

ELECTRICITY MARKET DESIGN And the Green Agenda

William W. Hogan

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

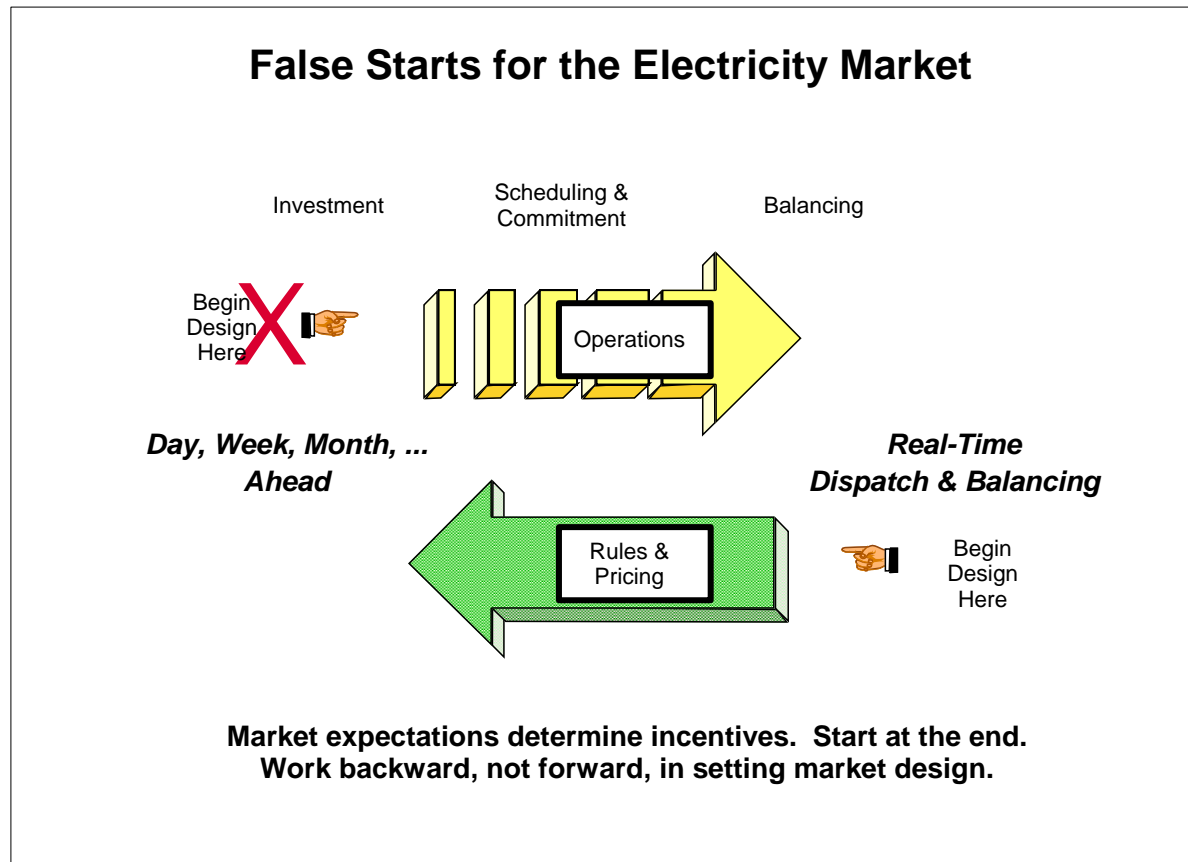
**EPSA Competitive Power Summit
Washington, DC**

March 29, 2022

ELECTRICITY MARKET

Focus on Balancing Markets First

The solution to open access and non-discrimination inherently involves market design. Good design begins with the real-time market and works backward. A common failure mode starts with the forward market, without specifying the rules and prices that would apply in real time.



ELECTRICITY MARKET

Energy Market Design

The U.S. experience illustrates successful market design and remaining challenges for both theory and implementation.

- **Design Principle: Integrate Market Design and System Operations**

Provide good short-run operating incentives.

Support forward markets and long-run investments.

- **Design Framework: Bid-Based, Security Constrained Economic Dispatch**

Locational Marginal Prices (LMP) with granularity to match system operations.

Financial Transmission Rights (FTRs).

- **Design Implementation: Pricing Evolution**

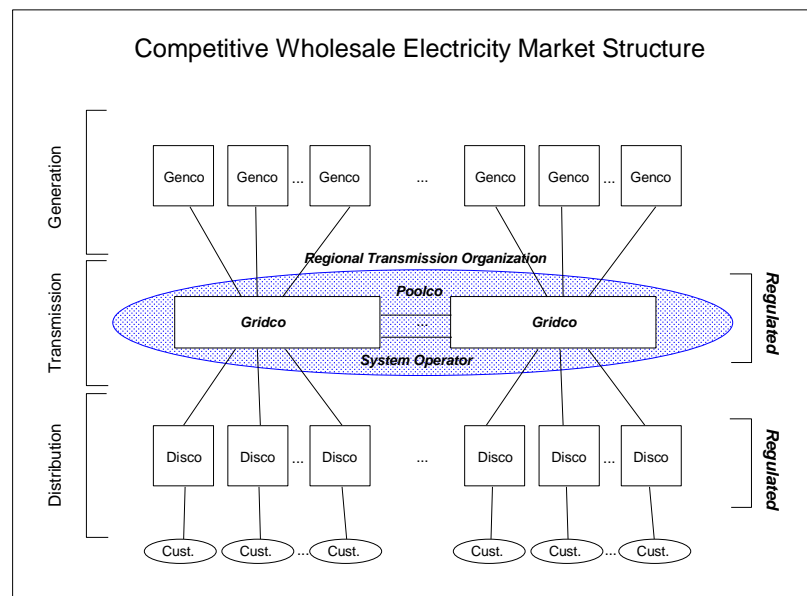
Better scarcity pricing to support resource adequacy.

Unit commitment and lumpy decisions with coordination, bid guarantees and uplift payments.

- **Design Challenge: Infrastructure Investment**

Hybrid models to accommodate both market-based and regulated transmission investments.

Beneficiary-pays principle to support integration with rest of the market design.



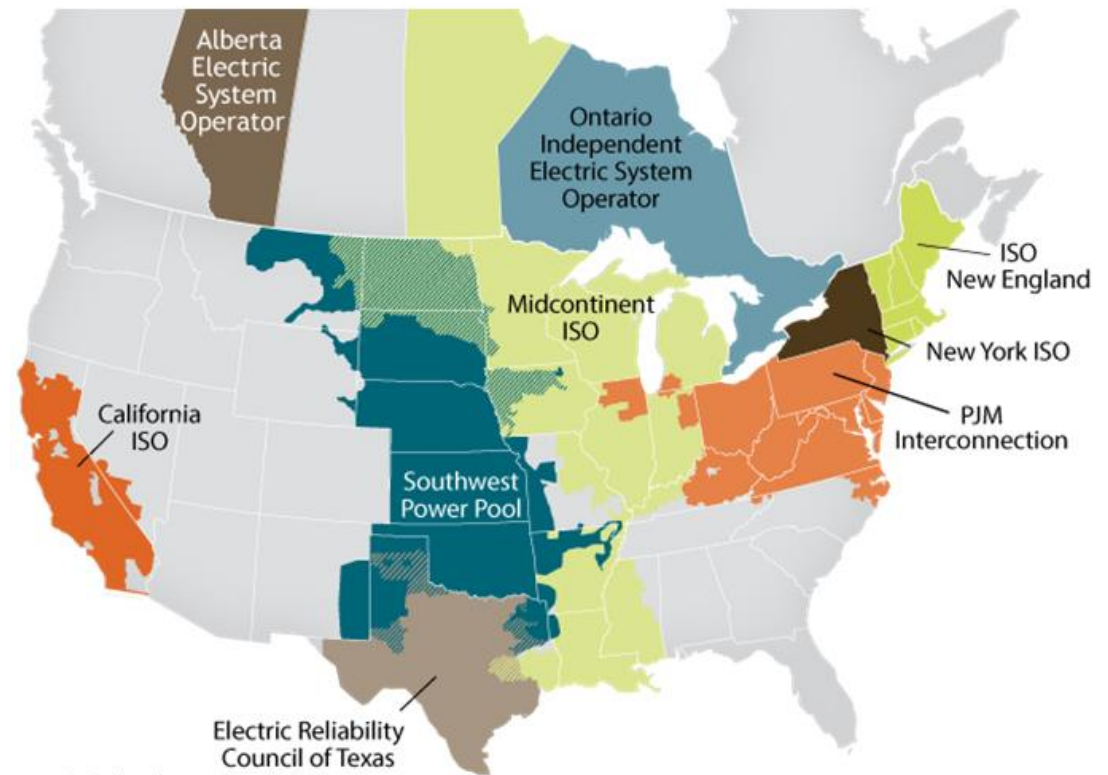
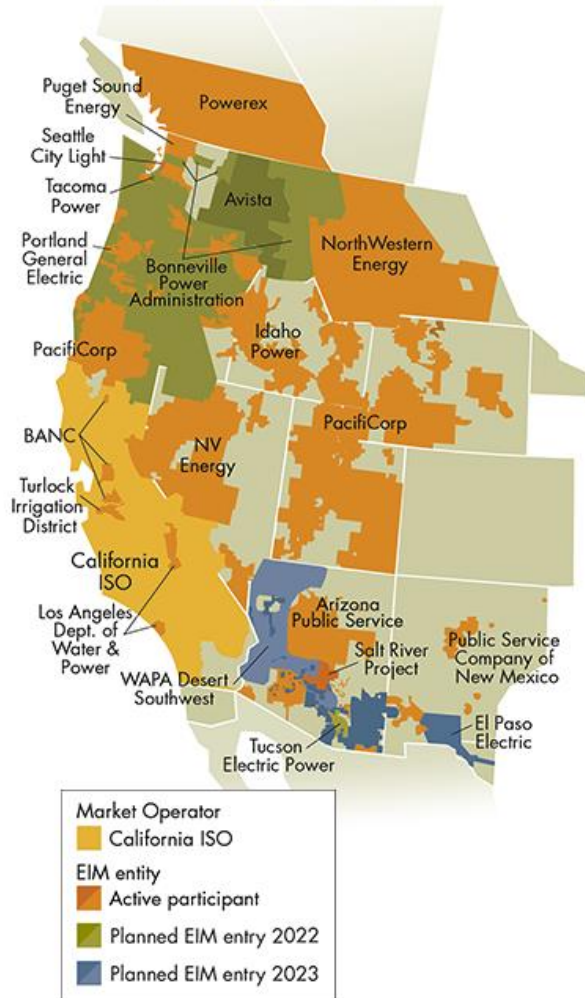
ELECTRICITY MARKET

A Consistent Framework

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

(IRC Council and CAISO maps)

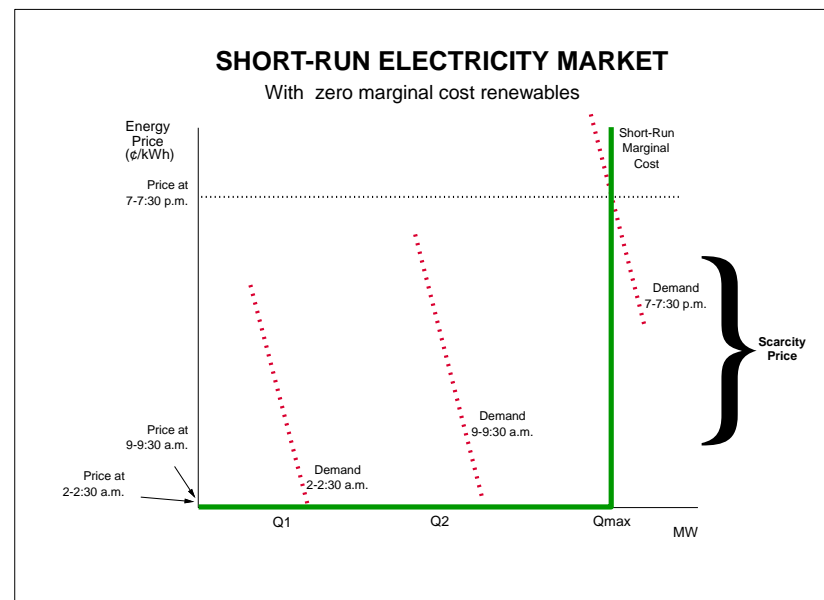
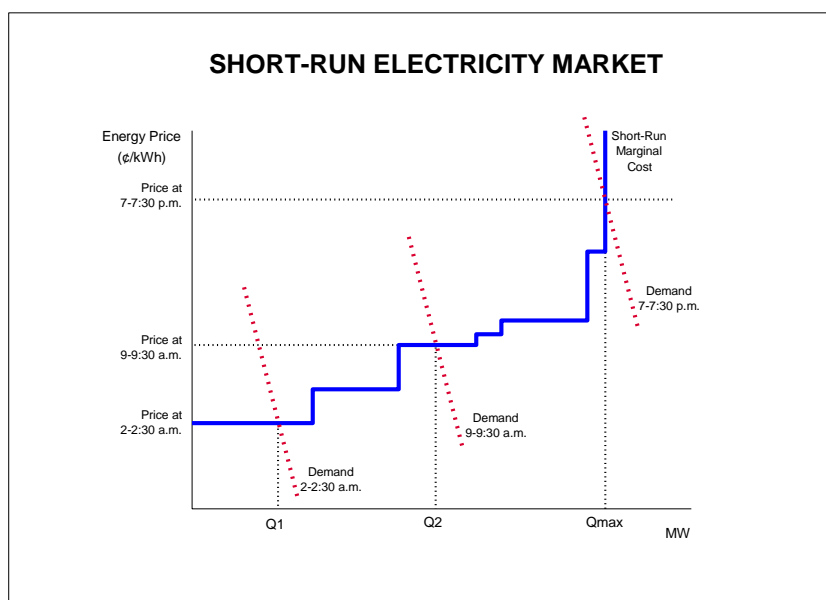
Active and pending participants



ELECTRICITY MARKET

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 thought experiment of a no-carbon/zero-variable-cost, green energy supply reveals that the basic efficiency principles still apply. The same principles apply in an electric network. (Schweppe et al., 1988) **Storage will be important, but does not change the basic design analysis.** (Korpås & Botterud, 2020)



A key feature would be to increase the importance of scarcity pricing. ERCOT adopted an Operating Reserve Demand Curve in 2014. (Hogan, 2013) 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) (PJM Interconnection, 2019) (Federal Energy Regulatory Commission, 2020)

CLIMATE CHANGE

Policy Challenge

The challenges of climate change present a ‘wicked problem’ that is difficult to solve because of incomplete, contradictory, and changing requirements. The scale is global, the duration covers many generations into the future, and the uncertainties can seem overwhelming.

“... global warming is a major threat to humans and the natural world.” (Nordhaus, 2013, p. 3)

“This is the challenge of our collective lifetimes. The existential threat to human existence as we know it. And every day we delay, the cost of inaction increases.” (Biden, 2021)

“Yes, it’s true that the globe is warming, and that humans are exerting a warming influence upon it. But beyond that—to paraphrase the classic movie *The Princess Bride*: ‘I do not think “The Science’ says what you think it says.’” (Koonin, 2021, p. 1)

“The science shows us that fears of a climate apocalypse are unfounded. Global warming is real, but it is not the end of the world. It is a manageable problem.” (Lomborg, 2020)

“The #COP26 is over. Here’s a brief summary: Blah, blah, blah.” (Thunberg, 2021)

“My experience tells me that we need to cool down the rhetoric so that we can understand the underlying issues.” (Nordhaus, 2013, p. 15)

The DICE model and its applications by Nordhaus have long been a focal point of a subset of climate policy debates. (Hogan, 2022)

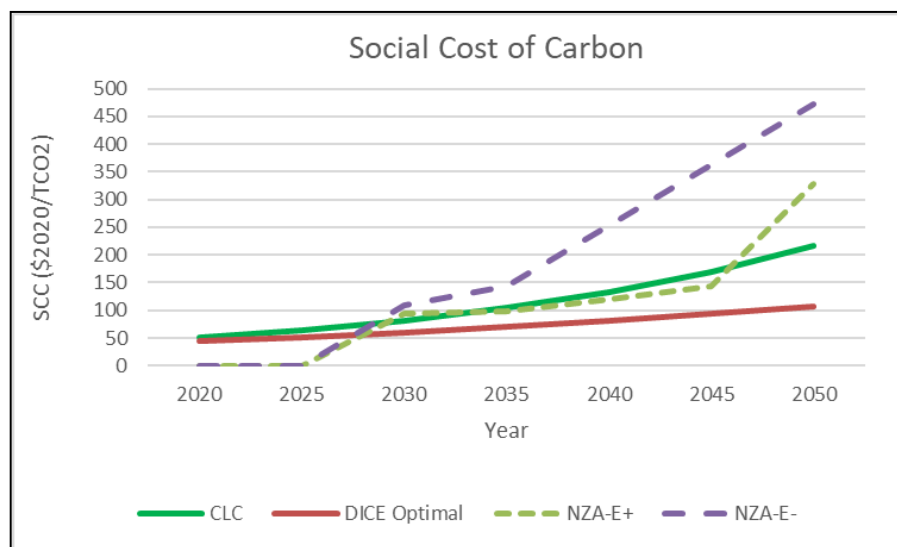
If Nordhaus is right:

- We have delayed, and delayed, and the climate problem is growing.
- Governments are making aspirational promises that they should not, and won't, keep.
- We are doing the wrong things and increasing the costs of mitigation.
- The gaps between the rhetoric and the reality threaten a policy backlash that strikes at the heart of assumed universal participation. This will make everything harder.
- Carbon pricing that incorporates the Social Cost of Carbon is necessary, if we are serious. Critical supplements include innovation support through Research, Development and Demonstration phases (RD&D) with less focus on Deployment (the third "D").
- Adaptation is unavoidable. Research on and a policy for geoengineering are necessary, just in case it is needed.

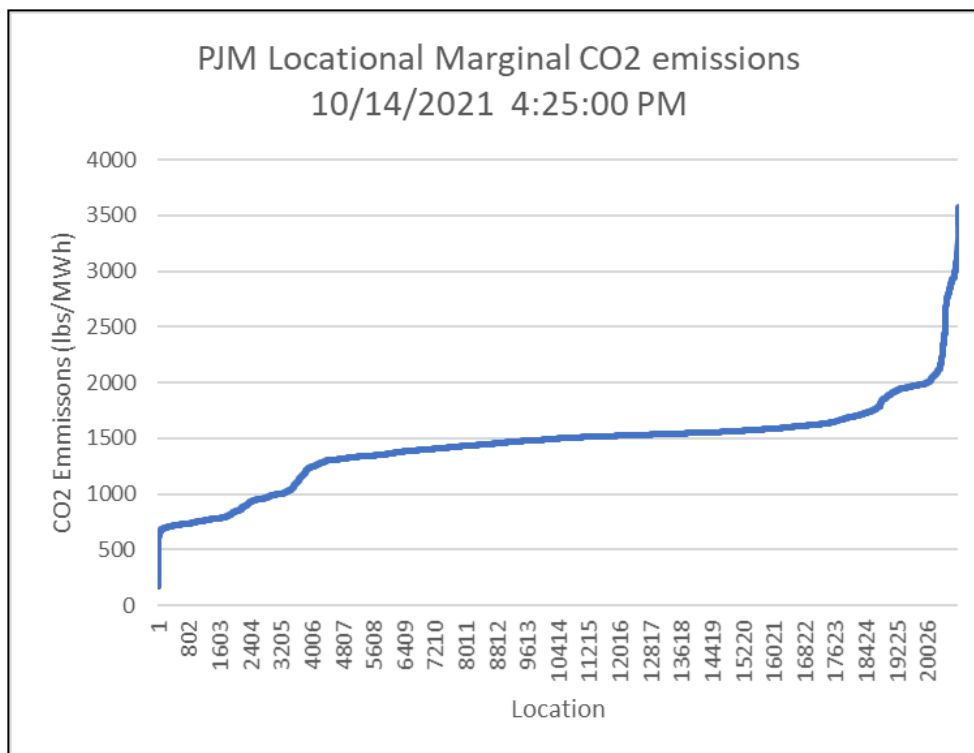
The focus here is on cost-benefit analysis with an emphasis on the Social Cost of Carbon (SCC) and the related implications for emissions, concentrations and temperatures over centuries and the implications for near-term policies.

Overview

- The Science helps identify the challenges and opportunities.
- The Science does not and cannot tell us what to do.
- There are tradeoffs and this points to the need for cost-benefit analysis.
- One guidepost is the Social Cost of Carbon that provides a standard for what to do and how much is enough.
- There are many critical uncertainties.
- A central problem is the continuing debate about discount rates.
- The climate policy choices will interact with everything else, including the design and operation of energy markets.



Heterogeneity in the electrical system implies variability in environmental impacts. At the margin, zero emission resources have different impacts on CO2 emissions. A PJM snapshot of locational marginal emissions (LME) illustrates the challenge.¹



- Matching load and emissions would confront the usual complications of flow on the power system coupled with this LME variability.
- Carbon pricing would address this problem in through economic dispatch and locational prices.

¹ https://dataminer2.pjm.com/feed/fivemin_marginal_emissions/definition

References

- Biden, J. (2021). *Remarks by President Biden at the COP26 Leaders Statement*. White House. <https://www.whitehouse.gov/briefing-room/speeches-remarks/2021/11/01/remarks-by-president-biden-at-the-cop26-leaders-statement/>
- Federal Energy Regulatory Commission. (2020). *Order on Proposed Tariff and Operating Agreement Revisions (PJM Reserve Market Proposal)*, Dockets EL19-00, ER19-1486. <https://www.ferc.gov/whats-new/comm-meet/2020/052120/E-3.pdf>
- Hogan, W. W. (2013). Electricity Scarcity Pricing Through Operating Reserves. *Economics of Energy & Environmental Policy*, 2(2), 65–86. http://www.pserc.cornell.edu/empire/2_2_a04.pdf
- Hogan, W. W. (2022). *CLIMATE POLICY AND THE GREEN AGENDA: Could Nordhaus be Right?* https://scholar.harvard.edu/files/whogan/files/hogan_iaee_green_011722.pdf
- Koonin, S. E. (2021). *Unsettled: What Climate Science Tells Us, What It Doesn't, and Why It Matters*. BenBella Books. <https://www.barnesandnoble.com/w/unsettled-steven-e-koonin/1137483249>
- Korpås, M., & Botterud, A. (2020). *Optimality Conditions and Cost Recovery in Electricity Markets with Variable Renewable Energy and Energy Storage* (WP-2020-005). <http://ceep.mit.edu/publications/working-papers/721>
- Lomborg, B. (2020). *False Alarm* (Kindle). Basic Books. <https://www.basicbooks.com/titles/bjorn-lomborg/false-alarm/9781541647480/>
- Nordhaus, W. D. (2013). *The Climate Casino: Risk, Uncertainty, and Economics for a Warming World*. Yale University Press. http://books.google.com/books?hl=en&lr=&id=YfzYAQAQAQBAJ&oi=fnd&pg=PT7&dq=The+Climate+Casino:+Risk,+Uncertainty,+and+Economics+for+a+Warming+World&ots=g2IR0ITh_s&sig=FMS8QxAOSGvw7pfCZugeOwjoX-E
- PJM Interconnection. (2017). *Proposed Enhancements to Energy Price Formation*. <http://www.pjm.com/-/media/library/reports-notices/special-reports/20171115-proposed-enhancements-to-energy-price-formation.ashx>
- PJM Interconnection. (2019). *Enhanced Price Formation in Reserve Markets of PJM Interconnection, L.L.C., Docket Nos. ER19-1486-000, EL19-58-000*. <https://pjm.com/directory/etariff/FercDockets/4036/20190329-el19-58-000.pdf>
- Schweppe, F. C., Caramanis, M. C., Tabors, R. D., & Bohn, R. E. (1988). *Spot pricing of electricity*. Kluwer Academic Publishers. http://books.google.com/books?id=Sg5zRPWrZ_gC&pg=PA265&lpg=PA265&dq=spot+pricing+of+electricity+schweppe&source=bl&ots=1MIUfKBjBk&sig=FXe_GSyf_V_fcluTmUtH7mKO_PM&hl=en&ei=Ovg7Tt66DO2x0AH50aGNCg&sa=X&oi=book_result&ct=result&resnum=3&ved=0CDYQ6AEwAg#v=onep
- Thunberg, G. (2021). *Greta Thunberg Tweet, November 13, 2021*. <https://twitter.com/gretathunberg/status/1459612735294029834?lang=en>

William W. Hogan is the Raymond Plank Research 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, AQUIND Limited, 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 Authority New Zealand, Electricity Corporation of New Zealand, Electric Power Supply Association, El Paso Electric, Energy Endeavors LP, Energy Security Board Australia, 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, Israel Public Utility Authority-Electricity, 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, Morrison & Foerster LLP, 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, Total Gas & Power North America, 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).