Regulation, Climate Change, and the Electric Grid

DAVID B. SPENCE*

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By all accounts, any serious attempt to combat climate change[1] in the

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* Associate Professor of Law and Co-Director for the Energy Management & Innovation Center, University of Texas School of Law.

1. I will proceed on the following premises: (i) that the Earth's climate is warming; (ii) that that warming is driven largely by human activity, primarily emissions of greenhouse gases ("GHGs") and deforestation; and (iii) it is desirable from both the technical and economic point of view to reduce the growth of carbon emissions, and stabilize concentrations of GHG emissions in the atmosphere. While there is no consensus in support of these views among the American public, an overwhelming majority of the world's climatologists and geoscientists support the first two premises above. In the words of the Intergovernmental Panel on Climate Change ("IPCC"), it is "*very likely*" that human activity is driving climate change. *See Summary for Policymakers*, INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (2007), http://www.ipcc.ch/publications_and_data/ar4/syr/en/spms2.html. For an accessible discussion of the impact of GHG emissions on climate, see *The Causes of Global Climate Change*, CTR. FOR CLIMATE & ENERGY SOLUTIONS (Aug. 2008), *available at* http://www. pewclimate.org/docUploads/global-warming-science-brief-august08.pdf. In May of 2011, the National Academy Of Sciences and the National Research Council issued a report once again endorsing the notion that global warming is a pressing national problem requiring policy

United States must address the ways in which Americans produce and consume electricity. Coal-fired power remains the largest fuel source in the American electric system, representing about half of the U.S. generation.[2] Coal and natural gas-fired generation, which emits about half as much carbon dioxide equivalent ("CO_2e"),[3] comprise a strong majority of the total, dwarfing the contribution of carbon-free sources of electricity, like nuclear, hydroelectric power, wind, and solar energy. Furthermore, America's nuclear power plants are old and aging fast. The U.S. Nuclear Regulatory Commission is considering applications for about 20 new nuclear power plants,[4] but the Fukushima disaster in 2011 has cast doubt on the wisdom of nuclear power, and even if licensed, it would take a decade or more for nuclear plants to be built.

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attention. *See America's Climate Choices*, NAT'L ACAD. OF SCIS. (2011), *available at* http://nas-sites.org/americasclimatechoices/files/2011/05/ACC _Final_Report_Brief04.pdf.

GHG concentrations in the atmosphere have increased from their pre-industrial level of 280 parts per million ("ppm") to their current level of about 390 ppm. *See* CO_2 NOW, http://co2now.org/ (last visited Sept. 25, 2011) (tracking atmospheric concentrations of CO_2). Because GHGs dissipate slowly in the atmosphere, today's emissions will have warming effects for many years to come. Among economists and policy analysts, a majority support the view that the net effects of climate change will be negative. *See, e.g.*, Frank Ackerman et al., *The Economics of 350: The Benefits and Costs of Climate Change Stabilization*, ECON. FOR EQUITY & THE ENV'T NETWORK 9 (Oct. 2009), *available at* http://www.e3network.org/papers/Economics_of_350.pdf; NICHOLAS STERN, THE ECONOMICS OF CLIMATE CHANGE: STERN REVIEW vi-vii (2006). "Over the last decade, climatologists and some political leaders have concluded that growth in [GHG] emissions ought to be managed so as to stabilize concentrations at a level of 450 ppm or lower, in order to minimize the probability of catastrophic effects. The 450 ppm number represents an estimate of the maximum atmospheric concentration that is necessary to keep global mean temperature increases at 2° C or lower. However, there is considerable disagreement among climatologists and others over the desirable maximum concentration of [GHGs] in the atmosphere. Some analysts argue that the 450 ppm figure is too high, because climate change is taking place considerably faster than scientists were predicting only a short time ago." There is also considerable disagreement about the geographic distribution of those effects, and about whether the costs of combating climate change exceed the benefits for the United States. For an analysis of these policy debates and brief description of the climatological literature, see David B. Spence, *Regulation, 'Republican Moments,' and Energy Policy Reform*, at 7 (2011) (on file with author).

2. *Electric Power Annual 2009*, U.S. ENERGY INFO. ADMIN. 2 (Apr. 2009), *available at* http://www.eia.gov/electricity/annual/archive/03482009.pdf.

3. Carbon dioxide is the most plentiful GHG, by volume in the atmosphere. Other GHGs, such as nitrous oxide and methane, have even greater heat-trapping qualities, but are much less plentiful. Hence, most discussions of GHG emissions calculate emissions and emissions reductions using carbon dioxide as an index gas, and speak of "carbon dioxide equivalent" ("CO_2e").

4. "By issuing a combined license (COL), the U.S. Nuclear Regulatory Commission (NRC) authorizes the licensee to construct and . . . operate a nuclear power plant at a specific site" for 40 years. The NRC also issues separate early site permits and operating licenses for applicants not wishing to pursue a COL. *Combined License Applications for New Reactors*, U.S. NUCLEAR REGULATORY COMM'N, http://www.nrc.gov/reactors/new-reactors/col.html (last updated March 10, 2011) (providing a table with information to the public on the COL applications the NRC has received as of March 10, 2011).

Similarly, most of the profitable locations for hydroelectric projects were taken up long ago, and few analysts anticipate large-scale growth in hydroelectric development in the United States.[5] For that reason, some argue that the United States must rely more heavily on renewable energy sources like wind and solar power, as well as conservation, if it is to achieve the goal of stabilizing carbon emissions.[6]

More specifically, Robert Socolow and Stephen Pacala suggest an approach for stabilizing greenhouse gas ("GHG") concentrations that focuses on so-called "stabilization wedges."[7] These wedges represent sets of measures (of roughly equal effect[8]) that society can take to reduce growth in the rate of GHG emissions sufficiently to stabilize GHG concentrations at roughly 500 parts per million.[9] Several of these sets of

5. While it is possible that rising electricity prices could make some undeveloped sites economical, or cause owners of existing dams to expand, environmental groups are exerting downward pressure on hydroelectric generating capacity, seeking the decommissioning of existing hydroelectric facilities on environmental grounds when they come up for relicensing. This effort has been led by environmental groups like American Rivers. *See, e.g.*, Edwards Mfg. Co., 84 F.E.R.C. ¶ 61,227, 62,091 (1998) (authorizing a negotiated removal of the Edwards dam on the Kennebec River in order to restore historic salmon migration routes); FPL Energy Maine Hydro, LLC, 107 F.E.R.C. ¶ 61,120, 61,403 (2004) (authorizing dam removal in connection with surrender of a license); *Dams and Dam Removal*, AM. RIVERS, http://www.americanrivers.org/our-work/restoring-rivers/dams/ (last visited Sept. 25, 2011).

6. *See* Martin L. Hoffert, *Farewell to Fossil Fuels?*, 329 SCI. 1292, 1293 (2010), *available at* http://www.sciencemag.org/content/329/5997/1292.full.pdf ("Maintaining world economic growth and keeping atmospheric CO_2 concentrations below 450 ppm, even with continuing improvements in energy intensity (the amount of CO_2 emitted per unit of energy, and a proxy for increasing energy efficiency and less consumptive lifestyles), will require ~30 terawatts (TW) of power from carbon-neutral sources at mid-century.").

7. "We idealize the 50-year emissions reductions as a perfect triangle in Fig. 1B. Stabilization is represented by a 'flat' trajectory of fossil fuel emissions at 7 GtC/year, and BAU is represented by a straight-line 'ramp' trajectory rising to 14 GtC/year in 2054. The 'stabilization triangle,' located between the flat trajectory and BAU, removes exactly one third of BAU emissions. To keep the focus on technologies that have the potential to produce a material difference by 2054, we divide the stabilization triangle into seven equal 'wedges.' A wedge represents an activity that reduces emissions to the atmosphere that starts at zero today and increases linearly until it accounts for 1 GtC/year of reduced carbon emissions in 50 years. It thus represents a cumulative total of 25 GtC of reduced emissions over 50 years." Stephen Pacala & Robert Socolow, *Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies*, 305 SCI. 968, 968 (2004), *available at* http://www.sciencemag.org/content/305/5686/ 968.full.

8. Each wedge would produce a decrease in projected carbon emissions out of roughly 25 Gt by 2050. *Id.* at 968.

9. The authors call them "wedges" because adoption of each measure would reduce the slope of the curve that depicts growth in GHG concentrations over time.

measures would prescribe fairly drastic increases in our reliance on renewable electricity, as well as the adoption of energy efficiency investments. For example, Socolow and Pacala call for raising average fuel economy standards for vehicles to 60 miles per gallon, doubling our reliance on nuclear energy, and increasing our wind and solar electric generating capacity by factors of 50 and 700, respectively.[10] Whether or not these specific prescriptions are followed, any serious attempt to stem the growth of carbon emissions must include significant increases in renewable electricity, as well as energy efficiency investments.

These changes, in turn, will have implications for the shape and operation of the American electric grid. It is logical to infer that if we *increase* the percentage of electricity that comes from clean sources like wind and solar power, we will realize a corresponding *decrease* in the GHG emissions associated with electricity generation. However, even if wind and solar power can overcome the problem of cost competitiveness to assume a growing proportion of our electric generation mix, that increase will not necessarily produce corresponding decreases in GHG emissions because wind and solar power is intermittent. Because it is intermittent, it must be backed up by a more reliable source of power, such as coal or natural gas-fired generation. When fossil fuel generation is used to back up intermittent sources, however, it operates much less efficiently, emitting more GHGs per unit of energy produced than when it is used to serve base load. This means that while the increased reliance upon renewable electricity may represent an environmental improvement (in terms of GHG emissions), it may be a much smaller improvement than most expect.

Similarly, it is equally logical to infer that rationally self-interested consumers will take advantage of potential money-saving opportunities represented by electricity conservation and the opportunity to manage demand. However, there exists a variety of behavioral and other impediments to the realization of these cost-saving (or money-making) opportunities.

In Part I of this essay, I outline some of the background characteristics of the electric grid, the way it is operated, and the way regulators and grid operators manage the sale and transmission of electricity across it. In Part II, I explore the opportunities and potential problems associated with integrating intermittent, renewable sources of electric generation into the grid. This discussion includes a review of a number of recent studies examining the GHG emissions effects of using fossil fueled

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Thus, each section of the area under the GHG concentration growth curve looks like a wedge. *Id.* at 969 fig.1(B).

10. *Id.* at 969–71.

generation to back up wind power, as well as the U.S. Federal Energy Regulatory Commission's ("FERC") recent rulemakings addressing this issue. Part III explores the potential cost and pollution reduction savings associated with better management of our electricity demand, and why many of those opportunities remain unrealized. This discussion includes a review of the behavioral economics literature addressing this phenomenon, as well as FERC's recent rulemakings aimed at reducing the growth in peak demand by encouraging demand response. Part IV offers some concluding thoughts.

I. THE AMERICAN ELECTRIC GRID

The American electric grid is an enormous network of transmission and distribution lines designed to transmit electric current from large central generating stations to "load"—that is, consumers of electricity. We make a distinction between transmission, the movement of electricity over longer distances at higher voltages,[11] and distribution, the delivery of electricity at lower voltages[12] from high-voltage transmission lines to end-users. Modern electric transmission systems became possible only after George Westinghouse's promotion of an alternating current transmission system in the late 1800s.[13] Westinghouse's system built upon Nikola Tesla's work with transformers (which enabled companies to increase and decrease voltage at key points in the system).[14] Most of the

11. "Voltage" is the force by which electric current moves along transmission or distribution lines. Generally, transmission lines move power at voltages exceeding 110 kilovolts ("kV"); some transmission lines, however, move power at voltages in excess of 1,000 kV.

12. Distribution lines move power at less than 110 kV, typically between 4 and 34.5 kV.

13. Prior to this innovation, electric power could move in only one direction along transmission lines. Alternating current allowed for bidirectional movement. In the early years of the electric industry, Thomas Edison championed direct current transmissions. Westinghouse's view, however, ultimately prevailed, leading to the alternating current system we use today. For a comprehensive description of these early days of electric power, see MAURY KLEIN, THE POWER MAKERS: STEAM, ELECTRICITY, AND THE MEN WHO INVENTED MODERN AMERICA (2008).

14. Transformers are used to increase or decrease voltage at junctions in the grid. For example, a transformer at the junction of a high-voltage transmission line in a distribution line may step power down to the appropriate distribution voltage. A transformer at the junction of a power plant connector and a high-voltage transmission line may step power up to the appropriate transmission voltage. Power must be stepped down to reach voltages used in homes and businesses, typically between 120 and 240 Volts. *Id.* at 329–30.

modern American electric grid consists of alternating current lines organized into three large systems, as shown in Figure 1: the Eastern Interconnection, the Western Interconnection and the Texas Interconnection.[15]

FIGURE 1: THE AMERICAN ELECTRIC GRID*

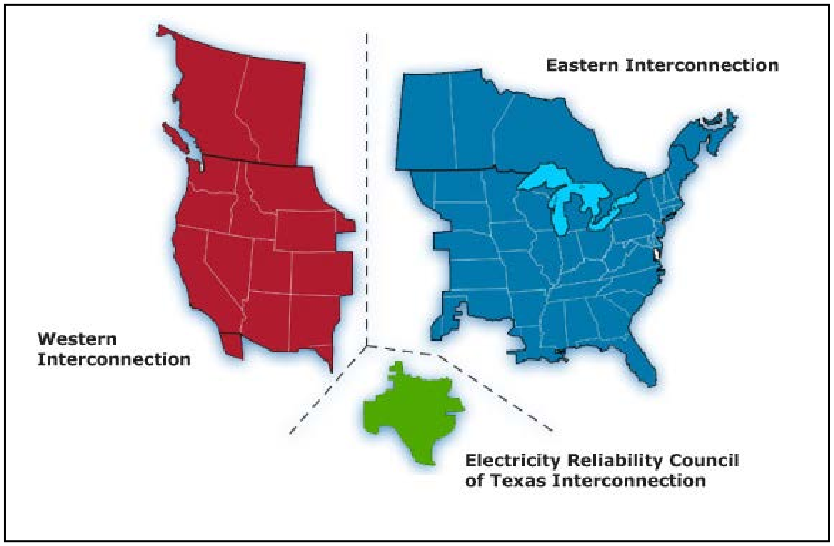


*Figure source: U.S. Dept. of Energy[16]

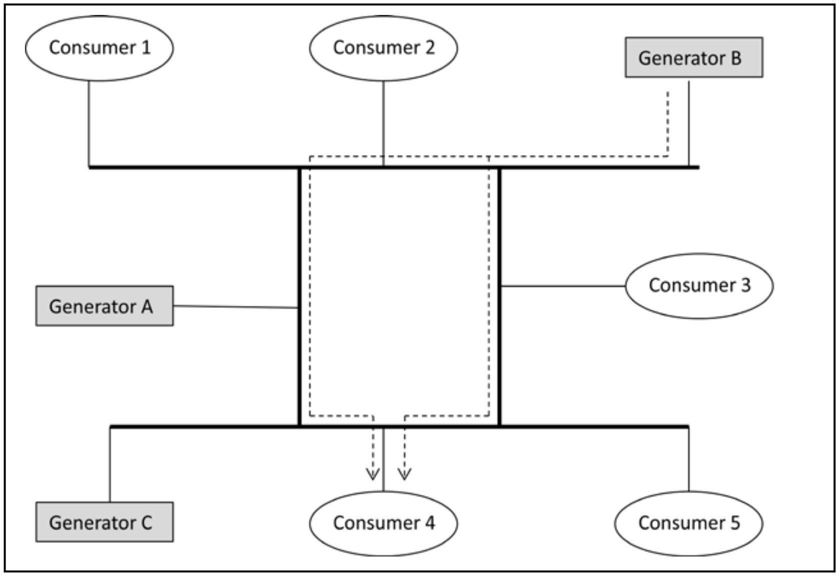
Within each of these three systems, virtually every generator of electricity is connected (however indirectly) with virtually every consumer by electricity. In an alternating current system, the seller of electricity cannot steer her particular electrons or particular bits of electric current to its customer. Rather, electric current follows the path of least resistance, irrespective of the intentions of individual buyers and sellers of electricity. That is, in Figure 2, if Generator B wishes to sell 100 kilowatt-hours ("kWh") of electricity to Consumer 4, Generator B cannot direct that

15. The Texas interconnection is separated from the remainder of the American grid primarily to avoid federal jurisdiction under the Federal Power Act, though Texas avoids some federal regulation only because of cooperation of the Federal Energy Regulatory Commission ("FERC") and Congress. For a description of this separate Texas system, see DAVID SPENCE & DARREN BUSH, ELECTRICITY RESTRUCTURING THE TEXAS STORY 9–21 (L. Lynne Kiesling & Andrew N. Kleit eds., 2009).

16. *Frequently-Asked Questions (FAQS) About Transmission Planning in the Western Interconnection*, WESTERN ELEC. COORDINATING COUNCIL 5, *available at* http://www.wecc.biz/Planning/TransmissionExpansion/RTEP/Transmission%20Planning/RTEP%20FAQs.pdf (last visited Sept. 25, 2011).

power to Consumer 4 over particular transmission and distribution lines, nor will all of the power travel across the most direct route to get to Consumer 4. Rather, as the dotted lines in Figure 2 indicate, once Generator B produces that electricity and dispatches it to the grid, some of the power will take a rather indirect or "circuitous" route. How much current moves along each of these two routes depends upon a number of factors, including differential levels of resistance in lines along these routes. This tendency for electric current to take multiple paths to its destination is known as "loop flow."

FIGURE 2: "LOOP FLOWS"



Because of loop flows, the grid's generation and consumption loads must be kept in balance. That is, at any given point in time, the amount of electricity being dispatched to the grid by generators must equal the amount been taken off the grid by consumers. If loads are not balanced, the system will fail, causing blackouts, for example. The grid's day-to-day managers, the "control area operators," perform this balancing function. Typically, there is quite a bit of variation in load, both over the course of a day, and seasonally.[17] Residential electric loads, for example, tend to be highest in the late afternoon and early evenings, when people get home from work, but before they go to bed. Seasonal loads are highest in the summer and hot weather climates, and in the winter in cold weather climates. To keep loads in balance, control area operators must marshal a great deal of information about historic usage patterns, weather forecasts, generators' operational plans, and more to estimate levels of supply and demand in the near term and longer-term future. With that information, control area operators can have supply resources ready and available[18] to dispatch power when demand increases; or, they can have demand-side resources ready to curtail their usage[19] should that become necessary to balance the load.

For most of the history of the American electric system, these balancing services were performed by vertically-integrated, investor-owned electric utilities, companies that owned generating facilities and the transmission and distribution lines necessary to get electric power from plants to customer. Under the traditional system of public utility rate regulation, these investor-owned utilities were granted monopoly status, chartered by the state public utilities commissions to be the sole provider of electric service within their specified geographic areas.[20] In return, they were obligated to provide reliable service on a nondiscriminatory basis. Rate regulation allowed (and still allows, where it remains in place) investor-owned utilities to recover through rates all of their reasonably incurred costs, and to earn a fair return on their prudently made

17. *See* Matt Davison et al., *Development of a Hybrid Model for Electrical Power Spot Prices*, 17 IEEE TRANSACTIONS ON POWER SYS. 257, 260 (2002), *available at* http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=1007890 ("It is known that power demand is tightly linked to weather and follows predictable seasonal and diurnal patterns.").

18. We refer to these excess supply resources as "reserves." "Spinning reserves" are generating facilities that are ramped up and ready to dispatch power to the grid at a moment's notice.

19. "Load control and demand side load management programs have been implemented in many competitive power markets. These programs can be classified as a set of system operator (usually ISO)-based programs that allow end users to provide interruptible load as a commodity in the electricity market . . . . These programs provide various incentives for end users to reduce load or use on-site generation during high price periods." *See* P. Jazayri et. al., *A Survey of Load Control Programs for Price and System Stability*, 20 IEEE TRANSACTIONS ON POWER SYS. 1504, 1504 (2005), *available at* http://ieeexplore.ieee.org/search/freesrchabstract.jsp?tp=&arnumber=1490604.

20. By the early 1900s, most states had established utilities commissions charged with the task of regulating electric and gas companies, and setting their retail rates. The first state public utility commission was created in the late 19th century. This was the Massachusetts Board of Gas and Electric Light Commissioners. Alfred E. Forstall, *Government Control of the Price of Gas, in* PUBLIC POLICY 329, 332 (1900) (describing the Massachusetts commission as the "only organized attempt at government control of the gas business in the United States").

investments—that is, investments in capital necessary to provide these generation, transmission and distribution services.[21]

In this system, investor-owned utilities traditionally generated most of the power they sold to their customers, and supplied it over lines they owned. Therefore, balancing loads was primarily an intra-company activity. On those rare occasions when it was necessary to coordinate transmission or distribution activities with the neighboring utility (for example, because one utility wishes to buy wholesale power from its neighbor during times of shortage, or to move power across service area lines in order to relieve congestion or ensure system reliability), neighboring utilities coordinated these transactions informally, knowing that the cost of the transaction would be recovered through rates. Wholesale rates were regulated by FERC,[22] but state utilities commissions typically allowed wholesale power purchase costs to be passed through to customers in retail rates. This informal coordination process took on greater importance after the 1965 blackout on the Eastern Seaboard. That accident prompted the formation of the North American Electric Reliability Council ("NERC"). NERC organized the creation of informal "power pools," regional associations of electric utilities charged with ensuring system reliability and facilitating reliability-based coordination of grid management activities between utilities.

In the 1980s, the electricity industry began to change in ways that complicated the task of grid management. The seeds of change were sown in the 1970s. First, in 1973, the Supreme Court issued its decision in *Otter Tail Power Co. v. United States*,[23] upholding charges of antitrust violations against an electric utility that refused to "wheel" power (that is, to transmit power for third parties over its own transmission lines) from a third-party supplier to a municipal utility. Prior to the *Otter Tail* decision, municipal utilities lying entirely within the service area of investor-owned electric utility were captive wholesale customers. The

21. The standard way of describing the ratemaking process is to say that in rate cases, utility commissions typically make rate decisions using the following equation: $R = Br + O$, where R represents the company's total revenue requirements, B represents the rate base, r represents the permissible rate of return on investment, and O represents permissible operating expenses. Assets that are used and useful to the company's task of supplying electric service are includable within rate base, and are those on which the company is guaranteed a fair return.

22. Under the Federal Power Act, FERC is charged with ensuring that wholesale rates are "just and reasonable." Federal Power Act § 205, 16 U.S.C. § 824d (2006).

23. Otter Tail Power Co. v. United States, 410 U.S. 366, 378 (1973).

Otter Tail decision raised the prospect that these municipal utilities and others might one day be able to buy power from someone other than the local investor-owned utility, and to have that power delivered over the utility's transmission and distribution lines. Five years later, the passage of the Public Utility Regulatory Policies Act of 1978[24] ("PURPA") promoted both electricity conservation programs and the construction of "alternative" forms of electricity production by providing financial incentives to new, nonutility producers[25] of renewable electricity and cogeneration.[26] The presence of nonutility generators in the market created additional pressure for nondiscriminatory access to the electric grid as a transmission service; these nonutility generators wanted to sell their electricity directly to retailers or industrial customers. Congress responded to that pressure in the Energy Policy Act of 1992[27] by authorizing FERC to order electric utilities to wheel power over their transmission lines.[28] FERC exercised that power in 1996 when it promulgated Orders 888 and 889, mandating (i) the *unbundling* of electricity transmission from electricity sales in wholesale markets, and (ii) that owners of transmission lines act as common carriers providing transmission service on a nondiscriminatory basis to affiliated and non-affiliated companies alike.[29] As a consequence of this unbundling, FERC began to authorize wholesale sellers to charge market-based rates.[30]

24. Policy Utility Regulatory Policies Act of 1978, 16 U.S.C. §§ 2602–3211 (2005).

25. In PURPA parlance, these nonutility generators were called "qualifying facilities" ("QFs") because they qualified for the financial benefits offered under the statute.

26. PURPA defined "alternative" energy facilities to include various forms of renewable energy like solar, wind, and geothermal, as well as small hydroelectric facilities and cogeneration plants. Cogeneration facilities produce electricity as well as usable heat energy, and most of the many hundreds of cogeneration facilities built after the passage of PURPA in the 1980s were gas-fired.

27. *See* Energy Policy Act of 1992, Pub. L. No. 102-486 § 721, 106 Stat. 2915 (1992) (codified as amended at 16 U.S.C. § 824j (2005)) (provision for open access to transmission lines).

28. *Id.* §§ 711–12.

29. Order 888 required transmission line owners to file so-called "open-access tariffs" offering nondiscriminatory transmission services, and to "functionally unbundle" transmission from electricity sales. Order No. 888, Promoting Wholesale Competition Through Open-Access Nondiscriminatory Transmission Services by Public Utilities, 61 Fed. Reg. 21,540 (May 10, 1996) (to be codified at 18 C.F.R. pt. 37). Order 889 mandated transparency in transmission services by requiring all takers of transmission services (including affiliates of the transmission owner) to take such services using an open-access posting system. Order No. 889, Open-Access Same-Time Information System (Formerly Real-Time Information Networks) and Standards of Conduct, 61 Fed. Reg. 21,737 (May 10, 1996) (to be codified at 18 C.F.R. pt. 37).

30. *See, e.g.*, Entergy Services, Inc., 58 F.E.R.C. ¶ 61,234, 61,753 (1992) (authorizing electricity sales at market-based rates).

At around the same time, a sizeable minority of American states began to introduce competition and market-based rates into their retail markets,[31] with California,[32] Texas,[33] and New York[34] leading the way. Because of all of these developments, many incumbent utilities in these states sold most of their generation assets or spun them off into subsidiaries, increasing the profile of independent merchant generators, marketers, and brokers within the industry. Consequently, the number and volume of arms-length transactions on wholesale electricity markets grew by leaps and bounds, straining the capacity of both the transmission grid and regulators. In response, FERC pushed owners of transmission lines to form "independent system operators" ("ISOs") and "regional transmission organizations" ("RTOs") to help manage the grid, ensure system reliability, and guard against discrimination and the exercise of market power in the provision of transmission services.[35] By the turn of the century, active electricity trading hubs had arisen around several of these ISOs and RTOs, including the Pennsylvania-New Jersey-Maryland ("PJM") RTO, the New York ISO, the California ISO, and the New England RTO.[36] In states that opted out of retail restructuring, some public utilities continued to generate most of the electricity they sold to customers, while others satisfied most of their electricity needs from wholesale markets. In any case, because electricity demand is highly variable (both daily and seasonally), most electricity retailers must participate in spot markets in order to balance supply with demand.

31. *See The Changing Structure of the Electric Power Industry 2000: An Update*, U.S. ENERGY INFO. ADMIN. 70–77 (Oct. 2000), *available at* http://www.eia.gov/cneaf/electricity/chg_stru_update/update2000.pdf.

32. *See* Assem. B. 1890, 1996 Leg., Reg. Sess. (Cal. 1999).

33. *See* TEX. UTIL. CODE ANN. §§ 39.001–.910 (Vernon 2002).

34. *See In re* Competitive Opportunities Regarding Elec. Serv., 1999 WL 1442552 (N.Y. Pub. Serv. Comm'n Dec. 6, 1999) (No. 94-E-0952); *In re* Competitive Opportunities Regarding Elec. Serv., 1996 WL 293495 (N.Y. Pub. Serv. Comm'n May 20, 1996) (No. 94-E-0952).

35. Order No. 2000, Regional Transmission Organizations, 89 F.E.R.C. ¶ 61,285 (1999) (to be codified at 17 C.F.R. pt. 53).

36. For a description of the status of electricity trading hubs at the turn of the century, see *The Changing Structure of the Electric Power Industry 2000: An Update*, *supra* note 31, at 9, 78.

FIGURE 3: ISOs AND RTOS IN NORTH AMERICA, 2009

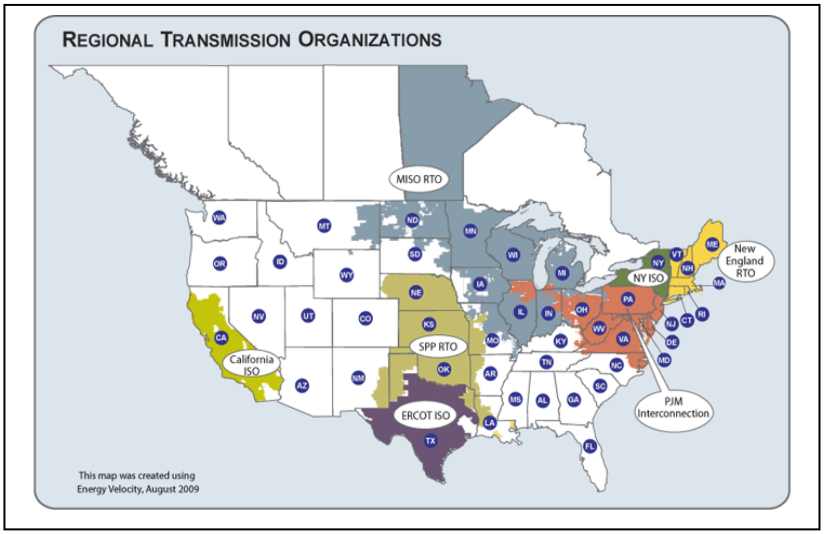


Figure source: U.S. Federal Energy Regulatory Commission[37]

In this new regime, more electricity travels farther than ever before. Individual ISOs and RTOs manage grid operations and electricity spot markets over geographic areas that are many times larger than even the largest investor-owned utility service area that existed under the traditional regime. Figure 3, a map of North American ISOs and RTOs, illustrates this point. Thus, one of the tasks of today's regulators and regulated companies alike is to adapt 20th-century grid to 21st-century electricity markets. These ISOs and RTOs oversee organized wholesale electric markets in at least three important ways. First, they oversee the operation of the electricity spot market, which typically involves matching day-ahead bids from buyers and sellers to produce a market-clearing price, typically one that will be paid by all buyers and sellers of spot electricity. Second, they schedule so-called ancillary services: reserves, spinning reserves, and regulation. The term "reserves" refers to the generating capacity that is currently unused but which is available to serve load; if that capacity is already running, so that operator may dispatch its electricity to the grid on very short notice, it qualifies as "spinning reserves."[38]

37. RTO/ISO Map, FERC, *available at* http://www.ferc.gov/industries/electric/indus-act/rto/rto-map.asp.

38. *See* Willett Klempton & Jasna Tomić, *Vehicle-to-Grid Power Fundamentals: Calculating Capacity and Net Revenue*, 144 J. OF POWER SOURCES 268, 271 (2005), *available at* http://www.sciencedirect.com/science/article/pii/S0378775305000352#SECX9 ("Spinning

"Regulation" services are the grid management activities that maintain voltages at their proper level, to ensure grid reliability.[39] Third, operators ensure that there is sufficient generating capacity over the long term to meet projected demand. They can ensure adequate reserves in either or both of two ways: one way is by including the value of capacity in energy prices, as is done in the ERCOT ISO system in Texas;[40] another is to create and manage separate capacity markets in which owners of electricity generators are paid to have capacity available in the event that capacity is needed in the future. In the PJM, New England, and New York systems, for example, capacity markets are run.[41]

Thus, the maintenance of a reliable electric grid poses technical and economic challenges. Each new source of electricity, including renewables, must be operated in such a way as to maintain grid reliability. Furthermore, ISOs and RTOs must try to find a way to ensure that each new "source" of generation (demand-side or supply-side) is adequately compensated for the services it provides, and pays for the costs it imposes on the system as a whole. These are not easy tasks.

II. RENEWABLE ENERGY

One appeal of renewable sources of power such as solar, wind and tidal or wave energy, is its absence of GHG emissions. Viewed on a lifecycle basis, these sources of power emit far fewer GHGs than their fossil fueled counterparts,[42] and compare favorably on other environmental

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reserves refers to additional generating capacity that can provide power quickly, say within 10 minutes, upon request from the grid operator.").

39. *See id.*

40. This system attempts to address the inadequate incentives to invest in infrastructure resources such as generation capacity by addressing the imperfections in the market's design. The resulting "energy only" market does not remove the need for regulatory interventions, but substantially changes the nature of those interventions. *See* William W. Hogan, *On an "Energy Only" Electricity Market Design for Resource Adequacy*, HARV. JOHN F. KENNEDY SCH. OF GOV'T 34 (Sept. 23, 2005), *available at* http://www.hks.harvard.edu/fs/whogan/Hogan_Energy_Only_092305.pdf.

41. "Capacity markets provide economic incentives to attract investment in new and existing supply-side and demand-side capacity resources . . . . [T]he [Forward Capacity Market] contains an auction structure through which capacity resources compete to obtain a market-priced capacity payment, in exchange for a commitment to be available in the years ahead to meet the region's electricity [demands]." *See Capacity Market*, ISO NEW ENG., http://www.iso-ne.com/nwsiss/grid_mkts/how_mkts_wrk/cap_mkt/index.html (last visited Jun 16, 2011).

42. "Greenhouse gas emissions . . . were generally estimated according to the full operational life cycle of each renewable energy technology including CO_2e emissions

criteria as well. According to the U.S. Energy Information Administration, total American electric generation from the electric power sector was a little over 2.4 million gigawatt-hours ("GWh") in 2010.[43] Of that total, coal-fired generation represented about 1.4 million GWh, natural gas-fired generation nearly another 380,000 GWh, and nuclear power about 424,000 GWh.[44] Non-hydro renewables represented only 130,000 GWh.[45] Why then, haven't renewables achieved greater penetration in American electricity markets?

A. The Rise of Renewables

Technically speaking, a great deal of potential wind and solar energy remains untapped in the United States.[46] Indeed, if cost (and opportunity cost) were no object, we could easily generate more power using the wind and the sun than we consume each year. However, costs (and opportunity costs) do matter. In most locations, the delivered cost of wind and solar power is higher than power from other sources.[47] However, the cost of generating electricity from renewable sources has decreased over time,[48]

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from manufacturing of the plant to full operation of the technology . . . . The emissions are found to vary widely within each technology . . . . Overall, wind has the lowest CO_2e emissions, with only around 25 g/kW h CO_2e. Hydro and photovoltaics also have low emissions, with average reported values at less than 100 g/kW h CO_2e. The average emissions from geothermal are fair at 170 g/kW h, however the range includes all possible values for gas emissions and may even be as high as a low-emitting coal fired power station. For all technologies except hydro, CO_2e emissions account for all significant carbon emissions." *See* Annette Evans et al., *Assessment of Sustainability Indicators for Renewable Energy Technologies*, 13 RENEWABLE & SUSTAINABLE ENERGY REV. 1082, 1084 (2009), *available at* http://www.sciencedirect.com/science/article/pii/S136403210 8000555.

43. *Total Electric Power Industry Summary Statistics, Year-to-Date 2011 and 2010*, U.S. ENERGY INFO. ADMIN., *available at* https://www.eia.gov/electricity/monthly/excel/ epmxlfilees1_b.xls.

44. *Id.*

45. *Id.*

46. *See* Benjamin K. Sovacool & Charmaine Watts, *Going Completely Renewable: Is it Possible (Let Alone Desirable)?*, 22 THE ELECTRICITY J. 95, 103 (2009) ("[T]he United States has an enormous cache of renewable energy resources that it has only begun to utilize.").

47. The mean price of electricity for photovoltaic and wind power is $0.24 kW h and $0.07 kW h respectively. This compares to $0.042 kW h for coal and $0.048 kW h for gas. These numbers account for the cost of capital, but not the cost of transmission, which can add up to $0.015 kW h when long transmission lines are necessary. Transmission over long distances is more common with renewables than non-renewables. *See* Annette Evans et al., *Assessment of Sustainability Indicators for Renewable Energy Technologies*, 13 RENEWABLE & SUSTAINABLE ENERGY REV. 1082, 1083–84 (2009).

48. "[C]ontinued technological advances will likely make renewable power plants cheaper. If current trends continue, the cost of solar electricity generation is expected to drop to 6 to 10¢/kWh by 2020 due to improvements in module production through thinner layers, the introduction of a broader range of materials (including crystalline

stimulated in part by government incentives and regulatory mandates. Specifically, we can point to three types of policies that have given a push to renewable electricity since the latter part of the 20th century: renewable portfolio standards, tax incentives, and carbon regulation.

__*Renewable portfolio standards.*__ As noted above, PURPA had given a boost to renewable electricity in the 1980s, stimulating a great deal of small hydro development, as well as some wind and solar development.[49] At around the same time, states began establishing "renewable portfolio standards" ("RPSs"), requiring electric utilities to buy a specified percentage (or, in some cases, amount) of electricity from renewable sources.[50] Since the 1980s, more than half of American states have adopted some form of a RPS. State RPSs vary widely: each define "renewable energy" differently, and establishes different targets as well, from Minnesota's requirement that 25 percent of all electricity come from renewables by the year 2025[51] and California's requirement that utilities acquire one-third of their electricity from renewables by 2020,[52] to Texas's rather modest goals, which are established not in percentages of power sold but rather in megawatts ("MW") of capacity.[53] In the

silicon, gallium arsenide, cadmium telluride, copper indium selenide, and recycled silicon), the integration of glass and PV production facilities, the construction of adhesives on-site, innovative designs, and better economies of scale. The same 'learning effect' will likely reduce costs by 20 to 60 percent for other wind and bioelectric power stations." *See* Sovacool & Watts, *supra* note 46, at 98–99.

49. *See* Sanya Carley, *Historical Analysis of U.S. Electricity Markets: Reassessing Carbon Lock-in*, 39 ENERGY POL'Y 720, 725 (2010), *available at* http://www.sciencedirect.com/science/article/pii/S0301421510007962 ("PURPA additionally gave rise to wind and industrial steam technologies, promoted the re-entry of small hydro dams, and encouraged research and development efforts in other technologies, such as the fuel cell, solar troughs, and fluidized bed combustion boilers.").

50. These targets, and definitions of qualified sources vary by state. For up-to-date information about state RPSs, see DATABASE OF STATE INCENTIVES FOR RENEWABLES & EFFICIENCY, http://www.dsireusa.org/.

51. MINN. STAT. § 216B.1691 (2010).

52. CAL. PUB. UTIL. CODE § 399.30(c)(2) (West 2011) ("The quantities of eligible renewable energy resources to be procured for all other compliance periods reflect reasonable progress in each of the intervening years sufficient to ensure that the procurement of electricity products from eligible renewable energy resources achieves 25 percent of retail sales by December 31, 2016, and 33 percent of retail sales by December 31, 2020.").

53. Texas's goals are modest for two reasons. First, each time the legislature has raised the target, the market has already built nearly that much capacity. Second, the goals are essentially voluntary, and there are no significant financial consequences for retail energy providers who fail to meet them. *See* TEX. UTIL. CODE § 39.904 (West 1999), *amended by* TEX. UTIL. CODE § 39.904 (West 2005) (replacing the renewable

summer of 2009, the House of Representatives passed H.R. 2454, the American Clean Energy and Security Act of 2009, also known as the "Waxman-Markey bill,"[54] which would have established a national RPS effective in 2012 (with an ultimate goal of requiring utilities to secure 20 percent of their electricity from renewable sources by the year 2020).[55] Its companion bill in the Senate was S. 1733, the Clean Energy Jobs and American Power Act, also known as the "Kerry-Boxer bill."[56] The Kerry-Boxer bill did not include a national RPS, and it was never reported out of committee in the Senate; for its part, the Waxman-Markey bill was pronounced "dead on arrival" in the Senate by various commentators.[57] The prospects for a federal RPS in the 112th Congress are uncertain at best. In his 2011 State of the Union address, President Obama proposed a "Clean Energy Standard" that would include some non-renewables under the definition of clean energy.[58] Although there have been reports that legislation reflecting the president's plan will be introduced in the Senate,[59] the Republican-controlled House of Representatives may be less favorably disposed to any sort of federal clean energy legislation, including a federal RPS. Nonetheless, despite the lack of a national RPS, some analysts credit state RPSs for increases in the development of renewable electricity.[60]

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capacity targets every two years from 2003–2009, with new targets every two years from 2007–2015). For an excellent comparison of state RPS programs, and assessment of their effectiveness, see Lincoln L. Davies, *Power Forward: The Argument for a National RPS*, 42 CONN. L. REV. 1339 (2010).

54. H.R. Res. 2454, 111th Cong. (2009) (enacted) [hereinafter Waxman-Markey]. The named sponsors are Congressman Henry Waxman of California and Congressman Ed Markey of Massachusetts.

55. *Id.* § 101.

56. S. Res. 1733, 111th Cong. (2010) [hereinafter Kerry-Boxer]. The named sponsors are Senator John Kerry of Massachusetts and Senator Barbara Boxer of California. Kerry-Boxer would impose many of the same new requirements as Waxman-Markey, with a few differences. For example, it did not contain a national RPS.

57. Harry Fuller, *Repubs Say Waxman-Markey Bill is DOA in Senate*, ZDNET (June 28, 2009), http://www.zdnet.com/blog/green/repubs-say-the-waxman-markey-bill-is-doa-in-senate/5667.

58. *See* President Barack Obama, 2011 State of the Union Speech (Jan. 25, 2011) (copy of transcript available at http://www.whitehouse.gov/the-press-office/2011/01/25/remarks-president-state-union-address) ("Some folks want wind and solar. Others want nuclear, clean coal and natural gas. To meet this goal we will need them all . . . .").

59. *See Tom Udall, Mark Udall Introduce Renewable Standard Legislation*, TOM UDALL SEN. FOR N.M., http://tomudall.senate.gov/?p=press_release&id=815 (last visited Jun. 2, 2011) ("U.S. Senators Tom Udall (D-NM) and Mark Udall (D-CO) today continued their fight to enact a federal Renewable Energy Standard (RES) by introducing legislation that would require utilities to generate 25 percent of their electricity from wind, solar and other renewable energy sources by 2025.").

60. *See Renewable & Alternative Energy Portfolio Standards*, CTR. FOR CLIMATE & ENERGY SOLUTIONS, http://www.pewclimate.org/what_s_being_done/in_the_states/rps.cfm (last updated Jan. 20, 2012) ("While the success of state efforts to increase

<u>*Tax credits.*</u> Many analysts ascribe even more of the credit for the growth in renewables to federal tax incentives. Ever since the 1970s, the federal government has periodically offered production tax credits and/or investment tax credits to wind, solar and other sources of renewable electricity. These programs have typically of a very short duration, but have been renewed regularly.[61] Production tax credits compensate producers (in the form of reductions of their tax liability) on a per kWh of renewable electricity produced basis. Investment tax credits offer similar tax liability reductions for investments in renewable electricity. The current federal production tax credit for wind power, for example, is 2.2 cents per kWh.[62]

Some contend that investment in wind and solar power has been disadvantaged over the years by the unpredictability of these tax credits. In the early 2000s, for example, a backlog on wind turbine orders slowed many wind projects, partly because wind turbine producers were dissuaded from investing in additional plant capacity by the unpredictability of federal renewable tax credits.[63] Nevertheless, production tax credits seem to be a fairly powerful incentive. For instance, the production tax credit for wind power has, on occasion, been credited with producing *negative prices* for electricity at night in West Texas, where wind power producers paid (something less than 2 cents per kWh) to dispatch their power to the grid in order to receive the production tax credit (of about 2 cents per kWh).[64]

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renewable or alternative energy production will depend in part on federal policies such as production tax credits, states have been effective in encouraging clean energy generation.").

61. The energy package signed by President Carter in 1978 included investment tax credits and accelerated depreciation for alternative energy projects. These tax credits expired during the Reagan administration. In 1992, Congress established a production tax credit for renewable energy projects in the Energy Policy Act of 1992. Congress has intermittently renewed short-term investment and/or production tax credits for renewable energy ever since, and production credits still remain in effect.

62. *See* Form 8835, IRS, *available at* http://www.irs.gov/pub/irs-pdf/f8835.pdf.

63. "While the industry was fortunate to gain short-term extensions in the past, these shorter time periods create uncertainty and a 'boom-and-bust' cycle of short-term planning, near annual job layoffs and higher cost projects. Without a long-term policy, manufacturers are discouraged from investing in, and expanding, manufacturing facilities in the U.S." *See Production Tax Credit (PTC)*, AM. WIND ENERGY ASS'N, *available at* http://www.awea.org/issues/federal_policy/upload/PTC_April-2011.pdf (last visited Jun. 9, 2011).

64. *See Lessons Learned from Renewable Energy Credit (REC) Trading in Texas*, BUREAU OF ECON. GEOLOGY 20 (2009), *available at* http://www.beg.utexas.edu/energyecon/transmission_forum/CEE_Texas_RPS_Study.pdf (wind generators, which

Carbon regulation. At first blush, it may seem unlikely that carbon regulation has stimulated development of renewable electricity. While the United States signed the Kyoto Accord in the 1990s (pledging reductions in GHG emissions[65]), the United States never ratified the agreement, and Congress has since declined to enact legislation regulating GHG emissions.[66] However, where Congress has been quiet, voluntary markets, the states, and the U.S. Environmental Protection Agency ("EPA") have been active. For example, the Chicago Climate Exchange operates a voluntary market in "carbon offsets," through which purchasers seeking to reduce their carbon footprint pay others to reduce CO_2e emissions.[67] Much of the demand for these offsets comes from outside the United States, though some companies and individuals within the country choose to purchase offsets voluntarily. According to a 2008 government accountability office study:

> A wide variety of consumers buy offsets, including individuals, businesses, nonprofits, governments, research institutions, universities, religious congregations, utilities, and other organizations. Consumers' motivations for purchasing offsets may include corporate responsibility and public relations, among others.[68]

At the state level, in 2006 the State of California enacted AB 32, a law establishing a statewide program of GHG emission regulation that aims to reduce emissions in California to 1990 levels by the year 2020.[69] AB 32 recently survived a judicial challenge[70] and the state governor has

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needed wind power to be dispatched to collect production tax credits, submitted negative bids in certain hours).

65. *See What Does the Kyoto Protocol Mean to U.S. Energy Markets and the U.S. Economy?*, U.S. ENERGY INFO. ADMIN. 2 (Oct. 1998), *available at* http://www.eia.gov/oiaf/kyoto/pdf/kyotobrf.pdf ("The Kyoto Protocol, negotiated by more than 160 nations in December 1997, aims to reduce net emissions of certain greenhouse gases.").

66. "[U]ntil recently, the federal government's attitude toward climate change ranged from 'simple inaction to outright obstructionism,' with little meaningful federal regulation and documented efforts to play down the extent and serious effects of climate change." Margaret Rosso Grossman, *Climate Change and the Law*, 58 AM. J. COMP. L. 223, 231 (2010).

67. "Chicago Climate Exchange is North America's largest and longest running greenhouse gas emission [offsets] program. From 2003 through 2010 CCX operated as a comprehensive cap and trade program with an offsets component. In 2011 CCX launched the Chicago Climate Exchange Offsets Registry Program to register verified emission reductions based on a comprehensive set of established protocols." *Chicago Climate Exchange*, INTERCONTINENTALEXCHANGE, http://www.chicagoclimatex.com/content.jsf?id=23 (last visited June 9, 2011).

68. *Carbon Offsets: The U.S. Voluntary Market is Growing, but Quality Assurance Poses Challenges for Market Participants*, U.S. GOV'T ACCOUNTABILITY OFFICE 10 (Aug. 2008), *available at* http://www.gao.gov/new.items/d081048.pdf.

69. This law has proven controversial and may be the subject of a failed recall referendum in California.

70. *See* Margot Roosevelt, *Prop. 23 Campaign Concedes Defeat*, L.A. TIMES (Nov. 3, 2010), http://latimesblogs.latimes.com/greenspace/2010/11/prop-23-defeat-global-warming-

pledged to meet that commitment.[71] Furthermore, using its unique power to establish independent automotive standards under the Clean Air Act,[72] the State of California in 2005 sought EPA permission to regulate carbon dioxide emissions from vehicles, permission that was ultimately granted by the Obama administration in 2009.[73] Other states have been active as well. In 2005, a group of northeastern states formed the Regional Greenhouse Gas Initiative ("RGGI"), a cooperative effort to regulate GHGs within their borders using a marketable permit system[74] not unlike the one already in place in the European Union.[75] The Western

climate-change.html ("Backers of Proposition 23, the ballot initiative to suspend California's ambitious global warming law, conceded defeat."). Also, I found information on a current judicial challenge to AB 32: "California's measures to combat climate change have suffered a temporary setback last week as Judge Ernest A. Goldsmith of San Francisco Superior Court enjoined California's Air Resources Board (CARB) from further rule-making to implement the California Global Warming Solutions Act (A.B. 32) in *Association of Irritated Residents v. California Air Resources Board*. The main crux of the opinion is that the Air Resources Board, which is tasked with preparing and approving a 'Scoping Plan' to reduce carbon emissions to 1990 levels by 2020 by A.B. 32, did not consider any alternatives to the cap and trade scheme it eventually decided on. The Court stated that 'the A.R.B. seeks to create a fait accompli by premature establishment of a cap-and-trade program before alternatives can be exposed to public comment and properly evaluated by the A.R.B. itself.'" Sinan Diniz, *California's Climate Change Law Suffers Legal Setback*, GEO. INT'L ENVTL. L. REV. (Mar. 25, 2011), http://gielr.wordpress.com/2011/03/25/californias-climate-change-law-suffers-legal-setback.

71. *See* Peter Henderson, *California Gov. to Get Chance to 'Mark' Climate Law*, REUTERS (Apr. 17, 2011), http://www.reuters.com/article/2011/04/17/carbon-california-idUSN1719801220110417 ("Brown's support of the state's broad climate change law was a hallmark of his campaign last year to be governor again . . . .").

72. California is the only state authorized to establish its own standards for automobiles. The other 49 states may choose to apply either the federal standards or the California standards.

73. California's petition to regulate carbon dioxide emissions from cars was rejected by EPA during the Bush administration on the grounds that carbon dioxide is not a "pollutant" under the Clean Air Act. In *Massachusetts v. EPA*, the Supreme Court determined that EPA does have the power to regulate carbon dioxide as a pollutant under the Clean Air Act. *See* Massachusetts v. EPA, 549 U.S. 497, 528 (2007). In June of 2009, EPA during the Obama administration reversed its position and granted California permission to regulate carbon dioxide emissions from cars. Gary Gengel & Kegan Brown, *President Obama Directs EPA to Reconsider California Waiver Request to Regulate Greenhouse Gases*, BLOOMBERG L. REP. (2009), *available at* http://www.lw.com/upload/pubContent/_pdf/pub2779_1.pdf.

74. Under RGGI, participating states are seeking a 10% reduction in carbon dioxide emissions from within their borders by 2018.

75. Under the RGGI program, most marketable permits (called "emissions allowances") are auctioned off to emitters, and the proceeds invested in energy efficiency, renewable energy, and other clean energy technologies. This marks a contrast with the acid rain program, in which pollution rights are distributed to emitters free of charge,

Climate Initiative, a western counterpart to RGGI, has struggled to get off the ground.[76] Meanwhile, the Obama EPA has begun the process of regulating GHGs as pollutants under the Clean Air Act.[77] That effort has met with resistance from Republicans and coal state Democrats in Congress.[78] However, as support for climate science's basic conclusions grows worldwide,[79] and EPA and the states continue to press for GHG emissions limits, the relative price of fossil fuel generation seems likely to increase.

All of these developments—state RPSs, tax credits and carbon regulation—have stimulated innovation and improvements in wind and

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based on past emissions. The European Union's carbon trading scheme also distributes its pollution rights free of charge, for the most part.

76. "The Western Climate Initiative ("WCI") will be the most ambitious attempt to reduce GHGs and combat global warming. However, with ambitions come pragmatic problems, chief among these is the question of how to enforce the parties' compliance with their obligations under the WCI. This is particularly relevant because the WCI contains no enforcement body, and relies on nothing but the good faith of the individual jurisdictions to enforce the agreement." *See* Brooks V. Rice, *The "Triumph" of the Commons: An Analysis of Enforcement Problems and Solutions in the Western Climate Initiative*, 22 PAC. MCGEORGE GLOBAL BUS. & DEV. L.J. 401, 402 (2010).

77. Prevention of Significant Deterioration and Title V Greenhouse Gas Tailoring Rule, 75 Fed. Reg. 31,514 (June 3, 2010) (to be codified at 40 C.F.R. pts. 51, 52, 70, and 71).

78. "Congressional Republicans vowed Wednesday to prevent the Environmental Protection Agency from reducing the pollution that contributes to global warming, underscoring the threat with a proposed deep cut to the agency's budget. 'Congress intends to reassert itself in the statutory and regulatory process at EPA and specifically the Clean Air Act,' said Rep. Ed Whitfield, R-Ky., chair of a House subcommittee on energy and power at the start of a hearing Wednesday on a draft bill that would block the EPA from using the act to control heat-trapping pollution." Dina Cappiello, *Global Warming Fix Heats up Hearing with EPA Chief*, ASSOCIATED PRESS (Feb. 10, 2011), http://www.timesfreepress.com/news/2011/feb/10/global-warming-fix-heats-hearing-epa-chief/?print.

79. In 2008, "the Rudd government released a 'Green Paper' outlining its initial plans for a Carbon Pollution Reduction Scheme (CPRS), a policy based on a cap-and-trade approach to emissions reductions along the lines of the European Emissions Trading Scheme (ETS). A 'White Paper' outlining the final plans for the proposed CPRS was subsequently released in December, 2008, as the Australian government announced a emissions reductions target of between 5% (unilaterally) and 15% (in concert with other nations) reduction below 2020 levels, and a proposed 60% reduction by 2050 (Commonwealth of Australia, 2008). In the face of severe criticism for its lack of ambition (Foley, 2008) the government justified its target in terms of the implications for per capita emissions, which it argued were on par with those promised by other nations. It was not long before the Rudd government responded to its critics who said that the targets were not ambitions enough. In May, 2009 the interim target was increased to a 25% reduction and the proposed starting implementation date for the CPRS was delayed to 2011, justified on the need to allow the economy to regain strength in the aftermath of the global financial crisis (Australian Government, 2009a)." Roger A. Pielke, Jr., *An Evaluation of the Targets and Timetables of Proposed Australian Emissions Reduction Policies*, 14 ENVTL. SCI. & POL'Y 20, 21 (Nov. 13, 2010), *available at* http://sciencepolicy.colorado.edu/admin/publication_files/2010.36.pdf.

solar power projects. The wind turbines of today are much larger and more efficient than the wind turbines of the late 20th century.[80] In the first decade of the 21st century, installed wind power capacity in United States has grown fifteen-fold, from 2,472 MW in 2000 to 40,180 MW in 2010.[81] Likewise, photovoltaic ("PV") solar cells have grown more energy-efficient over time,[82] and thin-film solar technology has helped improve the cost efficiency of PV solar power. Concentrated solar power ("CSP") has experienced similar efficiency improvements.[83] As a consequence, installed solar capacity in United States by the top 10 solar utilities has doubled since 2009.[84] Not surprisingly, the U.S. Energy

80. "[T]he main trends dominating the wind energy market in recent years . . . [are] the size increase of contemporary [wind turbines], . . . efficiency improvements, and a long-term reduction of the specific investment cost per kW (turnkey cost)." *See* John K. Kaldellis & D. Zafirakis, *The Wind Energy (R)evolution: A Short Review of a Long History*, 36 RENEWABLE ENERGY 1887, 1894 (2011), *available at* http://www.sciencedirect.com/science/article/pii/S0960148111000085.

81. *U.S. Installed Wind Capacity and Wind Project Locations*, U.S. DEP'T OF ENERGY, http://www.windpoweringamerica.gov/wind_installed_capacity.asp#current (last visited June 13, 2011).

82. *See* Martin A. Green, *The Path to 25% Silicon Solar Cell Efficiency: History of Silicon Cell Evolution*, 17 PROGRESS IN PHOTOVOLTAICS: RESEARCH & APPLICATIONS 183, 183 (2009), *available at* http://onlinelibrary.wiley.com/doi/10.1002/pip.892/abstract ("The first silicon solar cell was reported in 1941 and had less than a 1% energy conversion efficiency compared to the 25% efficiency milestone reported in this paper. Standardization of past measurements shows there has been a 57% improvement between confirmed results in 1983 and the present result.").

83. "The key to the commercial development of CSP is establishing a consistent annual deployment schedule leading to lower costs. In a US-DOE sponsored study, Sargent and Lundy (2003) estimated that such cost reductions could be realized through economies of scale by building large plants, through learning-curve experience with manufacturing components in volume, and through technical improvements from continuing research (Shinnar and Citro, 2006). The Solar Energy Task Force of the Western Governors' Association (WGA) concluded that CSP electricity prices of $0.10/kWh or lower are possible with construction of 4 GW by 2015 (San Diego Regional, 2005; WGA, 2006). To help meet the CSP deployment goal, the US-DOE's Energy Efficiency and Renewable Energy Office and the WGA agreed to promote the installation of 1 GW of new parabolic trough CSP plants by 2010." Vasilis M. Fthenakis et al., *The Technological, Geographical, and Economic Feasibility for Solar Energy to Supply the Energy Needs of the US*, 37 ENERGY POL'Y 387, 390 (2009), *available at* http://www.sciencedirect.com/science/article/pii/S0301421508004072.

84. *Table 4 U.S. Electric Net Summer Capacity, 2005–2009*, U.S. ENERGY INFO. ADMIN. (Aug. 2010), http://www.eia.gov/cneaf/alternate/page/renew_energy_consump/table4.html.

Information Administration projects further growth in installed capacity for these electricity generation technologies in the near future.[85]

B. Limits to Growth: Intermittency, Variability, and Geography

While renewables have done well in recent years, it remains true that most new renewable electricity comes from wind energy. Growth in wind power dwarfs the growth of all other renewable resources over the last decade. Of course, wind power is intermittent. It increases and decreases as wind speeds change. Therefore, the amount of electricity generated by a wind farm over time will be significantly less predictable than the amount of electricity generated by fossil fuel generation. This poses a problem for grid operators, who must continuously balance loads. Wind power is dispatched to the grid whenever it is available because in the usual case, generation sources are dispatched to the grid in ascending order of marginal cost. The marginal cost of wind generation is effectively zero, and so it is dispatched even before cheap coal power. Thus, because of the possibility that wind generation levels may decrease at any moment, grid operators must maintain spinning reserves and regulation from other sources.

Because grid operators cannot count on wind capacity, they may deny wind generation capacity credits available to more reliable sources of electricity, and/or penalize wind generators financially for failing to provide forecasted amounts of energy and for the additional ancillary services that must be made available to back up wind. Wind generators claim that these practices are unfair, and that wind forecasting has improved greatly,[86] reducing the amount of regulation and reserves needed to supplement wind power. FERC apparently agrees, and in November 2010 it proposed a rule on the integration of "variable energy resources" ("VERs").[87] The proposed rule would require transmission utilities

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85. The Annual Energy Outlook 2011 contains three different scenarios for the growth of renewable energy. Under the Reference Case, it is assumed that existing laws and regulations will remain unchanged throughout the projection period, unless the legislation establishing the law sets a sunset date or specifies how they will change. The No Sunset Case assumes the extension of tax credits for renewable energy sources and for energy-efficient building equipment. The Extended Policies Case includes the No Sunset assumptions, plus an increase in certain energy-efficiency standards. "In 2035, the share of total electricity generation accounted for by renewables is 14 percent in the Reference Case, as compared with 16 percent in the No Sunset case and the Extended Policies case." *See Annual Energy Outlook 2011 with Projections to 2035*, U.S. ENERGY INFO. ADMIN. 18–21 (Apr. 2011), *available at* http://www.eia.gov/forecasts/aeo/pdf/0383(2011).pdf.

86. Joshua Z. Rokach, *Bending to the Wind*, 24 THE ELECTRICITY J. 86, 88 (2011).

87. "Accordingly, the Proposed Rule would: (1) require public utility transmission providers to offer intra-hourly transmission scheduling; (2) incorporate provisions

(including RTOs and ISOs) to schedule transmission in smaller increments of time (15 minutes rather than 60 minutes), thereby increasing the probability that wind power will hit its projected generation target within the specified increment. In order to promote centralized wind forecasting, the rule would require wind generators to provide wind forecasting data to transmission utilities. Finally, the rule would also require transmission utilities to provide regulation service necessary to support wind. FERC hopes that these changes will ease wind integration into the transmission system.

Nevertheless, wind power remains an intermittent resource, and must be backed up by other sources. When that source is a fossil fuel generator, that generator will be burning fuel and producing emissions, even if it is not dispatching electricity to the grid. Moreover, a fossil fuel generator will be cycling up and down to match the variability of wind production. This means that the fossil fuel generator will be operating less efficiently, causing more wear and tear (and costs). More importantly, it will be consuming more fuel per megawatt-hour (MWh) of electricity dispatched to the grid, and therefore produce more pollution emissions.

Thus, if wind power is displacing fossil fuel generation, it will result in a reduction of GHG emissions, but not on a MWh to MWh basis. Recently, there have been a number of studies on the environmental effects of integrating wind into the electric grid, and they have reached somewhat inconsistent conclusions. The Eastern Wind Integration Study[88] examined four scenarios: three involved 20 percent penetration of wind into the Eastern Interconnection (about a tenfold increase above current levels) in different onshore and offshore configurations, and a fourth

into the *pro forma* Large Generator Interconnection Agreement requiring interconnection customers whose generating facilities are variable energy resources to provide meteorological and operational data to public utility transmission providers for the purpose of power production forecasting; and (3) add a generic ancillary service rate schedule through which public utility transmission providers will offer regulation service to transmission customers delivering energy from a generator located within the transmission provider's balancing authority area. The proposed reforms will remove barriers to the integration of variable energy resources." Integration of Variable Energy Resources, 133 Fed. Reg. 61,149, 61,149 (Nov. 18, 2010), *amending* 18 C.F.R. § 35.28(c)–(f), *available at* http://www.ferc.gov/whats-new/comm-meet/2010/111810/E-1.pdf.

88. EnerNex Corp., *Eastern Wind Integration and Transmission Study*, NAT'L RENEWABLE ENERGY LAB. (Feb. 2011), *available at* http://www.nrel.gov/wind/systems integration/pdfs/2010/ ewits_final_report.pdf.

looked at 30 percent wind penetration.[89] Carbon emissions reductions under these scenarios ranged from between 4 and 5 percent in the three "20 percent wind scenarios," and jumped to more than 18 percent in the "30 percent wind scenarios." Assuming future regulation yielding a high ($100/ton) carbon price, emissions reductions jump to more than 32 percent.[90] By contrast, a study of the integration of wind at high levels in Colorado and Texas, performed by the Bentek Corporation, concluded that integration of wind into those systems would require the cycling of coal-fired power plants; consequently, emissions reductions from integration of wind were negligible (for carbon dioxide) or negative (for sulfur dioxide and nitrogen oxides).[91] A study of the effects of integrating wind in the Southwest Power Pool reached similar conclusions, crediting the need to cycle coal plants more frequently.[92]

In some systems, however, wind power is backed up by something other than fossil fueled generators. In the Scandinavian grid, for example, Danish wind power is backed up by hydroelectric power, some of it Danish and some of it from elsewhere in Scandinavia.[93] The Spanish system also backs up renewables with hydroelectric power.[94] While hydroelectric power does not generate carbon emissions, using hydroelectric power to match wind requires hydroelectric stations to operate in storage rather than run-of-river mode,[95] which has adverse impacts on wetlands

89. The authors of the study deemed each of these scenarios technically feasible, but each would require additional investments and transmission infrastructure. They also concluded that with proper infrastructure investments, these levels of wind penetration would increase electricity prices by only about a half a cent per kWh. *Id.* at 27–30.

90. *Id.* at 47–50.

91. *How Less Became More: Wind, Power and Unintended Consequences in the Colorado Energy Market*, BENTEK ENERGY 73 (2010), *available at* http://www.bentekenergy.com/Index.aspx.

92. *See* J. Nicholas Puga, *The Importance of Combined Cycle Generating Plants in Integrating Large Levels of Wind Power Generation*, 23 ELECTRICITY J. 33, 33 (2010).

93. "As found in Northern Germany and Denmark, where wind is already responsible for 20% of generation, balancing may be achieved through good forecasting and use of geographic, as well as fuel, diversification. Here stored hydroelectric power and natural gas generation back up intermittent renewable supply . . . ." *See* M.K. Heiman, *Expectations for Renewable Energy Under Market Restructuring: The U.S. Experience*, 31 ENERGY 1052, 1057 (2005).

94. "Over the last ten years, [feed-in tariff] systems have become an effective instrument for European countries to generate electricity from [renewable energy sources ("RES")], especially through wind turbine production. Germany, Denmark, and Spain have been the most successful of these countries. Through this system, distributors are required to buy the energy generated by RES at the price determined by the regulator for a certain period of time." *See* Aitor Ciarreta et al., *Renewable Energy Sources in the Spanish Electricity Market: Instruments and Effects*, 15 RENEWABLE & SUSTAINABLE ENERGY REV. 2510, 2514 (2011), *available at* http://www.sciencedirect.com/science/article/pii/S1364032111000724.

95. A standard hydroelectric project can store water behind the dam and let the reservoir level rise when power is not needed, and run water through the powerhouse to

and aquatic ecology in the reservoirs of hydroelectric facilities. Moreover, sometimes other values will trump carbon emissions considerations. Recently, high river flows caused the temporary oversupply of hydroelectricity in the Northwest, leading the Bonneville Power Administration to limit the dispatch of otherwise available wind energy, in order to protect fisheries in the affected rivers and the reliability of the grid.[96]

More work needs to be done to resolve these conflicting projections, but there may be reason for some optimism. From a climate change point of view, it would be ideal if wind power could be backed up by another clean resource. Nuclear power cannot cycle quickly enough to back up wind, and is facing its own set of political and other problems in the wake of the Fukushima disaster.[97] The use of hydroelectric power as a backup for wind in Scandinavia and Spain seems ideal from a climate change perspective, but is only an option where hydroelectric power is plentiful and where there is a willingness to operate hydro stations to back up wind. As a backup for wind, natural gas is an option and has advantages over coal. It emits fewer GHGs, and newer combined cycle gas turbines are being built to cycle up and down more efficiently, reducing the emissions associated with cycling.[98] Moreover, the emissions effects of cycling in even the older, less efficient gas-fired turbines are less severe than those associated with cycling coal plants. Some speculate that solar power can match wind effectively, since their production profiles are complementary. The wind tends to blow harder at night, when the sun isn't shining, and less so during the day. It may also be possible to

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generate electricity when power is needed. The alternative (and the norm in the United States) is to operate hydroelectric projects in run of river mode, such that the amount of water entering the reservoir from upstream equals the amount of water being run through the powerhouse any given moment. Pumped storage hydroelectric projects do not use a dam and are designed as storage facilities. In pump storage projects, water is pumped uphill to a reservoir for storage, and then run down through a powerhouse when electricity is needed.

96. Press Release, Bonneville Power Admin., High River Flows Caused Limits on Thermal, Wind Generation (May 18, 2011), *available at* http://www.bpa.gov/corporate/BPANews/ArticleTemplate.cfm?ArticleId=article-20110518-01.

97. *See* Simon Lomax, *Japan Nuclear Crisis to Force U.S. Changes, NRC Members Say*, BLOOMBERG (June 16, 2011), http://www.bloomberg.com/ news/2011-06-16/japan-nuclear-crisis-to-force-u-s-changes-nrc-members-say-1-.html ("Lawmakers and regulators are taking a closer look at U.S. reactors after a magnitude-9 earthquake and tsunami on March 11 knocked out power lines at Tokyo Electric Co.'s Fukushima Dai-Ichi plant").

98. Puga, *supra* note 92, at 34.

back up wind with demand-side resources, which are the subject of the next section of this essay.

III. EFFICIENCY AND CONSERVATION

In principle, if our goal is to reduce the GHG intensity of our electric generation mix, we could back up wind with demand response—short term changes in demand that mirror changes in wind production. For that matter, we could do even more to fight climate change with demand-side management: that is, we could reduce our GHG emissions (irrespective of any change in the electric generation mix) simply by reducing the amount of electricity we use to provide the same services. Indeed, some analysts point to conservation and greater energy efficiency as the key to combating climate change. The logic of conservation and efficiency is simple. It is not electricity that we really want: rather, it is the services that electricity provides. If we can obtain those same services using less electricity, we can (i) save money, and (ii) reduce the environmental impacts associated with exploiting coal and other fuels to generate electricity. Because we can save money by using energy more efficiently, many of the gains associated with maximizing energy efficiency are already being realized. According to the U.S. Energy Information Administration, the energy intensity of the American economy (measured in year 2000 dollars) declined from $19.57 per British thermal unit ("BTU") in 1949 to $8.52 per BTU in 2008.[99] Businesses, in particular, have exploited energy efficiency opportunities better since the energy crises of the 1970s.

But there remain additional unrealized opportunities as well. The American economy generates more output per capita than other economies; however, despite efficiency gains, per capita energy consumption in the United States remains very high—nearly double that of the average Western European.[100] Nearly half of the possible reductions for stabilizing GHG concentrations that Socolow and Pacala identify in their stabilization wedges analysis can be realized through various forms of conservation

99. *See Annual Energy Review*, U.S. ENERGY INFO. ADMIN. (Oct. 19, 2011), *available at* http://www.eia.doe.gov/emeu/aer/txt/ptb/0105.html.

100. In 2006, United States per capita consumption of primary energy was 334.6 million BTU, compared to 134.8 million BTU per capita in Europe. *International Total Primary Energy Consumption and Energy Intensity*, U.S. ENERGY INFO. ADMIN., *available at* http://www.eia.doe.gov/emeu/international/energyconsumption.html (last visited Sept. 25, 2011). In 2007, estimates for electricity consumption as "kWh/capita" show that U.S. individual demand (13,616 kWh) greatly exceeds demand in Germany (7,185 kWh), Spain (6,296 kWh), and the United Kingdom (6,142 kWh). *See Key World Energy Statistics*, INT'L ENERGY AGENCY 48, 51, 57 (2009), *available at* http://www.iea.org/textbase/nppdf/free/2009/key_stats_2009.pdf.

or efficiency.[101] Similarly, a recent study by the consulting firm McKinsey and Co. predicted that energy efficiency investments could yield a 23 percent reduction in energy demand in the United States, and benefits that more than double the costs.[102]

If there remain cost-effective opportunities to reduce energy consumption, why aren't these opportunities being realized?[103] Some scholars ascribe these unrealized opportunities to behavioral heuristics that prevent people from recognizing the opportunities posed by efficiency investments, and suggest that the problem is one of "norm activation."[104] Economist Stephen DeCanio calls this tendency of consumers to miss opportunities to save money through energy efficiency "the energy efficiency paradox."[105] John Dernbach argues that people pass up opportunities to save energy and money because the issue of energy efficiency is not sufficiently salient to them. They lack information about the energy they are using, about opportunities to save money by using less energy, and (perhaps most importantly) about how much energy their peers are using. Dernbach argues that governments and private standard-setting organizations can activate norms of energy efficiency by ensuring that consumers understand national and local energy efficiency goals and

101. Pacala & Socolow, *supra* note 7, at 969–70. For a detailed breakdown of the various energy efficiency law and policy improvements that might comprise these various wedges, see John Dernbach, *Stabilizing and Then Reducing U.S. Energy Consumption: Legal and Policy Tools for Efficiency and Conservation*, 37 ENVT'L L. REV. 10003, 10014–27 (2007).

102. *Unlocking Energy Efficiency in the U.S. Economy*, MCKINSEY & CO. 7 (July 2009), *available at* http://www.mckinsey.com/Client_Service/Electric_Power_and_ Natural _Gas/Latest_thinking/~/media/McKinsey/dotcom/client_service/EPNG/PDFs/Unlocking %20energy%20efficiency/US_energy_efficiency_full_report.ashx.

103. The problem, argued McKinsey, is that the various energy-saving opportunities in the U.S. economy are fragmented, spread across more than 100 million locations and billions of individual devices, making coordinated solutions difficult. Thus, part of the problem is that many of the remaining unrealized energy efficiency opportunities can be realized only by individuals, not businesses. They are attached to individual consumers' decisions: to purchase relatively energy inefficient homes, cars, and appliances, for example. *Id.* at viii, 22–23.

104. *See, e.g.*, Hunt Allcott & Sendhil Mullainathan, *Behavior and Energy Policy*, 327 SCIENCE 1204 (2010) (summarizing some of the literature on new norms and energy consumption, and suggesting ways to activate norms of conservation and efficiency investment); Michael P. Vandenbergh & Anne C. Steinemann, *The Carbon Neutral Individual*, 82 N.Y.U. L. REV. 1673, 1697 (2007); John C. Dernbach, *Overcoming the Behavioral Impetus for Greater U.S. Energy Consumption*, 20 PAC. MCGEORGE GLOBAL BUS. & DEV. L.J. 15 (2007).

105. Stephen J. DeCanio, *The Efficiency Paradox: Bureaucratic and Organizational Barriers to Profitable Energy-Saving Investments*, 26 ENERGY POL'Y 441, 443 (1998).

have access to information about their (and their peers') energy usage.[106] This view is echoed by many others,[107] including the authors of the McKinsey & Co. study.[108] Of course, only some of these opportunities involve electricity consumption; others involve consumption of transportation fuels, natural gas in homes and businesses, etc. On the other hand, Socolow and Pacala identify electricity consumption efficiency (including demand reduction) as a stand-alone carbon wedge,[109] implying the possibility of significant emissions reduction gains through more efficient electricity consumption.

One way to promote demand reduction is to price the electricity to reflect scarcity, that is, to allow consumers to be exposed to higher retail prices when demand is highest and reserve (supply) margins lowest. A few states are beginning to experiment with dynamic pricing,[110] but only tentatively. The ERCOT wholesale market in Texas, has recently moved to "locational marginal pricing," also known as "nodal pricing," which prices wholesale electricity in ways that reflect the full cost of delivery to particular nodes on the Texas electric grid at particular times of day.[111] This is a form of dynamic pricing at the wholesale level. However, these tentative steps aside, state regulators have not shown much appetite for this kind of dynamic pricing or real-time pricing at the retail level,[112] which, after all, exposes customers to substantial price risk.

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106. Dernbach, *supra* note 104, at 28–35, 40.

107. *See* Michael P. Vandenberg, *Order Without Social Norms: How Personal Norm Activation Can Protect the Environment*, 99 NW. U. L. REV. 1101 (2005) (exploring the implications of norm activation in environmental law generally); Michael P. Vandenberg, Amanda R. Carrico & Lisa Schultz Bressman, *Regulation in the Behavioral Era*, 95 MINN. L. REV. 715, 763–79 (2011) (exploring the implications of behavioralism for aspects of energy policy); Dean Karlan, *Nudges for Energy Conservation*, ECOALIGN (June 2010), http://www.ecoalign.com/node/365?sid=3197 (proposing a variety of regulatory policies aimed at promoting energy conservation); Robert Spencer & Mani Vadari, *Smart Grid: A Customer Challenge*, 147 PUB. UTILS. FORTNIGHTLY 48 (2009), *available at* http://www.fortnightly.com/display_pdf.cfm?id=10012009SmartGridCust Challenge.pdf (contending that reducing consumption requires much more than new pricing structures).

108. *Unlocking Energy Efficiency in the U.S. Economy*, *supra* note 102, at 26, 93, 95–97.

109. Pacala & Socolow, *supra* note 7, at 968–69.

110. Real-time pricing and dynamic pricing is referred to as a pricing system under which customers would pay rates for electricity that reflect the cost of providing it is on a real-time basis.

111. *ERCOT—What's Changing*, ELECTRIC RELIABILITY COUNCIL OF TX., http:// nodal.ercot.com/about/wc/index.html (last visited Sept. 25, 2011).

112. FERC is also encouraging the use of real-time pricing, or dynamic pricing, reasoning that for electricity markets to allocate resources efficiently, electricity prices must fluctuate. Specifically, during times of scarcity, high prices will provide customers with an incentive to reduce their demand and will send a signal to prospective entrants to the generating capacity market to increase supply. This requires the ability to measure electricity consumption on a real-time basis, rather than the once-a-month, meter-reader

In states that have moved to competitive retail markets, electricity retailers manage price risk on behalf of their retail customers. Electric retailers may face volatile scarcity prices as buyers in organized wholesale markets (those managed by RTOs and ISOs), but they generally protect their customers from those rapid price swings by offering customers fixed price contracts or variable price contracts that mute the effects of short-term wholesale price swings on retail prices. To protect themselves against wholesale market price risks, utilities turn to futures markets or other derivatives markets.[113]

For its part, FERC has promoted policies encouraging demand response by nudging ISOs and RTOs to use demand reduction in times of electricity scarcity. FERC's Order 719 required ISOs and RTOs to examine both demand- and supply-side responses to the problem of scarcity, and required RTOs and ISOs to accept demand response bids in supply-constrained spot markets for the physical delivery of electricity.[114] FERC's Order 890 did the same for the provision of ancillary services in electricity markets.[115] In addition, many ISOs and RTOs are addressing the problem of long-term resource adequacy (that is, the problem of ensuring that there will be adequate electric generating capacity in the future) by maintaining "capacity markets," in which electric service providers pay suppliers of electric generating capacity for making that

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measurements that have been traditional in the electricity industry. The introduction of "smart meters" and "smart grid" architecture will enable these kinds of more refined measurements. Many states are engaged in complementary efforts, which have led to the introduction of smart meters and smart grid architecture in some parts of the country.

See FERC: Industries—Smart Grid, FERC, http://www.ferc.gov/industries/electric/indus-act/smart-grid.asp (last visited Sept. 25, 2011).

113. Derivatives markets allow companies exposed to price risk to hedge that risk by purchasing the right to buy or sell energy at a fixed price in the future. An electricity retailer may use futures or other types of derivatives to ensure the right to acquire electricity on the wholesale market at a price certain in the future. Alternatively, it may purchase a futures contract, which entitles it to purchase natural gas (to feed its natural gas-fired electric generating facilities) at a price certain in the future. In this way, derivatives products allow energy companies to minimize the effects of price swings in the future. For more on energy derivatives markets, see David B. Spence, *Can Law Manage Competitive Energy Markets?*, 93 CORNELL L. REV. 765, 804–06 (2008).

114. Order No. 719, Wholesale Competition in Regions with Organized Electricity Markets, 73 Fed. Reg. 64,100, 64,107 (Oct. 28, 2008) (to be codified at 18 C.F.R. pt. 35).

115. Order No. 890-A, Preventing Undue Discrimination and Preference in Transmission Service, 73 Fed. Reg. 2,984, 3,044–45 (Dec. 28, 2007) (to be codified at 18 C.F.R. pt. 37); Order 719, 73 Fed. Reg. at 64,107.

capacity available to serve load in the future.[116] Order 719 specified that ISOs and RTOs must accept bids for future demand reduction, along with bids for supply capacity from plants, in those capacity markets.[117]

More recently, FERC issued Order 745, requiring ISOs and RTOs to compensate providers of demand response resources in balancing markets by paying those providers the full locational marginal price for those resources.[118] FERC's intention is to provide a further incentive for ISOs and RTOs to look to demand response rather than generation alternatives when trying to balance loads. Some commentators contend that paying full locational marginal price for demand response resources overcompensates the providers of those resources. Locational marginal prices reflect the value of both generation capacity and the energy provided to a particular location on the grid. The provider of demand response essentially agrees to forgo consumption in order to help balance loads at a particular time and place. Under Order 745, when a provider of demand response forgoes consumption in this way, he forgoes paying for that energy. Critics say that by compensating the provider of these demand response services with a price that reflects not only the avoided generating capacity but also the avoided energy costs, the provider is double compensated for those energy costs.[119] FERC has responded to these concerns by limiting the requirement that providers of demand response receive full locational marginal price for their resources to situations in which paying that price increases net benefits to consumers as a group.[120]

All of these developments should push organized electricity markets toward greater energy efficiency, but progress will be incremental. There remains a strong political resistance to exposing end-users (at least, residential consumers) to prices that reflect the true cost of delivered electricity over short-term increments of time. This resistance will mean that some price inefficiency will remain in the system, dampening the energy efficiency gains realizable from proper pricing, for the foreseeable future.

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116. For a description of the New York Independent System Operator's capacity markets, see *NYISO (About NYISO—Understanding the Markets—The Capacity Market)*, NYISO, http://www.nyiso.com/public/about_nyiso/understanding_the_markets/capacity_market/index.jsp (last visited Oct. 24, 2011).

117. Order No. 719, 73 Fed. Reg. at 64,114.

118. Order No. 745, Demand Response Compensation and Organized Electricity Markets, 76 Fed. Reg. 16,658, 16,666–67 (Mar. 15, 2011) (to be codified at 18 C.F.R. pt. 35).

119. Order No. 745, 76 Fed. Reg. at 16,662–63.

120. FERC established a "net benefits test" in Order 745 for determining when consumers will benefit from the provision of demand response resources in organized markets. That test is described at Order No. 745, 76 Fed. Reg. at 16,671.

IV. CONCLUSION

A large part of our carbon emissions come from fossil fueled electric generating plants. Therefore, it is entirely understandable that we might look to renewable sources of electricity as a way to reduce our carbon emissions, and to energy efficiency as a way to reduce our electricity consumption. We know that we are capable of generating electricity from wind, solar and other clean sources, and that we are improving our ability to integrate that electricity into the grid. Similarly, we know that there exist significant opportunities to reduce our electricity usage through efficiency improvements. It follows, then, that we ought to be able to drastically increase the percentage of electricity that comes from renewable sources, and drastically decrease the amount of electricity we consume. However, it is not that simple. There are still important and fundamental impediments to the integration of very large quantities of wind and solar power into the electric generation mix.

First, these sources of electricity remain significantly more expensive than their traditional counterparts. Even if it were technically possible for us to rely primarily on renewable sources of electricity, doing so would drastically increase electricity costs. Second, renewable electricity is often intermittent, and that intermittency continues to pose problems for operators of the electric grid. In order to maintain a reliable electricity delivery system, grid operators must find ways to match short-term fluctuations in wind and solar power with corresponding adjustments to other (often fossil-fueled) sources of power, and/or to demand. This is not easy. More importantly, the process of scaling electricity production from fossil-fueled plants up and down to match fluctuations in renewable power reduces energy efficiency and increases the pollution intensity of that generation. Thus, according to some recent studies, the integration of much larger amounts of wind power into the electric system will result in only nominal or small reductions in GHG emissions. As an alternative, we might match fluctuation in renewable electricity supply with demand-side responses in order to balance loads. However, that too has proven a complicated and difficult proposition, at least so far. There are behavioral impediments to investment in energy efficiency improvements, and we underinvest in those kinds of improvements. For its part, FERC is trying to encourage grid operators and electric utilities to make better use of demand-side resources. Orders 719 and 745 provide incentives and mandates that ought to result in better usage of demand reduction and demand response as tools to balance loads. Nevertheless, electric retailers seem loath to expose retail customers to the kinds of price risks that would encourage greater efficiency or demand response.

This is not to say that we are doomed to a fossil fueled future. Electric utilities and their suppliers are devoting a great deal of energy and creativity to overcoming the technical impediments to greater reliance on clean sources of electricity, or to greater energy efficiency. Policymakers are attempting to facilitate those efforts, so far in small and measured ways. A policy or technical breakthrough could hasten this process along in currently unforeseeable ways. However, in the near-term, it seems that renewable energy and energy efficiency will remain a relatively small, if growing, part of the electric system.