ELECTRICITY MARKETS AND THE CLEAN POWER PLAN

William W. Hogan

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

Energy Bar Association

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The proposed standards for carbon emission raise a number of issues.

- The scale and challenge of the climate problem.
- The costs of clean energy technologies.
- The framework for climate policy.
- The constraints of law and current public policy.
- The structure of the proposed rules under the Clean Power Plan.
- The unintended consequences of interactions with electricity markets.

The scale of the climate problem is enormous. Obtaining cooperation across sectors and countries will require transforming the energy system. The costs of this change present a first-order issue in developing the policy. One argument implies that the costs will be minimal.

> “In remarks on Twitter, Obama said: “This study [“Better Growth, Better Climate”] concludes that no one has to choose between fighting climate change and growing the economy.” (Barak Obama, September 16, 2014.)

> “This report [“Better Growth, Better Climate”] argues for a new model where economic growth and climate action are mutually reinforcing – and it shows how we can build it. There is no time to lose." (Ban Ki Moon, September 16, 2014.)

> "It doesn't cost more to deal with climate change; it costs more to ignore it ... and we need to make that clear to people in this country," Kerry told reporters. (John Kerry, New York, September 23, 2014.)

(Global Commission on the Economy and Climate. (2014). “Better Growth, Better Climate.” Retrieved from http://newclimateeconomy.report/)

An alternative argument is that the costs will be significant but worth it.

"I am very well aware that these are not easy choices for any country to make – I know that. I've been in politics for a while. I know the pull and different powerful political forces. Coal and oil are currently cheap ways to power a society, at least in the near term." (John Kerry, Jakarata, February 16, 2014.)

"Doing what is necessary to achieve the United Nations' target for reducing emissions would reduce economic growth by about 0.06 percent annually from now through 2100, according to the I.P.C.C. That sounds trivial, but by the end of the century it means a 5 percent loss of worldwide economic activity per year.

"And this cost projection assumes optimal conditions — the immediate implementation of a common global price or tax on carbon dioxide emissions, a significant expansion of nuclear power and the advent and wide use of new, low-cost technologies to control emissions and provide cleaner sources of energy.

"If the new technologies we hope will be available aren't, like one that would enable the capture and storage of carbon emissions from power plants, the cost estimates more than double." (Robert Stavins, NYT, Sep. 20, 2014.)

A central debate focuses on policies to deploy clean renewable energy technologies. The German *Enrgiewende* is the poster child for this discussion.

" … proponents [of Germany's *Energiewende*] highlight the dynamic success of the policy in spurring an increase in renewable energy from 6 percent of total electricity supply in 2000 to 23 percent in 2012.5 This increase in renewable energy in electricity generation has created additional environmental, economic, and security benefits. Renewable energy in the electricity sector is estimated to have saved Germany €11 billion from 2009 to 2012 in fossil fuel imports and avoided 101 million tonnes of GHG emissions in 2012 alone.

… Moreover, the government and other supporters view the *Energiewende* as a model for other countries, even suggesting that the fate of the global battle to combat climate change hinges on Germany's success." (Ebinger, C., Banks, J. P., & Schackmann, A. (2014). *Transforming the Electricity Portfolio: Lessons from Germany and Japan in Deploying Renewable Energy*. Energy Security Initiative, Brookings Institution.)

"In Germany, a system of subsidies has supported and encouraged the rapid expansion of renewable energy production. On the whole, these well-intentioned laws have proved to be an extraordinarily wasteful means of supporting improvements in environmental quality and reducing greenhouse gas emissions." (Morey, M., & Kirsch, L. (2014). Germany's Renewable Energy Experiment: A Made-to-Order Catastrophe. *The Electricity Journal*, 27(5), 6–20.)

The costs of clean technologies are high, but declining. Success stimulating the development of less expensive will be crucial in achieving the climate goals.

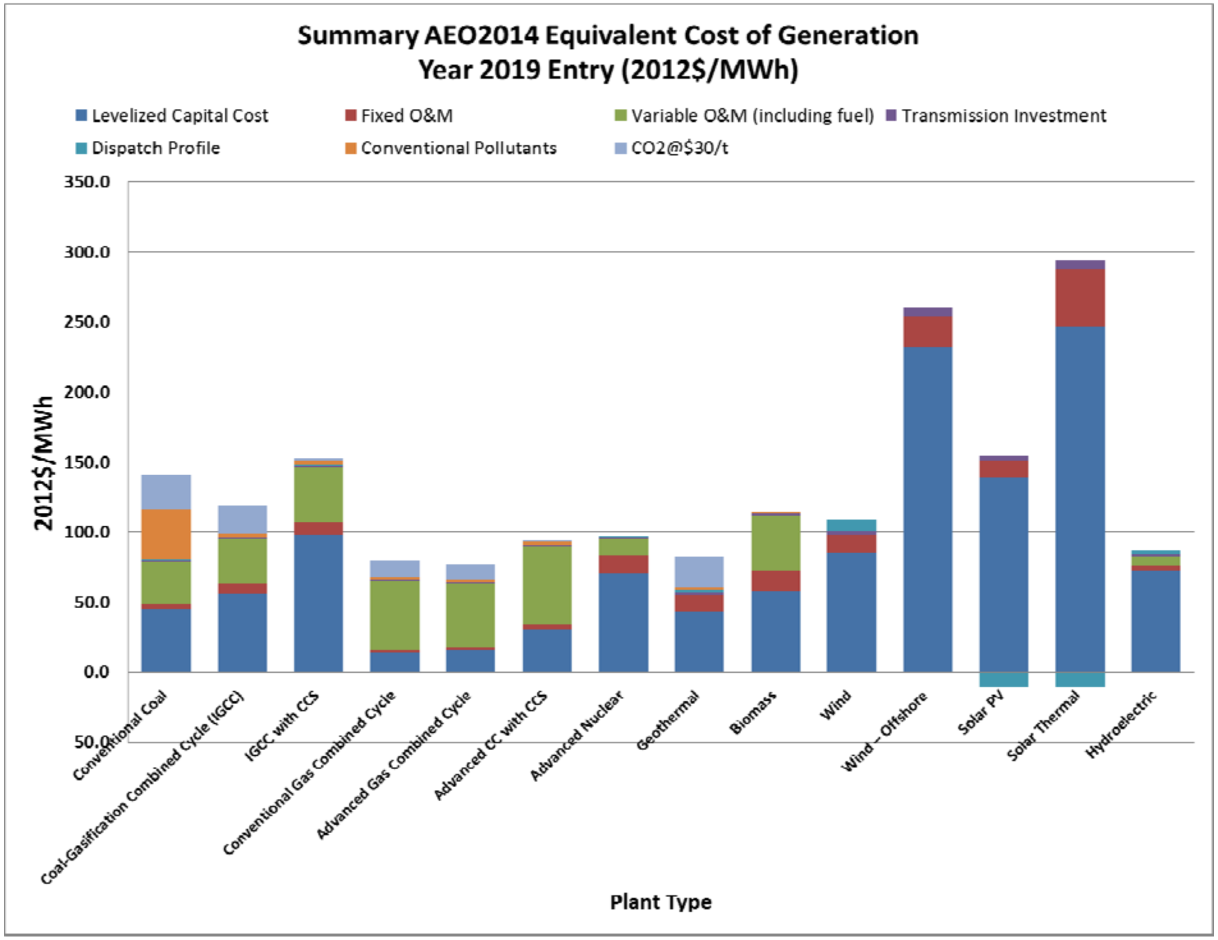
- **RE<C.** The earlier mantra from Google, where renewable energy (RE) is cheaper than coal (C). This would make adoption of renewables an easy choice even without considering the environmental benefits.

- **RE<C+Carbon Price.** The economic welfare outcome that internalizes the carbon externality. Renewable energy is expensive, but it is worth it. Climate policy includes a mix of mitigation and adaptation.

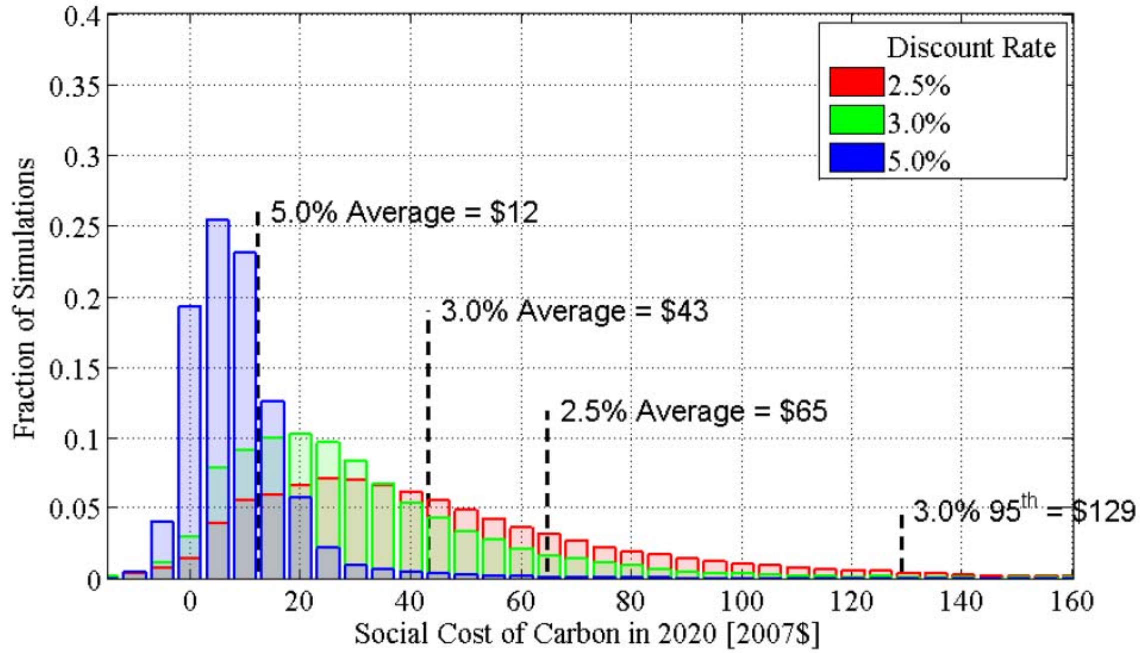
- **RE>C+Carbon Price.** Renewable energy is too expensive, and climate policy leans heavily towards adaptation.

It is important to know where we are and where we are going. The policy prescription depends on the diagnosis. How and how much should we be supporting the development of clean energy technologies?

A starting point is an assessment of the current costs of competing energy supply technologies. The levelized cost of energy (LCOE) provides one benchmark. This is an apples-to-apples comparison based on the assumptions and input data for the United States as developed by the Energy Information Administration. (Energy Information Administration, 2014)



Although there is significant uncertainty, the estimates from the U.S. government imply a substantial social cost of carbon dioxide ($/ton CO2) that is not internalized in the market.



Regulatory Impact Analysis - Under Executive Interagency Working Group on Social Cost of Carbon. (2013). Technical Update of the Social Cost of Carbon for Order 12866, p. 14.

The EPA Clean Power Plan seeks to apply a carbon policy within the framework of Clean Air Act authority applied to existing fossil fuel electricity generation.

The clean energy agenda seeks to reduce greenhouse gas emissions. A framework for evaluating regulation of greenhouse gases would reflect the nature of the problem. A carbon tax would provide the benchmark for evaluation.

- **Theory**
  - Global impacts.
  - Balance of costs and global benefits.
  - Marginal benefits match marginal costs.
  - Non-discriminatory: Equate marginal impacts across technologies and sectors.

- **Practice**
  - Regional perspectives.
  - Quantitative targets.
  - State implementation of inconsistent rules.
  - Command and control framework discriminates across technologies and vintages.

The Supreme Court rejected the argument that greenhouse gases were not pollutants as defined in the Clean Air Act (CAA), and in 2009 EPA came forward with its endangerment finding that required regulation of greenhouse gas emissions.

- **The Court decision settled the jurisdictional question as a legal matter.**
- **Debates continue over the merits of the resulting regulations.**
  - The “Tailoring Rule” defers addressing many sources. “The rule establishes a schedule that will initially focus CAA permitting programs on the largest sources with the most CAA permitting experience. … The CAA permitting program emissions thresholds for criteria pollutants such as lead, sulfur dioxide and nitrogen dioxide, are 100 and 250 tons per year (tpy). While these thresholds are appropriate for criteria pollutants, they are not feasible for GHGs because GHGs are emitted in much higher volumes. … Without this tailoring rule, the lower emissions thresholds would take effect automatically for GHGs on January 2, 2011. PSD and title V requirements at these thresholds would lead to dramatic increases in the number of required permits —tens of thousands of PSD permits and millions of title V permits. State, local, and tribal permitting authorities would be overwhelmed and the programs’ abilities to manage air quality would be severely impaired.” (Enviornmental Protection Agency, 2010)
  - Different authorities apply to mobile sources, new stationary sources and existing stationary sources. Some authority allows for federal implementation, and others require state implementation plans.

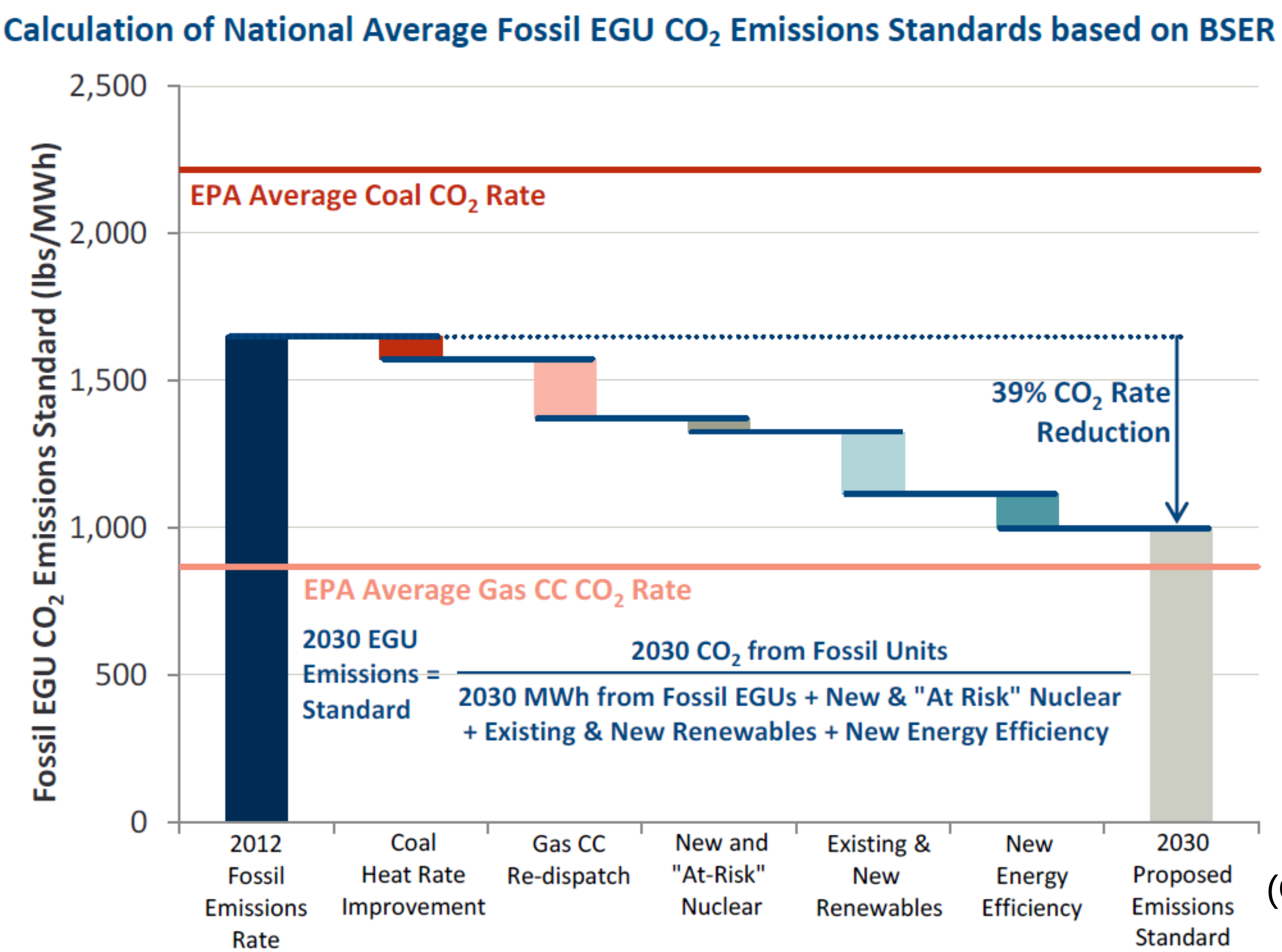
The Environmental Protection Agency proposed different standards for new and existing stationary sources. The final rule scheduled for "Summer 2015."

"The Clean Air Act lays out distinct approaches for addressing new and existing sources under Section 111: a federal program for new sources and state programs for existing sources.

- Section 111 (b) is the federal program to address new, modified and reconstructed sources by establishing standards of performance.
  - EPA is proposing two standards for natural gas-fired stationary combustion units, depending on size. … 1,000 lb CO_2/MWh-gross for larger units, 1,100 lb CO_2/MWh-gross for smaller units.
  - New natural gas-fired stationary combustion turbines can meet the proposed standard without the need for add-on control technology.
  - The proposed limits for fossil fuel-fired utility boilers and IGCC units are based on the performance of a new efficient coal unit implementing partial carbon capture and storage (CCS).
  - These limits require capture of only a portion of the CO_2 from the new unit. … 1,100 lb CO_2/MWh-gross over a 12-operating month period, or 1,000-1,050 lb CO_2/MWh-gross over an 84-operating month (7-year) period
- Section 111 (d) is a state-based program for existing sources. EPA establishes guidelines. States then design programs to fit their particular mix of sources and policies and get the needed reductions."

(Enviornmental Protection Agency, 2015)

EPA's Clean Power Plan (CPP) under Sec 111(d) envisions four building blocks, including changing the dispatch of Electricity Generating Units (EGUs). There is confusion about what this means. So far, the CPP is not a plan—it is a proposed rule for setting standards.



(Chang, 2014)

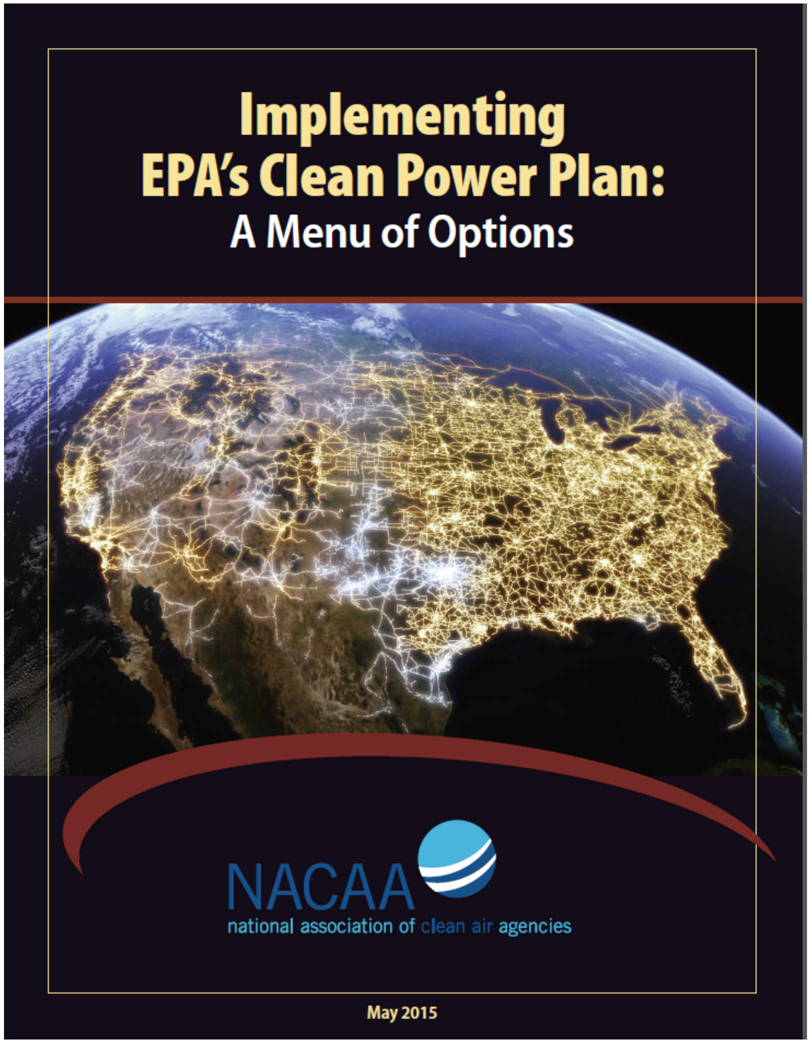
EPA's Clean Power Plan sets forth a complicated mix of clean energy initiatives.

$$\text{2030 EGU Emissions Standard} = \frac{\text{2030 } CO_2 \text{ from Fossil Units}}{\text{2030 MWh from Fossil EGUs + New \& "At Risk" Nuclear + Existing \& New Renewables + New Energy Efficiency}}$$

(Chang, 2014)

- The standard includes measurable observables (fossil outputs, renewables) and unobservables that must be estimated from a counterfactual (new energy efficiency).
- The proposed rule treats old and new differently (nuclear and efficiency).
- The proposed rule allows for mass-based and rate-based standards. These are not the same and have different incentive effects.
- The proposed rule is applied differently for each state, undermining cooperation.
- The call for flexibility is not matched with incentives to make efficient choices.
- The state-based authority under Section 111(d) and concerns about "inside the fence" (fossil plant emissions) versus "outside the fence" (everything else) appear to drive the unusual structure.

A study by the National Association of Clean Air Agencies addressed options for implementation.



The 465 page study by the National Association of Clean Air Agencies described 26 categories of implementation options. (National Association of Clean Air Agencies, 2015)

Optimize Power Plant Operations	Implement Combined Heat and Power in the Electric Sector
Implement Combined Heat and Power in Other Sectors	Improve Coal Quality
Optimize Grid Operations	Increase Generation from Low-Emission Resources
Pursue Carbon Capture and Utilization or Sequestration	Retire Aging Power Plants
Switch Fuels at Existing Power Plants	Reduce Losses in the Transmission and Distribution System
Establish Energy Savings Targets for Utilities	Foster New Markets for Energy Efficiency
Pursue Behavioral Efficiency Programs	Boost Appliance Efficiency Standards
Boost Building Energy Codes	Increase Clean Energy Procurement Requirements
Encourage Clean Distributed Generation	Revise Transmission Pricing and Access Policies
Revise Capacity Market Practices and Policies	Improve Integration of Renewables into the Grid
Change the Dispatch Order of Power Plants	Improve Utility Resource Planning Practices
Improve Demand Response Policies and Programs	Adopt Market-Based Emissions Reduction Programs
Tax Carbon Dioxide Emissions	Consider Emerging Technologies and Other Important Policies

EPA's Clean Power Plan (CPP) under Sec 111(d) envisions four building blocks, including changing the dispatch of Electricity Generating Units (EGUs). There is confusion about what this means.

"Overall, the BSER proposed here is based on a range of measures that fall into four main categories, or ''building blocks,'' which comprise improved operations at EGUs, dispatching lower-emitting EGUs and zero-emitting energy sources, and end use energy efficiency."

Environmental Protection Agency, "Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units; Proposed Rule," 40 CFR Part 60, June 18, 2014, p. 34835.

"Environmental dispatch is a policy in which the system operator explicitly considers environmental criteria (primarily air pollution emissions) when making dispatch decisions, even if the environmental impacts do not lead to an actual regulatory compliance cost." (National Association of Clean Air Agencies, 2015, p. ES-7)

How does EPA address the matter of environmental dispatch?

The Clean Power Plan analysis utilizes EPA's "Integrated Planning Model (IPM) … a multi-regional, dynamic, deterministic linear programming model of the U.S. electric power sector. It provides forecasts of least cost capacity expansion, electricity dispatch, and emission control strategies while meeting energy demand and environmental, transmission, dispatch, and reliability constraints." This is a zonal model built on load duration curves and inter-zonal transmission limits. IPM cannot replicate the impact of transmission constraints in actual dispatch operations. (http://www.epa.gov/airmarkt/progsregs/epa-ipm/BaseCasev513.html)

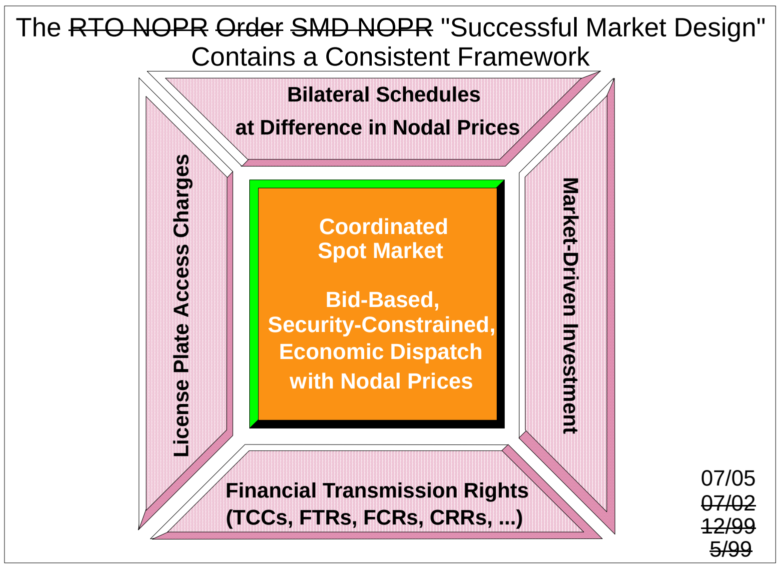
"EPA recognizes that the word "dispatch" can be used to describe how balancing authorities conduct real-time selection of specific generation (supply) to meet load (demand), on an hourly or even 15-minute basis. In the context of the proposed CPP and in this [Technical Support Document], the word "dispatch" is intended to refer to broader patterns of generation across different generating technologies over longer periods of time, in keeping with the compliance flexibilities afforded under this rule (e.g., where emission performance can be averaged over multiple years)."

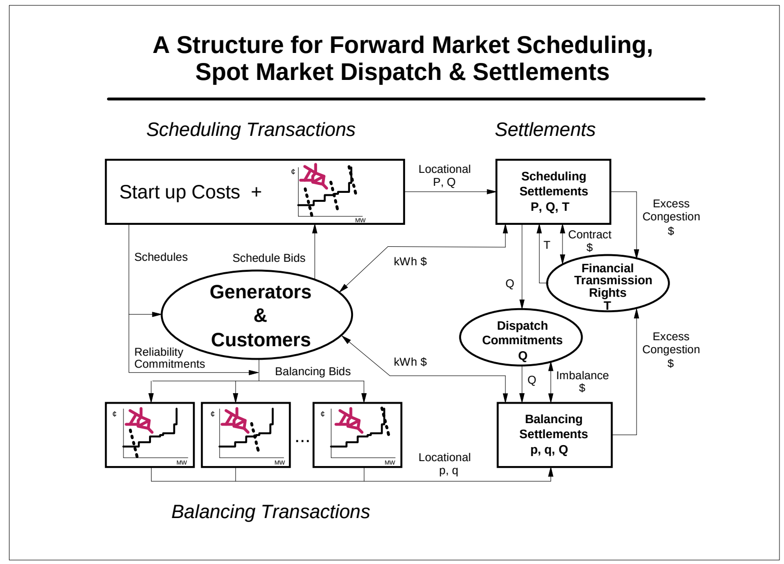
U.S. Environmental Protection Agency, Office of Air and Radiation, "Translation of the Clean Power Plan Emission Rate-Based CO2 Goals to Mass-Based Equivalents," Technical Support Document (TSD) for Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units, Docket ID No. EPA-HQ-OAR-2013-0602, November 2014, footnote 6.

What does all this mean? Why does it matter?

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.

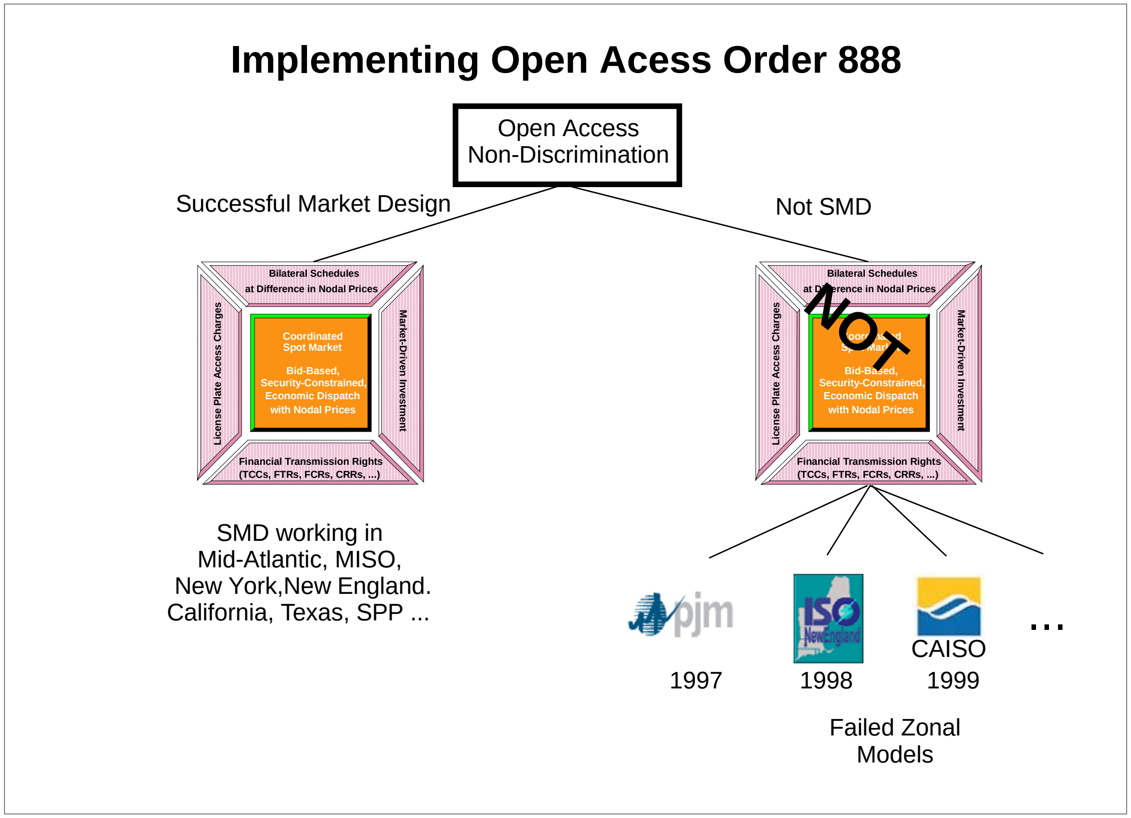
> "Locational marginal pricing (LMP) is the electricity spot pricing model that serves as the benchmark for market design – the textbook ideal that should be the target for policy makers. A trading arrangement based on LMP takes all relevant generation and transmission costs appropriately into account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





ELECTRICITY MARKET A Consistent Framework

Why is this important? The basic structure of the organized electricity markets depends on the successful market design framework of economic dispatch and financial transmission rights.



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.

Mechanisms that put a price on carbon will change the environmental footprint of economic dispatch.

- **Carbon Tax.** The most direct means. The tax becomes part of the marginal cost for carbon emitting plants. There is a seamless integration with short-run economic dispatch.
- **Cap and Trade.** An indirect approach. If the cap and trade system allows for banking and borrowing over any reasonably extended period, the current price of permits operates like a carbon tax. There can be a seamless integration with economic dispatch.
    - **Regional Greenhouse Gas Initiative (RGGI).**
    - **CARB and CAISO-Pacificorp Energy Imbalance Market.**

EPA acknowledges the importance of pricing carbon: "… there are a number of different ways that states can design programs that achieve required reductions while working within existing market mechanisms used to dispatch power effectively in the short term and to ensure adequate capacity in the long term. These programs and programs for conventional pollutants, such as the Acid Rain Program under Title IV of the CAA, have ***demonstrated that compliance with environmental programs can be monetized*** such that it is factored into power sector economic decision making in ways that reduce the cost of controlling pollution, maintain electricity system reliability and work within the ***least cost dispatching principles that are key to operation of our electric power grid*****.** The proposal would also allow states to work together with individual companies on potential specific challenges. These and other flexibilities are discussed further in Section VIII of the preamble."

Environmental Protection Agency, "Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units; Proposed Rule," 40 CFR Part 60, June 18, 2014, p. 34834. (emphasis added)

Pricing carbon is the only way to maintain integrity of the electricity market design. Failure to acknowledge this reality can lead to mistaken or unintended consequences. The EPA Clean Power Plan analysis proceeds as though economic dispatch is not central to the market.

"Based on the analytic approach summarized above, the EPA has identified the following four principal categories—''building blocks''—of measures that provide the foundation of our BSER determination for CO2 emissions from existing EGUs:

1. Reducing the carbon intensity of generation at individual affected EGUs through heat rate improvements.

2. Reducing emissions from the most carbon-intensive affected EGUs in the amount that results from substituting generation at those EGUs with generation from less carbon-intensive affected EGUs (including NGCC units under construction).

3. Reducing emissions from affected EGUs in the amount that results from substituting generation at those EGUs with expanded low- or zero-carbon generation.

4. Reducing emissions from affected EGUs in the amount that results from the use of demand-side energy efficiency that reduces the amount of generation required."

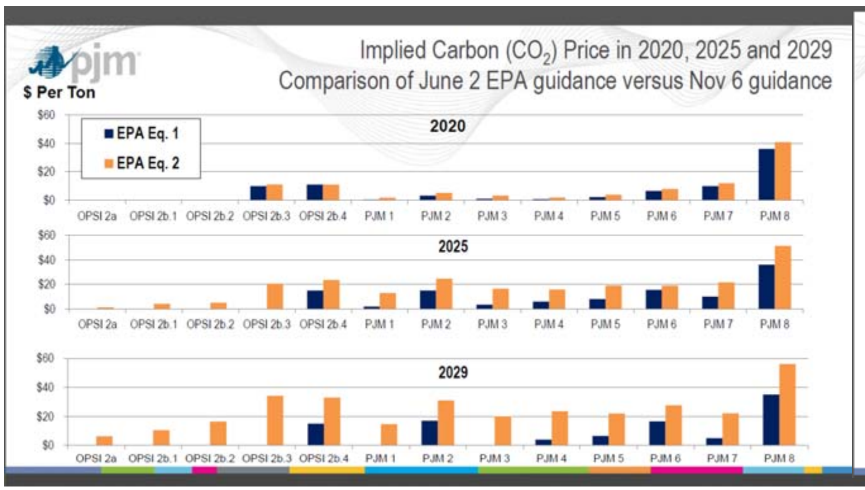
Environmental Protection Agency, "Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units; Proposed Rule," 40 CFR Part 60, June 18, 2014, p. 34858.

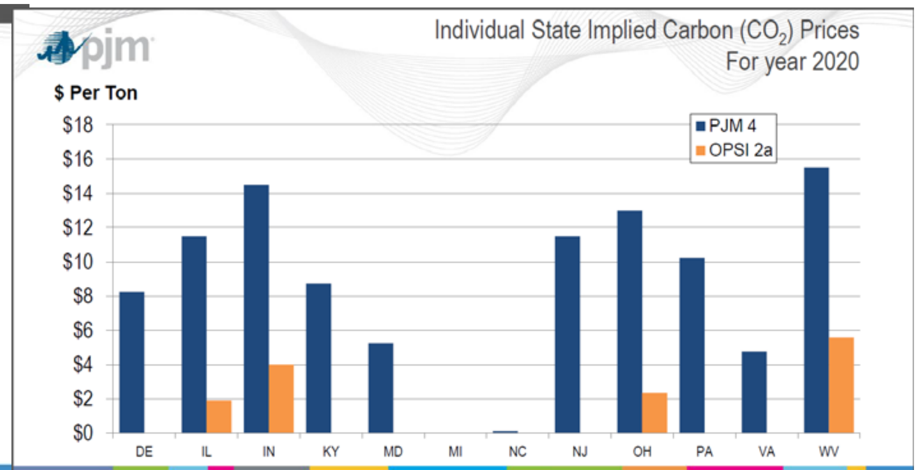
Yet, real dispatch results may be different.

- **Improved efficiency for coal plants can result in more CO2 emissions.** (EPA p.34882)
- **Increased use of gas may substitute for other renewables or nuclear.**
- **New renewable plants may substitute for other renewables or nuclear.**
- **Energy efficiency can interact with grid congestion to cause higher CO2 emissions.**

The PJM analysis of the Clean Power Plan confirms both the importance of pricing carbon and the surprising results of actual dispatch testing.

- **PJM modeled everything by using a price on carbon.** The analysis included coordinated regional solutions and individual state solutions.
- **The result is uncertainty about the implied price of carbon.** The uncertainty is not related to the long-run climate factors driving uncertainty for the social cost of carbon.





Sotkiewicz, Paul and Muhsin Abdur-Rahman, "EPA's Clean Power Plan Proposal Review of PJM Analyses Preliminary Results," November 17, 2014, p.26, 36.

With a well-designed carbon policy, all the options would produce the same price of carbon. These disparities signal trouble in electricity markets.

The proposed Clean Power Plan emphasizes the flexibility allowed in state implementation plans. There is much less attention to the incentives to exploit this flexibility towards an efficient outcome.

The conclusion of an important investigation of the incentives of the proposed rule finds important unintended consequences:

"There are many contexts in which environmental regulation and trade can interact to under-mine the efficiency of both. The EPA's Clean Power Plan is a clear and timely example of these interactions. The CPP proposes major reductions in carbon emissions from generators of electricity, a good that is perfectly substitutable across neighboring states. The CPP establishes state-level targets for carbon emissions rates in lbs of carbon dioxide per megawatt hour of electricity generated. … We find lack of coordination, when states independently pursue their own emissions targets without regard to electricity trading partners, leads to large inefficiencies. For example under state-specific caps, average abatement costs are nearly 25% higher than under a uniform mass-based standard. Under state-specific rate based targets, average abatement costs can nearly double relative to a uniform mass-based standard. Regional cooperation does little to mitigate these concerns. When two regions of the west coordinate internally, but adopt different instruments, average abatement costs remain 20-30% higher than costs under a uniform mass-based standard. Unfortunately, we find generator incentives do not favor coordination and may lead to adoption of less efficient mixed policies.

Overall, our findings indicate that despite the opportunities the CPP provides for states to coordinate and implement compliance plans that can efficiently achieve their joint targets, the incentives of individual states to participate in those plans are conflicted. Indeed, there can easily be circumstances when states find it in their own interest to adopt a regulatory approach that is contrary to those of its neighbors." (Bushnell et al., 2014)

The EPA analysis implicitly assumes that there is one-for-one substitution between green energy and fossil fuels. This is not true.

> "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 CO_2 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)

Why is this important? The Clean Power Plan embeds contradictions of the Clean Air Act, carbon policy, and a collision with electricity market design.

- Wholesale power markets depend on the economic dispatch framework.
- Monetizing carbon is the key to meshing environmental goals and electricity market design.
- National carbon policy rejects a carbon tax (so far).
- EPAs Clean Power Plan does not require monetizing carbon.
- The Clean Power Plan proceeds with CAA supported rate-based standards and new ad hoc “building blocks” that are only loosely connected to the underlying social cost of carbon or the workings of electricity markets.

Will state implementation plans thread the needle to meet environmental goals?

Will the necessary electricity market design survive the regulatory gauntlet?

Will environmental dispatch implementation create perverse outcomes and arbitrage opportunities?

Will the future be the RGGI or CARB-CAISO-Pacificorp models, meshing carbon pricing and economic dispatch? Or will the future repeat the fiasco of the California-Enron electricity market design that prohibited economic dispatch?

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APPENDIX

The case for the success of the German *Enrgiewende* emphasizes the reduction in costs for future deployment rather than the immediate environmental benefits.

> "The German (and Spanish, and several U.S. states) commitments to solar in the early, expensive years were not simply to purchase zero-carbon energy: **Their main point was to drive down the price, so that there would be vast amounts of clean energy available at a reasonable price in the future.** Looking back at the Energiewende, the proper question is not whether the initial tranche of renewable energy was cost-competitive with other technologies, but whether the investment drove the price down enough to give the world new, affordable, clean technology options." (emphasis in original) (Hal Harvey. (2013)."A Tale of Two Countries: Renewable Energy in Germany." Energy Innovation LLC.)

A classification of major opportunities for cost reduction pathways focuses on "learning" broadly conceived. The terminology is not fully settled, but the basic ideas have been widely discussed. (Junginger, Sark, & Faaij, 2010)

- **Learning by searching (LBS):** This is R&D broadly writ. The most important features include an intentional and costly effort to develop innovations. Typically the R&D is risky and there are large spillover effects. The goal is to develop the innovation until it is at or near the stage of large scale deployment.
- **Learning by doing (LBD):** Early production produces new information which reduces the cost of future production. Critical characteristics include that LBD learning is passive (Thompson, 2010) and is treated as a free by-product of deployment. There can be significant spillover effects.
- **Learning by using (LBU):** The demand side counterpart for learning by doing. Often not treated separately from learning by doing.
- **Learning by waiting (LBW):** The spillover effects from other industries, technologies or countries are essentially exogenous from the perspective of the firm in the present industry. (Thompson, 2010) The resulting benefits from the innovative technology will appear over time and can be exploited by waiting.

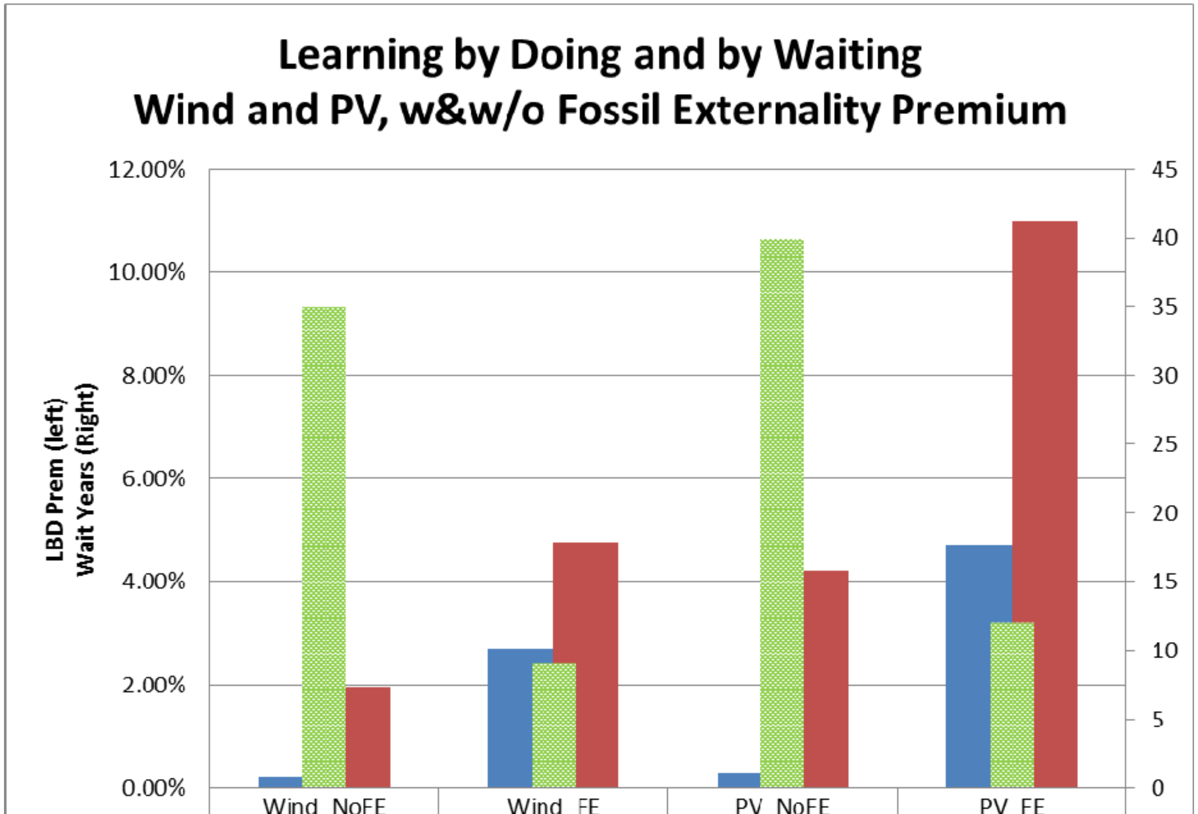
Another pathway often mentioned is important but has different policy implications.

- **Economies of scale:** The standard argument about decreasing unit production costs as production plant reaches an efficient size. In the energy market this is unlikely to be a market-wide phenomenon, i.e. the case of natural monopoly, but may be relevant at the firm level. (Gillingham & Sweeney, 2010) However, "significant economies of scale in any industry, short of creating a natural monopoly, are not generally seen as a basis for government intervention." (Borenstein, 2012) (p. 83)

The alternative cases illustrate the tradeoff between "LBS-LBW", and LBD. The LBD premium is relatively small, especially when compared with the impact of the assumed fossil externalities.

Without a fossil externality price, an assumed 5% rate of exogenous technological change takes a very long time to make the clean technologies competitive. The wait is essentially forever. Hence, the LBD premium is essentially zero. The premium becomes larger in the distant future and reaches its maximum when deployment begins, but the maximum learning premium is still relatively small.

With a fossil externality, it is still optimal to wait. The immediate premium is larger and the optimal waiting period is shorter for the wind type technology. The learning premium is small compared to the benefits of reducing the dirty externality.



	Wind_NoFE	Wind_FE	PV_NoFE	PV_FE
LBDNow	0.21%	2.70%	0.28%	4.71%
LBDMax	1.96%	4.76%	4.22%	11.01%
Wait	35	9	40	12

William W. Hogan is the Raymond Plank Professor of Global Energy Policy, John F. Kennedy School of Government, Harvard University. This paper draws on research for the Harvard Electricity Policy Group and for 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, Atlantic Wind Connection, Australian Gas Light Company, Avista Corporation, Avista Utilities, Avista Energy, Barclays Bank PLC, Brazil Power Exchange Administrator (ASMAE), British National Grid Company, California Independent Energy Producers Association, California Independent System Operator, California Suppliers Group, Calpine Corporation, CAM Energy, Canadian Imperial Bank of Commerce, Centerpoint Energy, Central Maine Power Company, Chubu Electric Power Company, Citigroup, City Power Marketing LLC, Cobalt Capital Management LLC, Comision Reguladora De Energia (CRE, Mexico), Commonwealth Edison Company, COMPETE Coalition, Conectiv, Constellation Energy, Constellation Energy Commodities Group, Constellation Power Source, Coral Power, Credit First Suisse Boston, DC Energy, Detroit Edison Company, Deutsche Bank, Deutsche Bank Energy Trading LLC, Duquesne Light Company, Dyon LLC, Dynegy, Edison Electric Institute, Edison Mission Energy, Electricity Corporation of New Zealand, Electric Power Supply Association, El Paso Electric, Energy Endeavors LP, Exelon, Financial Marketers Coalition, FirstEnergy Corporation, FTI Consulting, GenOn Energy, GPU Inc. (and the Supporting Companies of PJM), GPU PowerNet Pty Ltd., GDF SUEZ Energy Resources NA, Great Bay Energy LLC, GWF Energy, Independent Energy Producers Assn, ISO New England, Koch Energy Trading, Inc., JP Morgan, LECG LLC, Luz del Sur, Maine Public Advocate, Maine Public Utilities Commission, Merrill Lynch, Midwest ISO, Mirant Corporation, MIT Grid Study, Monterey Enterprises LLC, MPS Merchant Services, Inc. (f/k/a Aquila Power Corporation), JP Morgan Ventures Energy Corp., 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 Attorney General, Ontario IMO, Ontario Ministries of Energy and Infrastructure, Pepco, Pinpoint Power, PJM Office of Interconnection, PJM Power Provider (P3) Group, Powerex Corp., Powhatan Energy Fund LLC, PPL Corporation, PPL Montana LLC, PPL EnergyPlus LLC, Public Service Company of Colorado, Public Service Electric & Gas Company, Public Service New Mexico, PSEG Companies, Red Wolf Energy Trading, Reliant Energy, Rhode Island Public Utilities Commission, Round Rock Energy LP, San Diego Gas & Electric Company, Secretaría de Energía (SENER, Mexico), Sempra Energy, SESCO LLC, Shell Energy North America (U.S.) L.P., SPP, Texas Genco, Texas Utilities Co, Tokyo Electric Power Company, Toronto Dominion Bank, Transalta, TransAlta Energy Marketing (California), TransAlta Energy Marketing (U.S.) Inc., Transcanada, TransCanada Energy LTD., TransÉnergie, Transpower of New Zealand, Tucson Electric Power, Twin Cities Power LLC, Vitol Inc., Westbrook Power, Western Power Trading Forum, Williams Energy Group, Wisconsin Electric Power Company, and XO Energy. 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).