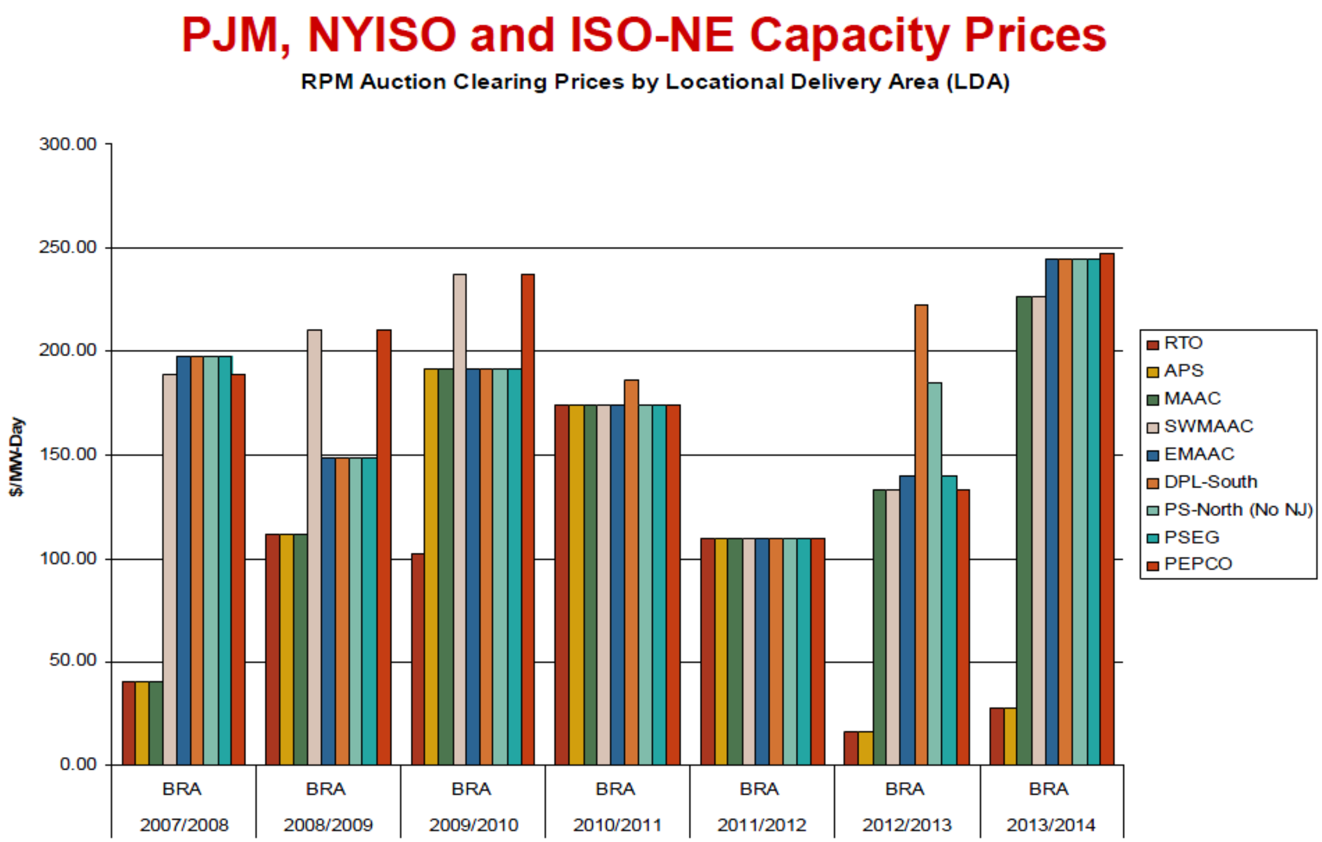


Source: Monitoring Analytics, *2010 State of the Market Report* , March 10, 2011, p. 392.

In PJM, the Reliability Pricing Model (RPM) illustrates results that often reflect material locational differences in capacity requirements and prices.

PJM Electric Market: RTO Capacity Prices

Federal Energy Regulatory Commission • Market Oversight @ FERC.gov



Note: PJM values are for Base Residual Auctions only.

ISO-NE results for 2010/2011 and 2011/2012 are based on preliminary FCM auction before pro-rationing and EAS adjustment.

Source: Derived from *PJM, NYISO and ISO-NE* data

Updated May 27, 2011

PJM has seen increases in capacity resources. The total RPM 2010 demand was 156,637 MW.

	ICAP (MW)				
Delivery Year	New Generation Capacity Resources	Reactivated Generation Capacity Resources	Uprates to Existing Generation Capacity Resources	Net Increase in Capacity Imports	Total
2007/2008	19.0	47.0	536.0	1,576.6	2,178.6
2008/2009	145.1	131.0	438.1	107.7	821.9
2009/2010	476.3	0.0	793.3	105.0	1,374.6
2010/2011	1,031.5	170.7	876.3	24.1	2,102.6
2011/2012	2,332.5	501.0	896.8	672.6	4,402.9
2012/2013	901.5	0.0	946.6	676.8	2,524.9
2013/2014	1,080.2	0.0	418.2	963.3	2,461.7
Total	5,986.1	849.7	4,905.3	4,126.1	15,867.2

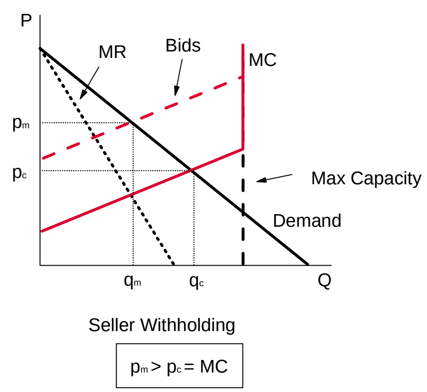
Source: Monitoring Analytics, *2010 State of the Market Report*, March 10, 2011, p. 368.

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

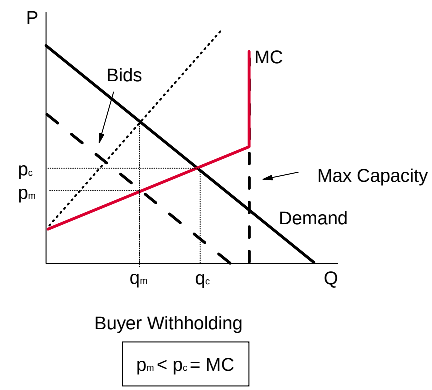
> "In the face of these diverging opinions, the Commission observes that, as the courts have recognized, 'issues of rate design are fairly technical and, insofar as they are not technical, involve policy judgments that lie at the core of the regulatory mission.' We also observe that, in making such judgments, 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



Defining Market Power: Monopsony Withholding



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.)

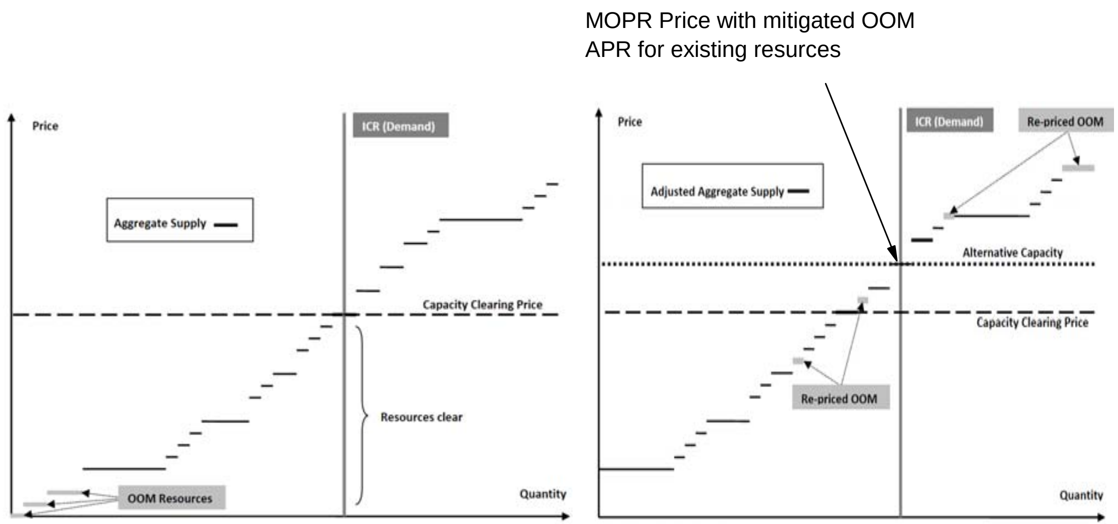
PJM Capacity Markets

"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.)

The FERC ruling on the Minimum Offer Price Rule (FERC PJM MOPR Rule, Docket Nos. ER11-2875-000, EL11-20-000, April 12, 2011), with applications in all the RTOs with capacity markets, targets state intervention with Out of Market (OOM) offers reducing capacity prices. A comparison of the MOPR and the ISONE proposal for an "Alternative Price Rule (APR)" illustrates some of the tensions. The MOPR mitigates some offers, produces one price, and excludes some OOM offers. The APR mitigates all offers, produces new and old prices, but includes all OOM. The different models have different effects on green projects.

ISONE Proposed Alternative Price Rule



MOPR: Awards=ICR at single price.
APR: Awards>ICR at different prices for new and old.

Source: ISONE, FERC FCM Docket No. EL10-50-000, Docket No. EL10-57-000, July 1, 2010, pp. 13-15.

Capacity markets in the United States are a work in progress.

“Smitherman [Chairman of Texas PUC] believes that capacity markets do not work and has not heard good things about them from his state colleagues in PJM, New York, and New England.” (*Restructuring Today*, May 13, 2011).

Short run attention to immediate issues such as offer price mitigation operates against a background of continuing questions about a workable market design.

- **Bankable Contracts for New Capacity.** How long should contracts extend?
- **Integration of Flexible Demand.** How would real-time demand response change capacity requirements and impacts of cost socialization?
- **Consolidation of Reliability Criteria.** How do we address limits on the willingness to pay for reliability?
- **Renewable Energy.** How do we address offer price mitigation and capacity price impacts of OOM green energy?
- **Plant Retirements.** Will new EPA regulations on emissions other than CO2 raise costs and lead to accelerated retirement?
- **Scarcity Pricing.** How would improved scarcity pricing affect future operation and need for capacity markets?

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.[3]

Smart Grids Need Smart Prices.

---

3 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. David Lawrence provided helpful comments with information on the NYISO. 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).