

ELECTRICITY MARKET DESIGN
Can Electricity Markets Meet the Challenge
of Meeting Non-Market Objectives?

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October 4, 2018

Turmoil in electricity market policy is a normal state of affairs.

“Trump-appointed regulators reject plan to rescue coal and nuclear plants.”

(Washington Post, 1/8/18)

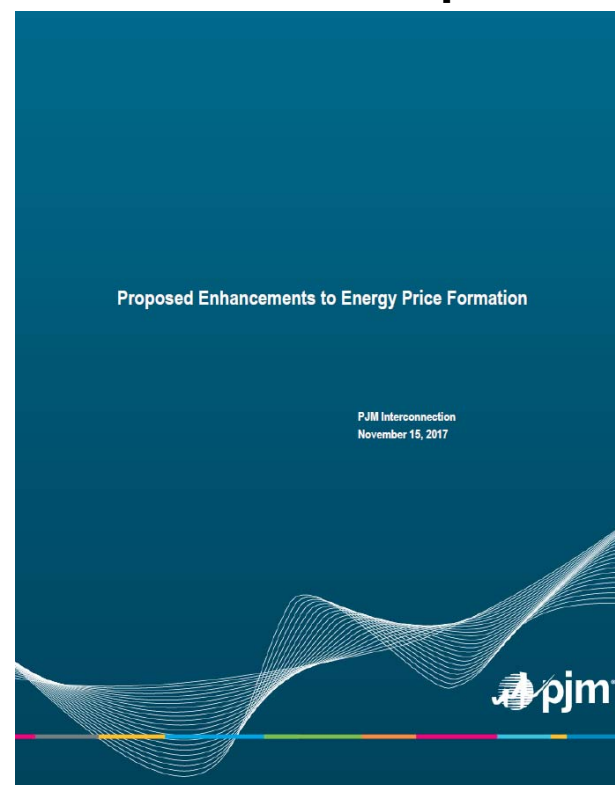
“The Federal Energy Regulatory Commission on Monday unanimously rejected a proposal by Energy Secretary Rick Perry that would have propped up nuclear and coal power plants struggling in competitive electricity markets. ...

...the language in the current order suggested it would stand by the trend toward free competitive electricity markets.”

A prominent element of the FERC response included newly focused attention on efforts to improve electricity market design and price formation.

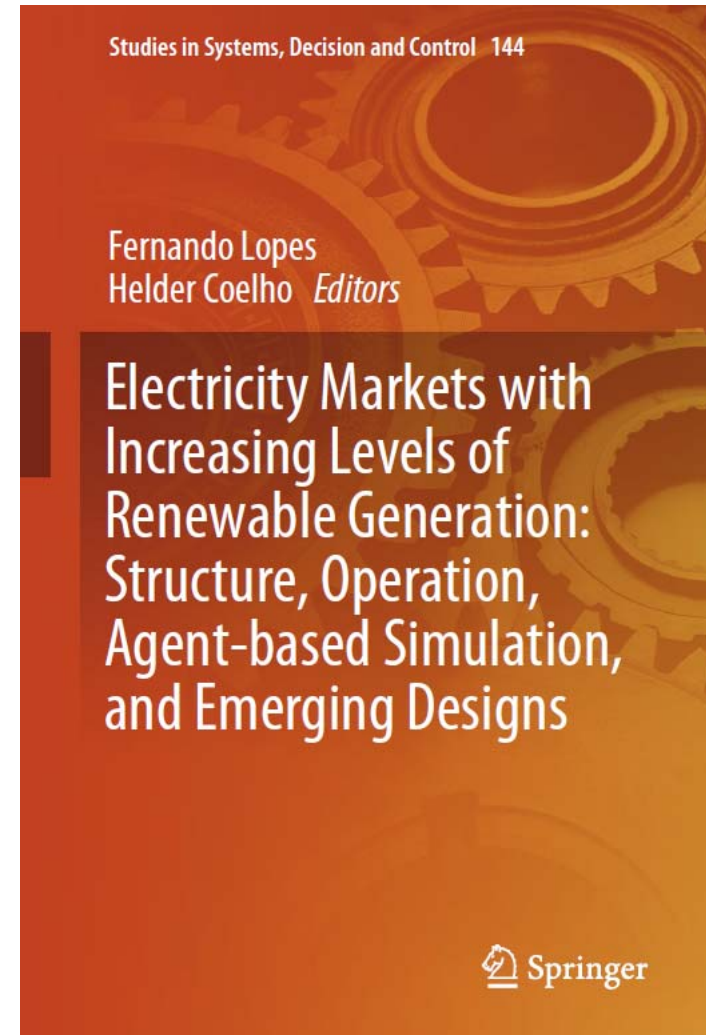
One focus is on proposed enhancements to energy price formation in PJM. (PJM Interconnection, 2017)

“Murky Trump order on coal, nuke plant closures follows mystery memo. ... [Press Secretary] Sanders concluded: ‘President Trump has directed Secretary of Energy Perry to stop the loss of these resources, and looks forward to his recommendations.’” (Energy Daily, pp.1-2, Vol. 46, No. 106, 6/4/18)



A major challenge is the integration of increasing levels of renewables. There is a large and growing literature on the subject. (Lopes & Coelho, 2018) (Hogan & Pope, 2017)

- **Are renewables fundamentally different?**
 - Zero marginal cost, which affects the system economics.
 - Intermittency of supply, which affects system operations.
- **Will increasing levels of renewables require a fundamentally new approach to electricity market design?**
 - Clean Power Plan mandates with effects both on investment and operations.
 - Expanded state subsidies (NY, IL), inconsistent carbon markets (CA and EIM), net energy metering (Belmont, MA), and ever present rent seeking.
- **What is wrong with the existing market design fundamentals?**



Subsidies are growing: RPS, RECs, PTCs, ITCs, DR, and ZECs.

Soon DECs (Dirty Energy Credits)?¹

“Subsidies are contagious. Competition in the markets could be replaced by competition to receive subsidies.” (Monitoring Analytics, 2017, p. 2)

Regarding the FERC decision on the application of minimum offer price rules in NYISO:

“The premise of the MOPR appears to be based on an idealized vision of markets free from the influence of public policies. But such a world does not exist, and it is impossible to mitigate our way to its creation. The fact of the matter is that all energy resources receive federal subsidies, and some resources have received subsidies for decades.” (Commissioner Norman Bay concurrence) (FERC, 2017, p. 2)

¹ Anonymous.

If you are willing to spend enough money, you can make anything look cheap.

“Subsidies pose a more general problem in this context. They attempt to discourage carbon-intensive activities by making other activities more attractive. One difficulty with subsidies is identifying the eligible low-carbon activities. Why subsidize hybrid cars (which we do) and not biking (which we do not)? Is the answer to subsidize all low carbon activities? Of course, that is impossible because there are just too many low-carbon activities, and it would prove astronomically expensive. Another problem is that subsidies are so uneven in their impact. A recent study by the National Academy of Sciences looked at the impact of several subsidies on GHG emissions. It found a vast difference in their effectiveness in terms of CO₂ removed per dollar of subsidy. None of the subsidies were efficient; some were horribly inefficient; and others such as the ethanol subsidy were perverse and actually increased GHG emissions. The net effect of all the subsidies taken together was effectively zero!”

So in the end, it is much more effective to penalize carbon emissions than to subsidize everything else.” (Nordhaus, 2013, p. 266)

The discussion of the implications of subsidies entails several related issues.

Market conditions are putting pressure on generators, and system operators.

- Subsidized renewables have low variable costs that reinforce low market prices. Intermittency creates more volatility in operations.
- Low natural gas prices have changed the marginal units in the supply and the result is relatively low electricity energy prices.
- Subsidized generation presents challenges for capacity markets.

Important questions include:

- Are these subsidies and related market interventions good public policy?
- Does the Dormant Commerce Clause apply to prevent restraint of interstate trade?
- Does FERC jurisdiction extend over the many and growing state policies?
- Should FERC act to prohibit or reverse the market effects of subsidies and other interventions?
- What should FERC do?
 - Get the prices right.
 - Address market manipulation.
 - Support consistent infrastructure expansion.

Market design improvements would help address challenges going forward.

Deference to Markets

A dangerous definition of market failure. “The market fails to do what the central planner wants.” It is not hard to see where this goes: most investments would be left to the purview of the regulators and central planners, who operate a better collection agency.

Pricing Externalities such as Carbon Emissions.

Internalize the cost of externalities. The Social Cost of Carbon provides a guide for how much is enough. Quantity mandates, as in the Fuel Use Act, do not balance costs and benefits.

Address regional leakage through imports, exports and interactions with emission caps.

Scarcity Pricing.

The ERCOT experience and the Operating Reserve Demand Curve.

Multi-period Pricing.

Standard marginal cost pricing accounts for ramping and flexibility value.

Transmission Investment.

Hybrid systems that integrate costs, benefits, merchant investment and regulated investment.

The NYISO Tariff provides the closest example.

Price Manipulation.

Seller-side Market Power Mitigation.

Buyer-side Market Power Mitigation?

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Reality Tests

A passing reflection on history reinforces the view that there is great uncertainty about energy technology choices for the future. There are many examples of both bad and good surprises.

TVA's nuclear plant auction set for November

"The Tennessee Valley Authority, in apparently a first in the US power industry, plans to auction its unfinished Bellefonte nuclear plant in Alabama on November 14 in what amounts to a "fire sale" of epic proportions.

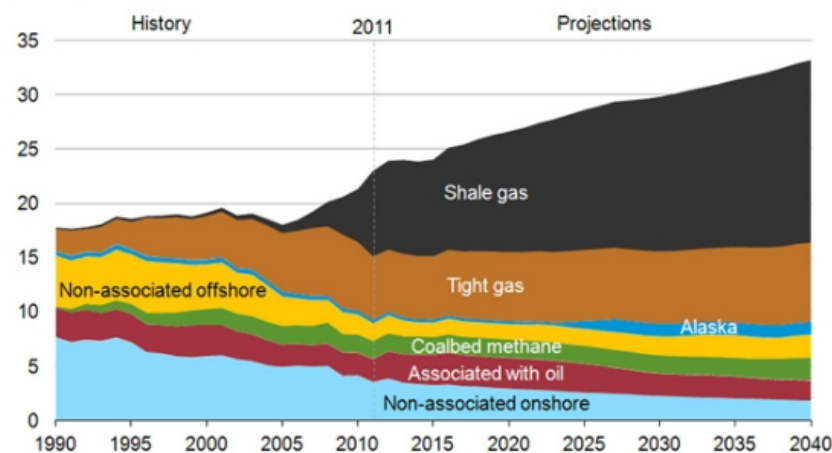
Over more than four decades, an estimated \$6 billion was pumped into the project imagined at a time of far different economic and electricity projections and expectations. Bellefonte's minimum asking price — \$36.4 million."

(Megawatt Daily, October 18, 2016, p. 3)

U.S. Shale Miracle:

Once the technology crossed the market threshold, deployment was both large and rapid.

U.S. dry natural gas production
trillion cubic feet



Source: U.S. Energy Information Administration, Annual Energy Outlook 2013 Early Release

Good wholesale electricity market design is necessary to provide open access with non-discrimination principles that encourage entry and innovation.

The expansion of subsidy systems has implications for electricity market design.

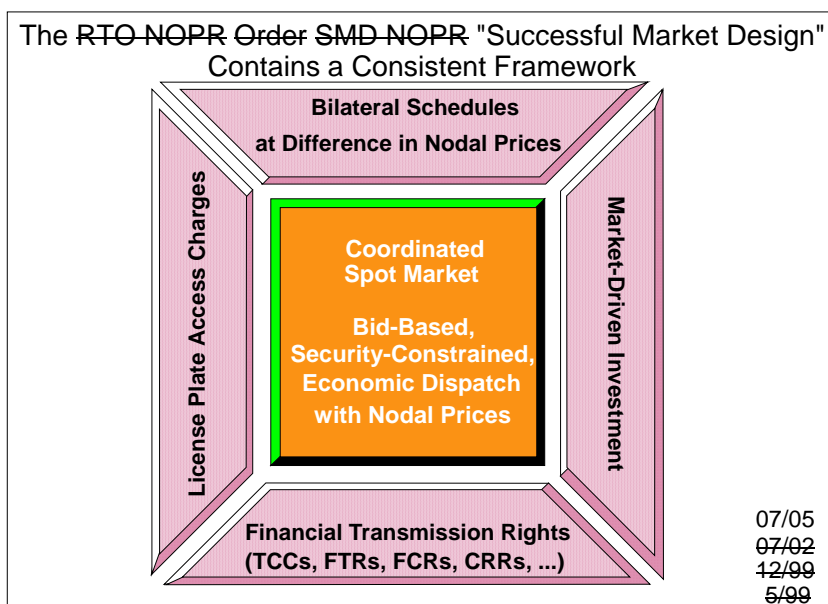
“The most market-oriented solution with the greatest transparency, simplicity, and, perhaps, efficiency would be to transition over time to an energy-only market. Assuming the scarcity pricing level is set at the appropriate level (the value of lost load), it addresses the “missing money” problem and eliminates the need for a capacity market. But I recognize that it would be a big step for a wholesale market operator to propose an energy-only market – only ERCOT has adopted this design – and that some may be concerned about the politics of scarcity pricing. The trade-off for critics concerned about costs, however, is that there would not be a capacity market. A decade ago, in the aftermath of the Western Power Crisis, there would have been little appetite for an energy-only market. Now, however, the wholesale market operators, market monitors, and FERC do much better market monitoring, FERC has an anti-manipulation authority, and natural gas is abundant and low priced, so there should be less price volatility in most regions.” (Commissioner Norman Bay concurrence) (FERC, 2017, p. 7)

“We agree that we don’t want to go back fifty years to before open access. Let’s drop that argument. We agree on the value of wholesale competition. Let’s drop that argument. We agree on the operational value of RTOs and ISOs can provide. Let’s drop that argument as well.” (Jay Morrison, “Clarifying the Conflicts in Wholesale Market Design,” Public Utilities Fortnightly, September 2018, p.59)

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A Consistent Framework

The example of successful central coordination, ~~GRT, 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.



Poolco...OPCO...ISO...IMO...Transco...RTO... ITP...WMP...: "A rose by any other name ..."

“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, 2007)

This is the only model that can meet the tests of open access and non-discrimination.

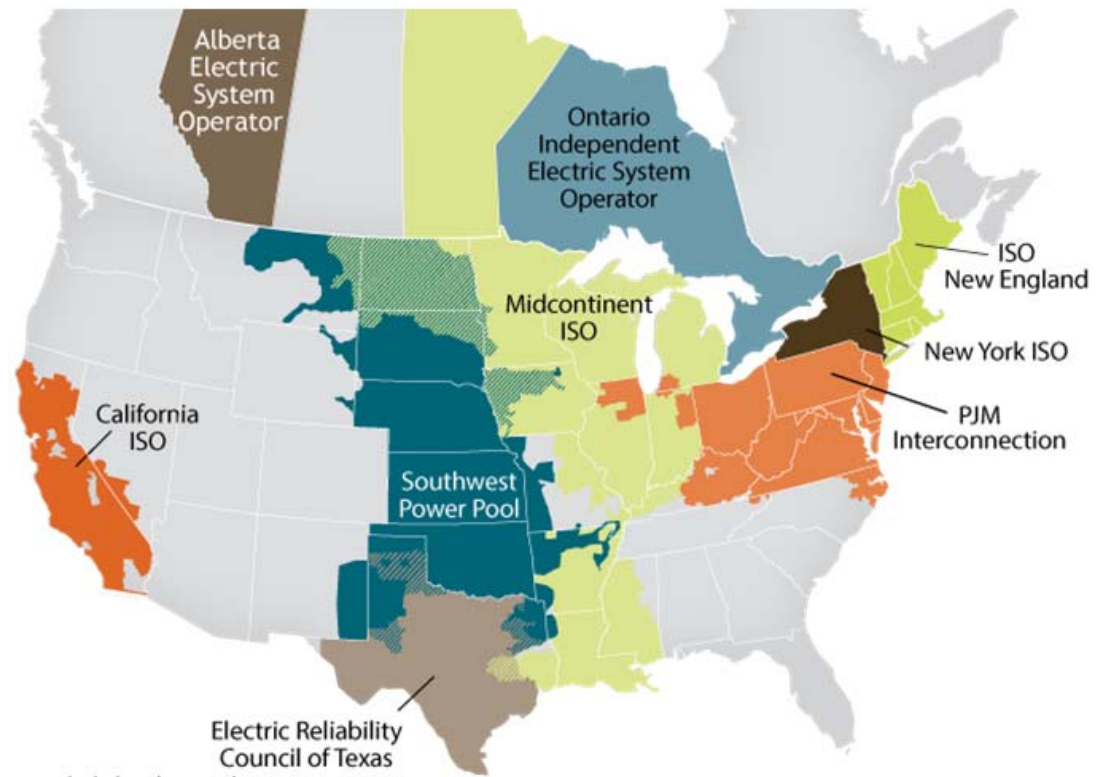
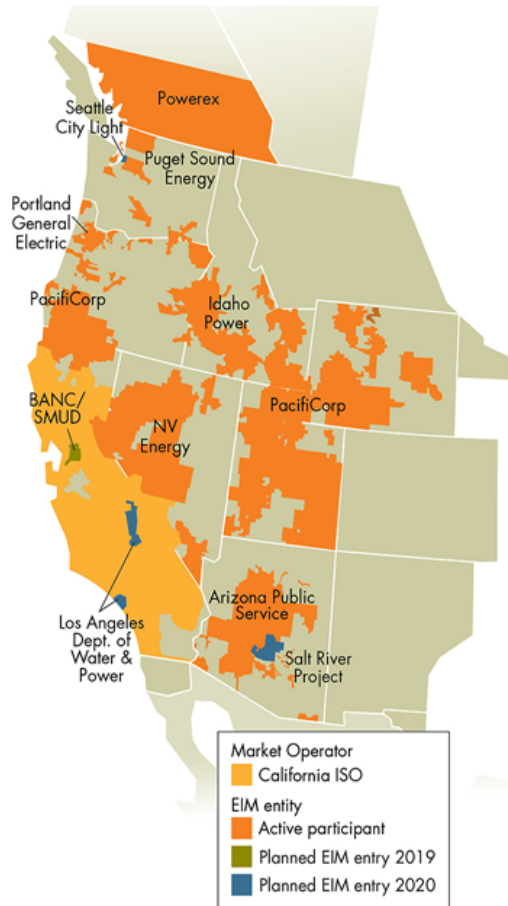
Anything that upsets this design will unravel the wholesale electricity market. The basic economic dispatch model accommodates the green energy agenda, as in the expanding Western Energy Imbalance Market (EIM).

ELECTRICITY MARKET

A Consistent Framework

The basic model covers the existing Regional Transmission Organizations and is expanding through the Western Energy Imbalance Market. (www.westerneim.com)

Western EIM active and pending participants

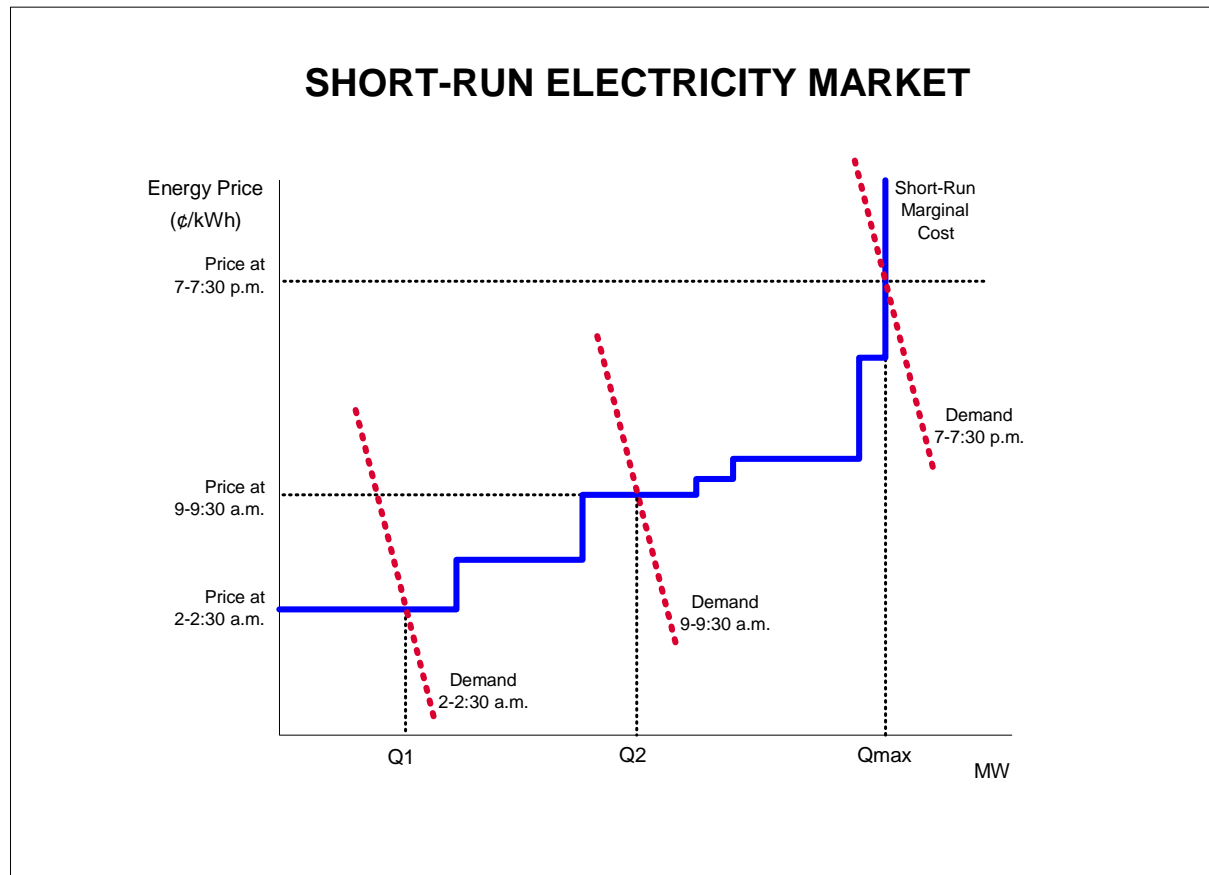


(IRC Council and CAISO maps)

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Pool Dispatch

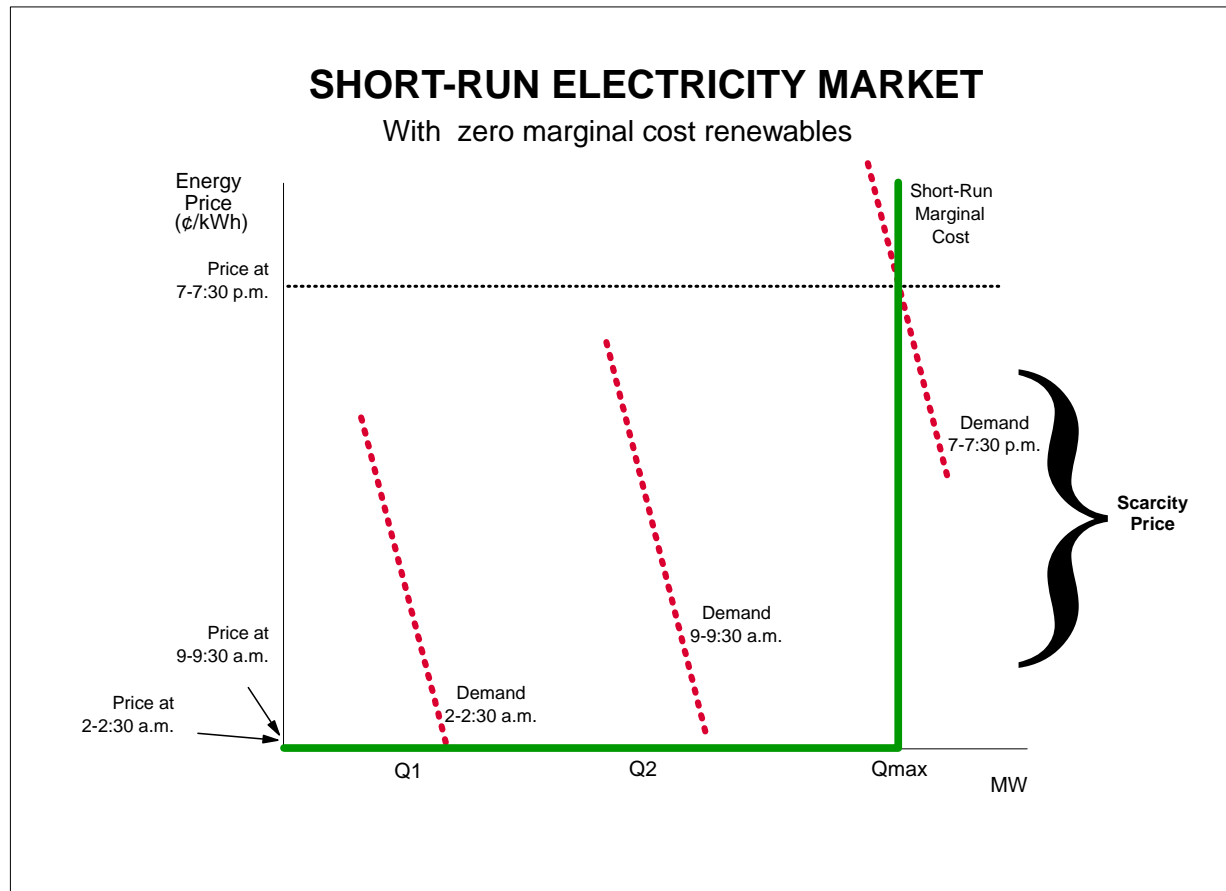
An efficient short-run electricity market determines a market clearing price based on conditions of supply and demand balanced in an economic dispatch. Everyone pays or is paid the same price. The same principles apply in an electric network. (Schweppe, Caramanis, Tabors, & Bohn, 1988)



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Pricing and Demand

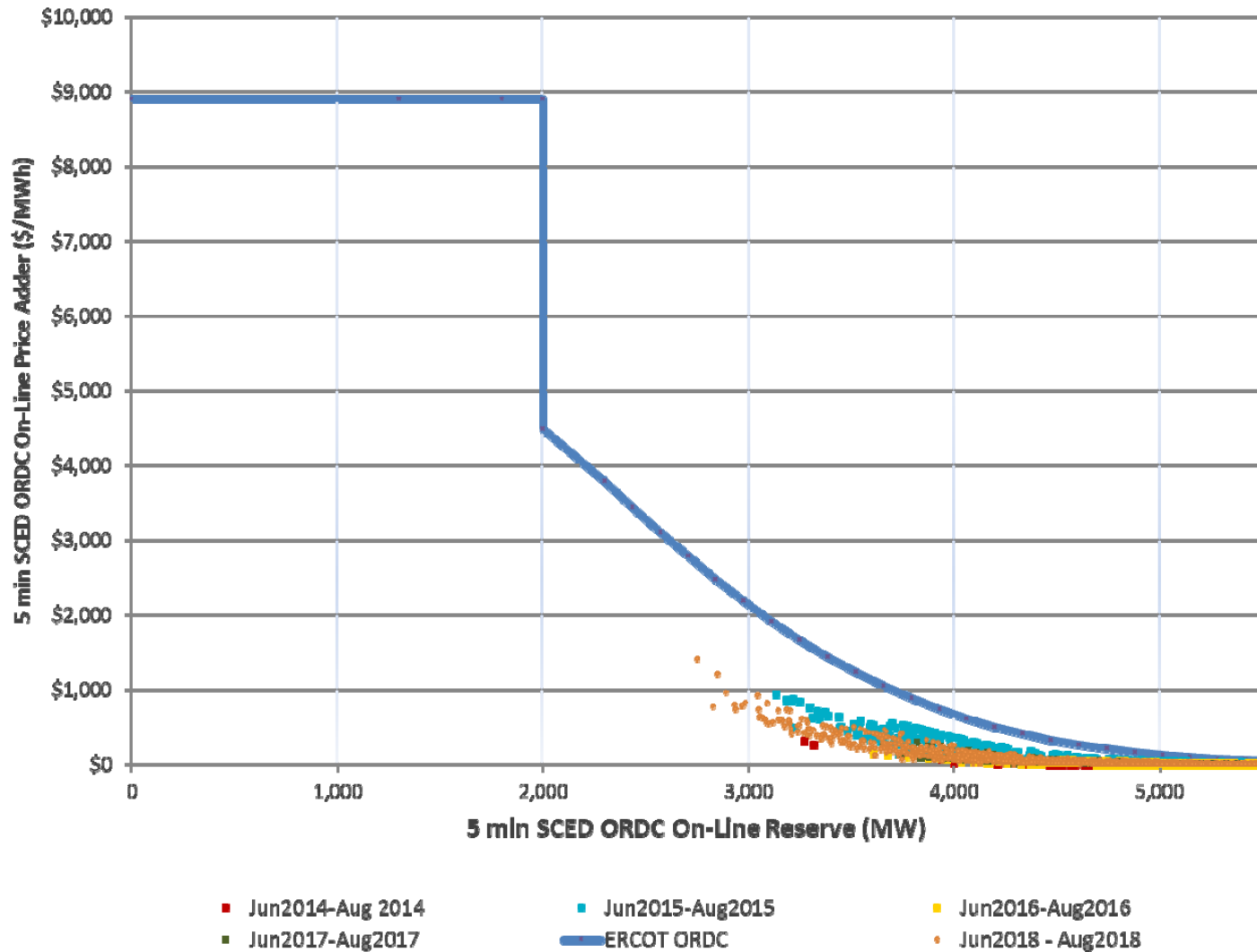
A limiting case illustrates a key issue. Electricity market design with even complete penetration by zero-variable cost renewables would follow the same analysis. But scarcity pricing would be critical to provide efficient incentives.



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ERCOT Scarcity Pricing

ERCOT launched implementation of the ORDC in 2014. The summer peak is the most important period. The first four years of results showed high availability of reserves and low reserve prices.



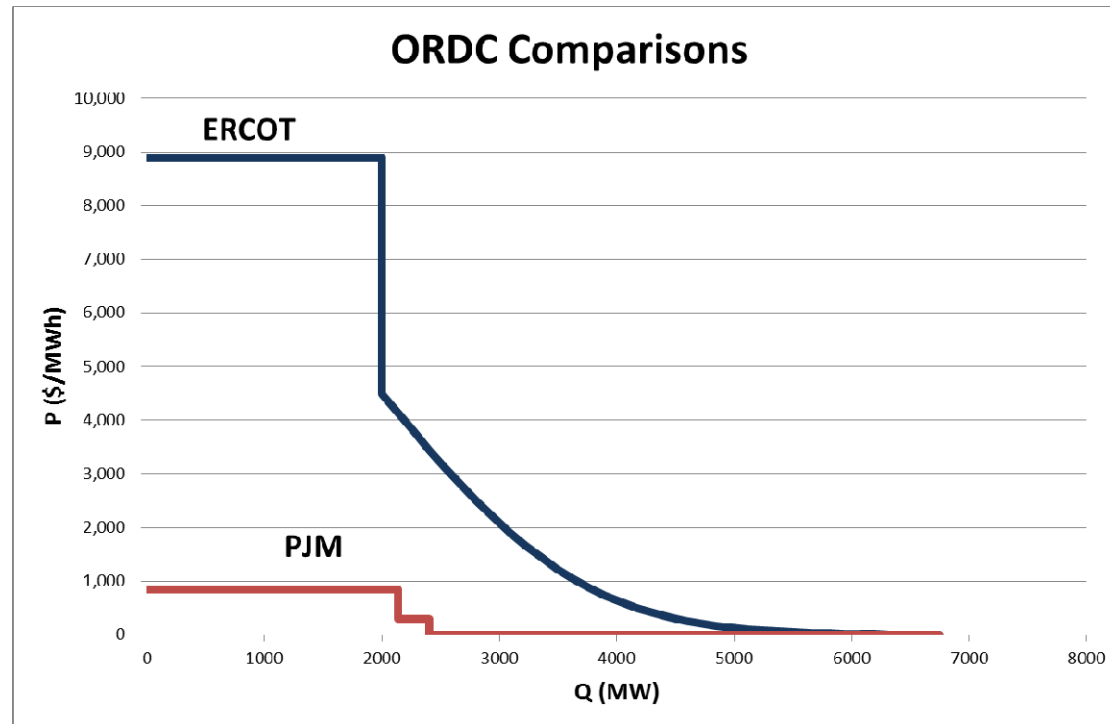
Source: Resmi Surendran, ERCOT, EUCI Presentation, Updated 8/31/2018. The ORDC is illustrative. See also (Hogan & Pope, 2017)

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Markets and Scarcity Pricing

Other RTOs have long used ORDCs, but without building the design on basic principles.

- **Limited to Declared Shortage Conditions.** “The ORDCs PJM currently utilizes were designed under the assumption that shortage pricing would only occur during emergency operating conditions and therefore the curves are a step function.” (PJM and SPP, “Joint Comments Of PJM Interconnection, L.L.C And Southwest Power Pool, Inc. Addressing Shortage Pricing,” FERC Docket No. RM15-24-000, November 30, 2015.)
- **Based on the Cost of Supply, not the Value of Demand.** “[T]he \$300/MWh price is appropriate for reserves on the second step of the proposed ORDC based on an internal analysis of offer data for resources that are likely to be called on to provide reserves in the Operating Day.” (PJM, Proposed Tariff Revisions of PJM Interconnection, L.L.C., Docket No. ER15-643-000, December 17, 2014)



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Price Formation

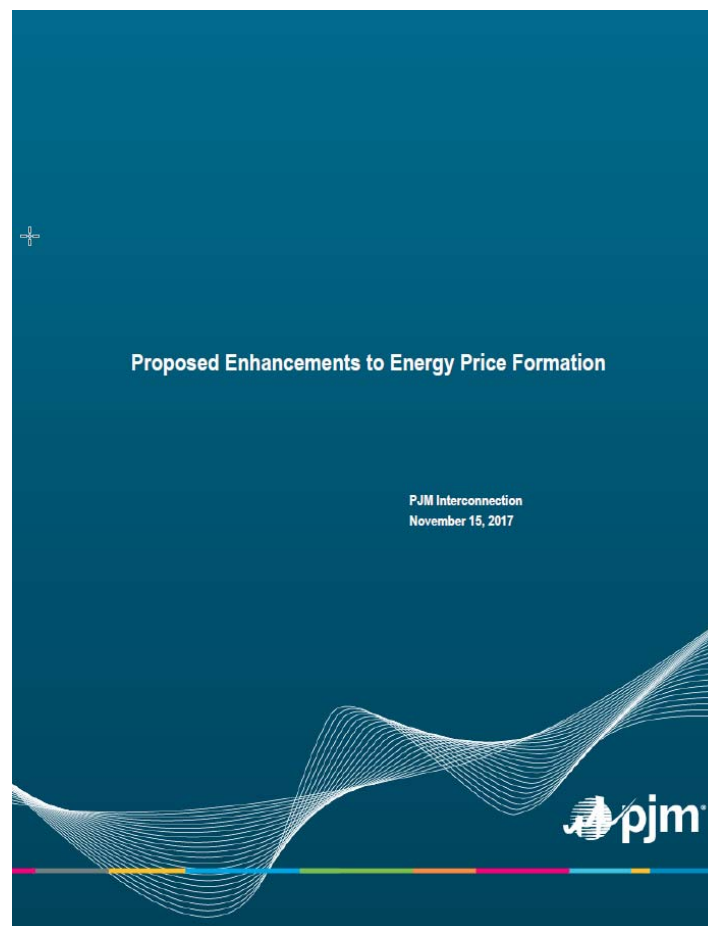
PJM has proposed a series of reforms for energy price formation, motivated in part by the impact of increased penetration of intermittent renewable resources. (PJM Interconnection, 2017)

“...the continuing penetration of zero marginal cost resources, declining natural gas prices, greater generator efficiency and reduced generator margins resulting from low energy prices have resulted in a generation mix that is differentiated less by cost and more by physical operational attributes.” (p. 1)

Figure 9. Demand Curve for Operating Reserves with Minimum Reserve Requirement



“Redefining PJM’s ORDCs using this methodology would enhance PJM’s shortage pricing mechanism by assigning a value to reserves consistent with their reliability benefit to the system. Additionally, this ORDC model allows reserves to be committed in excess of the nominal requirement when it lowers the LOLP but assures that the cost of such reserves will never exceed the reliability benefit.” (p.23)



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Subsidies and Market Design

Analysis of an energy-only market highlights the challenges for regulators. Everything affects markets and market prices, but not everything should be addressed by regulators. “[A]n idealized vision of markets free from the influence of public policies. But such a world does not exist, and it is impossible to mitigate our way to its creation.” A key challenge is to internalize the costs of market and non-market actions.

Conditions Addressed Markets Requiring no intervention

Related Costs: Cogeneration plants.
Exogenous Shocks: U.S. Shale Miracle.
Optimistic Expectations: Panda Power.
Externalities: Carbon Pricing.

Problems Arising in Markets Requiring a regulatory response

Seller-side Market Power and Price Manipulation.
Buyer-side Market Power and Price Manipulation.

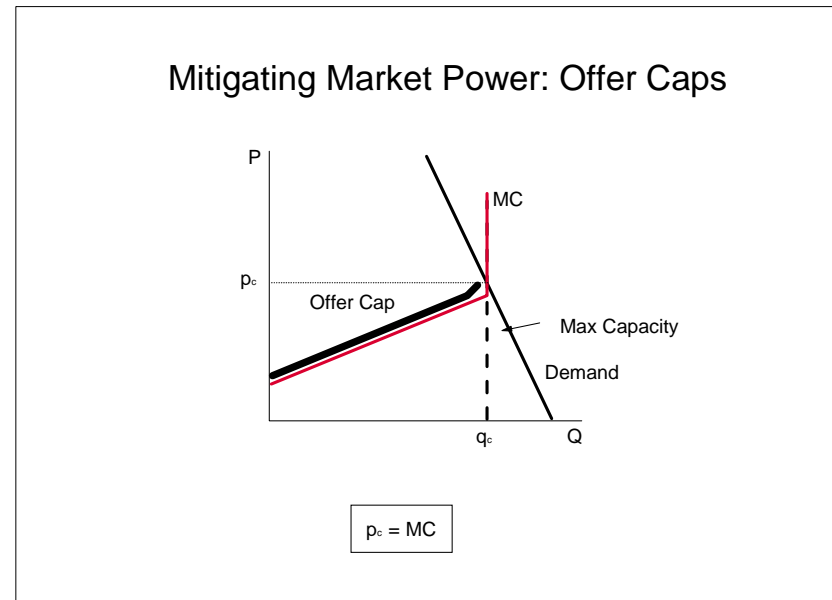
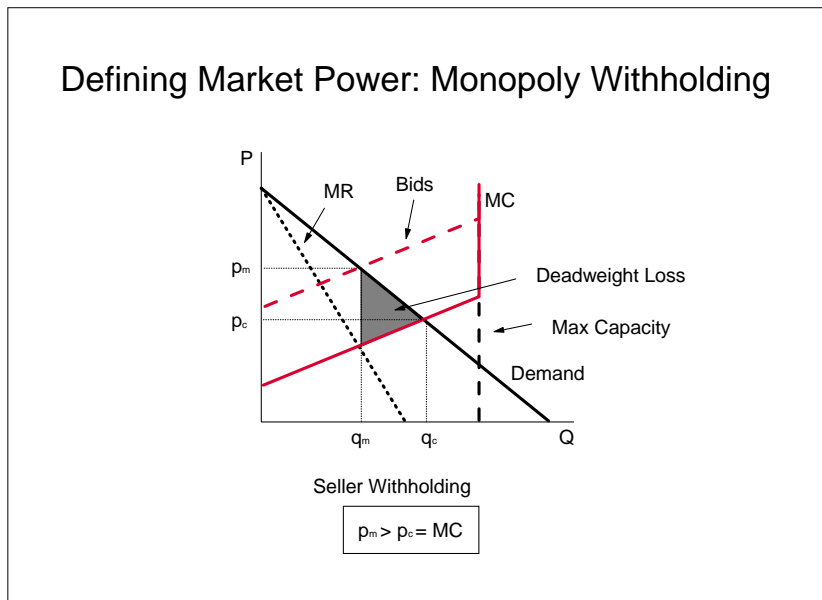
Establishing the difference between a condition and a problem is easier said than done.

Would a price-taker accept the transaction, or is price manipulation essential to the strategy?

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Seller-side Market Power

The standard argument for economic or physical withholding of supply is that it raises market prices and a firm with other generators can profit from the manipulation of prices. The result is inefficient operations, rent transfers, and a welfare loss. The same effect would follow from subsidized increase of uneconomic energy demand.



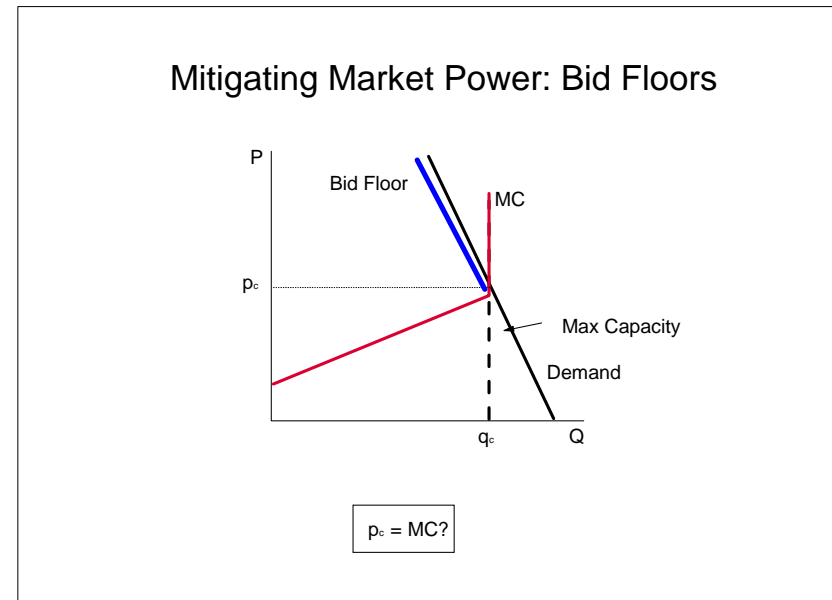
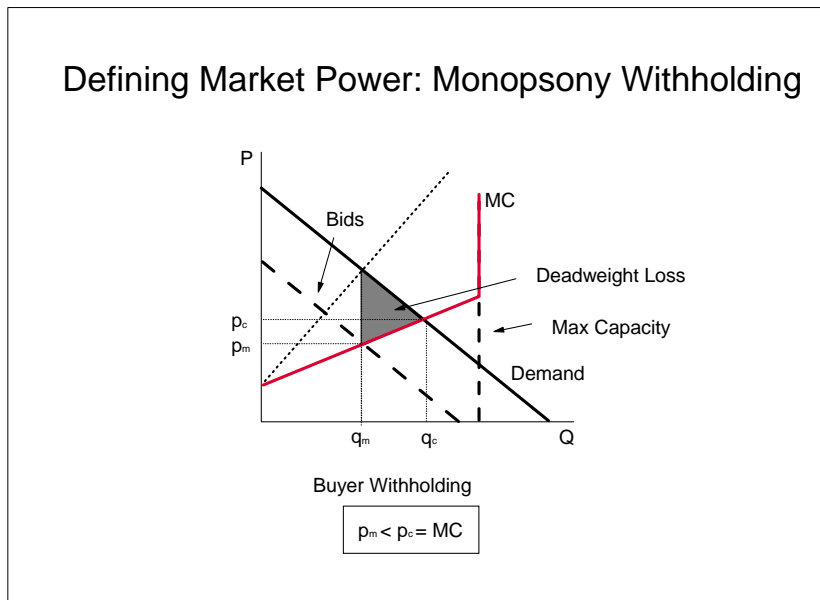
Operating condition solution: Offer caps.

Investment impact solution: Plant Retirement Auctions.

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Buyer-Side Market Power

The symmetric problem arises in principle from buyer-side market power. The standard argument for economic or physical withholding of demand is that it lowers market prices and a customer with other loads can profit from the manipulation of prices. The result is inefficient operations, rent transfers, and a welfare loss. The same effect would follow from subsidized increase of uneconomic energy supply.



Operating condition solution: Bid floors?

Investment impact solution: “Untethered” generation investments?

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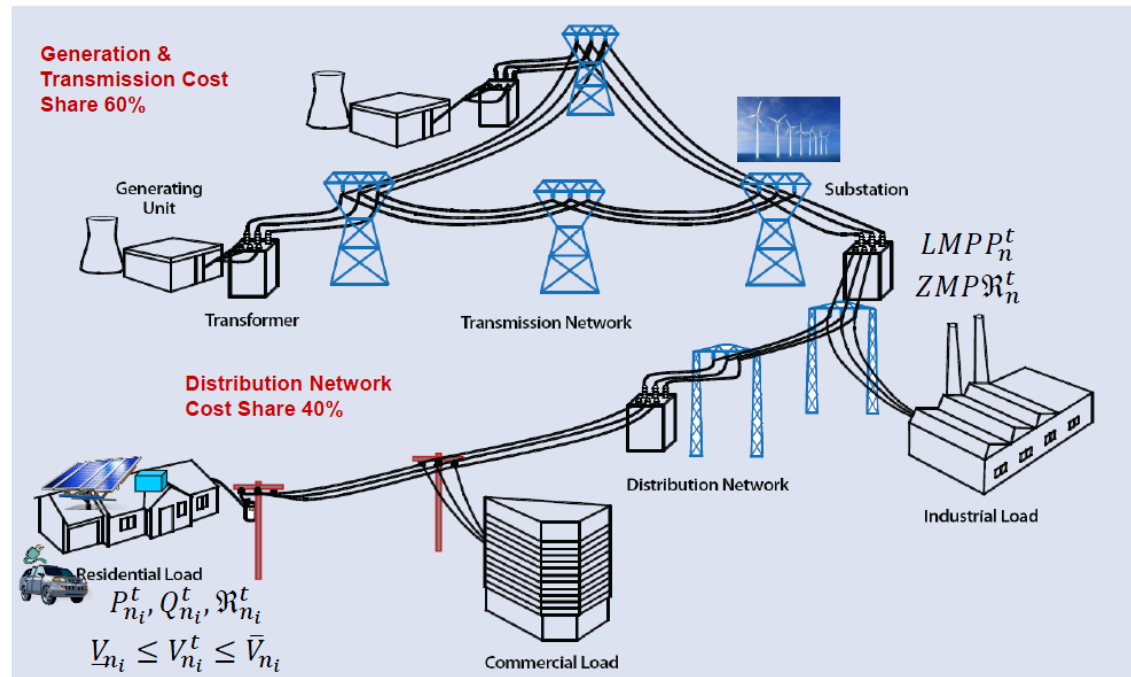
Distributed Energy Resources

The integration of flexible distributed energy resources presents challenges and opportunities for “Reforming the Energy Vision.”

“Drawing from an exhaustive analysis of trends in technology, markets, and environmental policy, the Commission has concluded that its core statutory duties can no longer be met with the utility regulatory model of the previous century. ... The ratemaking changes adopted in this order add to other actions taken by the State and by this Commission under REV to enable the growth of a retail market and a modernized power system that is increasingly clean, efficient, transactive and adaptable to integrating and optimizing resources in front of and behind the meter.” (New York Public Utilities Commission, 2016)

“Choose the core electric products to be transacted on the financial digital platform. The paper presents a rationale for choosing real energy (real power), reactive power, and reserves.” (Tabors, Parker, Centolella, & Caramanis, 2016)

Incurring Cost Distribution, Congestion, Reserves, Voltage Control, Losses, Transformers, Deliverability



$LMPP_n^t = \Pi_n^{E,t}$ = Locational Marginal Price of Real Power at bus n , during hour t

$ZMP_{\mathcal{R}_n}^t = \Pi_n^{\mathcal{R},t}$ = Locational Zonal Price of Reserves at bus $n \in \text{zone } Z$, during hour t

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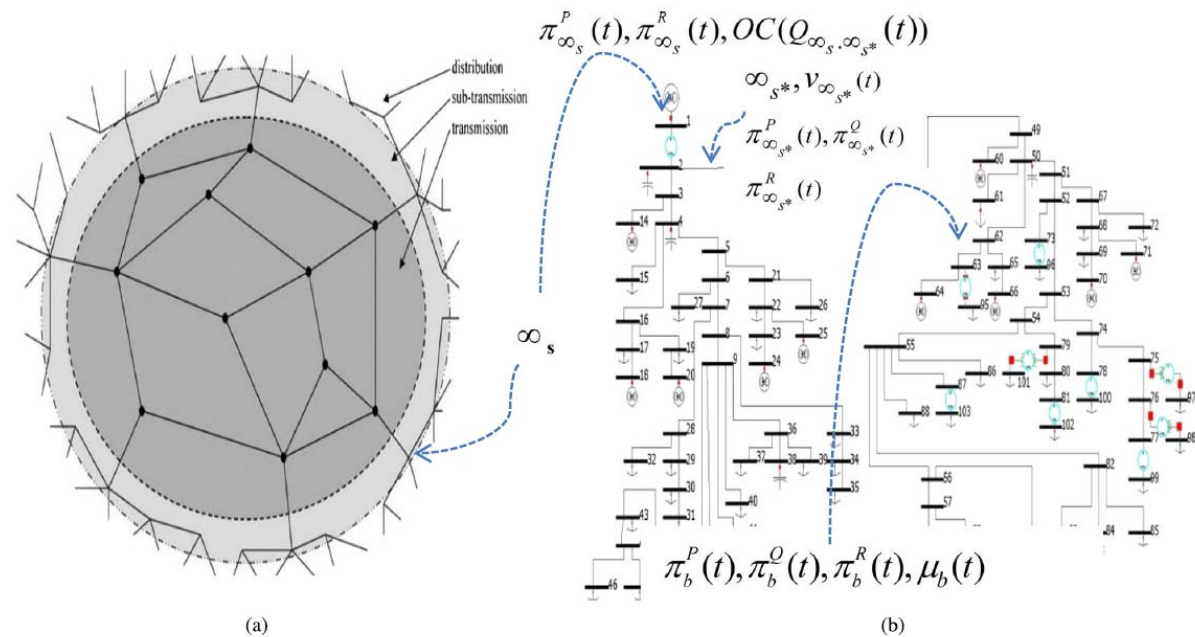
Distributed Energy Resources

Extension of the “transactive” market to the distribution system moves from thousands of location on the (a) high voltage grid to millions of locations and devices that must coordinate on (b) the lower voltage distribution system. (Caramanis, Ntakou, Hogan, Chakraborty, & Schoene, 2016)

Transmission

Distribution

The prices expand from treating real power and reserves to include the important reactive power effects. In principle, the numbers of prices, quantities and constraints expand by several orders of magnitude.



A computational challenge for tomorrow: “This paper presents a distributed, massively parallel architecture that enables tractable transmission and distribution locational marginal price (T&DLMP) discovery along with optimal scheduling of centralized generation, decentralized conventional and flexible loads, and distributed energy resources (DERs). ...[an] architecture intended to realize Fred Schweppe’s 1978 visionary “power systems 2000 ...”.

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