NEW MEXICO LAW REVIEW

Volume 43
Issue 1 *Spring*

Spring 2013

Smart Incentives for the Smart Grid

Roberta F. Mann

SMART INCENTIVES FOR THE SMART GRID

Roberta F. Mann*

You say you want a revolution
Well, you know
We all want to change the world. . .
You say you got a real solution
Well, you know
We'd all love to see the plan[1]

I. INTRODUCTION

Clean, renewable energy from the sun and wind—the green revolution is supposed to change the world. Since 2005, the United States has increased government investment in renewable energy generation, both from direct subsidies and indirectly through tax subsidies. Many other countries also provide incentives for producing electricity from renewable sources. But before renewable energy can change the world, it has to get to the customers who use it. Thomas Edison did change the world when he developed the first working electric power system. Unfortunately, the system for transmitting electrical power throughout the United States (the "grid") has not changed much since then. The grid was designed and built around fossil energy generation. Intermittent renewable sources such as wind and solar pose logistical challenges to maintaining a consistent flow of electricity to users. This problem can be solved the hard way or the soft way. The hard way is building more and longer transmission lines. The soft way is conserving energy and smoothing demand by smart grid technology.

The term "smart grid" refers to a distribution system that allows for flow of information from a customer's meter in two directions: both inside the house to thermostats, appliances, and other devices, and back to the utility. This will allow for better planning and operations during peak

---

* Frank Nash Professor of Law, University of Oregon School of Law. Thanks are due to the University of Oregon School of Law for supporting my research; my superb research assistant, Craig Ashford; the organizers of the 12th Global Conference on Environmental Taxation; and the participants at the 2012 Law & Society Conference, in particular, Neil Buchanan, Adam Chodorow, and Omri Marian. Any errors are entirely my fault, unless someone else would like to take the blame.

1. THE BEATLES, *Revolution* (Apple 1968).

demand. It is estimated that a 4 percent peak load reduction could be achieved using smart grid technologies. The goal is to use advanced, information-based technologies to increase power grid efficiency, reliability, and flexibility, and reduce the rate at which additional electric utility infrastructure needs to be built.

Smart grid technology can overcome logistical challenges at a much lower cost than building more transmission lines. This article will examine the incentives provided through the tax system for development and implementation of smart grid technology, assessing the progress of the United States and considering strategies for the future. Tax policies that could facilitate the development of the smart grid include incentives for plug-in electric vehicles used to store and manage energy, the credit for qualified advanced manufacturing and enhanced cost recovery to facilitate additional investment in grid technology.

A. Renewable Fuels Statistics

While fossil fuels still run the world economy, providing about 80 percent of the world's energy needs, climate change, energy security, and supply concerns are encouraging a shift to renewable fuels.[2] Among renewable fuels, wind and solar top the list in terms of availability, abundance, and environmental desirability.[3] Worldwide investment in renewable energy, led by wind and solar, is at all-time highs.[4] In 2009, more wind power was installed in Europe than any other electricity-generating technology.[5] In the United States, wind power has increased more than fifteen-fold since 2000.[6] The developing world is catching up fast: China overtook the United States in 2009 as the country with the most installed clean energy capacity.[7] In the United States, the growth of re-

2. Zhenguo Yang et al., *Enabling Renewable Energy—and the Future Grid—with Advanced Electricity Storage*, 62 JOM 14 (2010).

3. *Id.*

4. INT'L ENERGY AGENCY, ENERGY TECHNOLOGY PERSPECTIVES: EXECUTIVE SUMMARY – SCENARIOS & STRATEGIES TO 2050, at 11 (2010), *available at* http://www.iea.org/techno/etp/etp10/English.pdf.

5. *Id.*

6. U.S. ENERGY INFO. ADMIN., U.S. DEP'T OF ENERGY, DIRECT FEDERAL FINANCIAL INTERVENTIONS AND SUBSIDIES IN ENERGY IN FISCAL YEAR 2010, at xviii (2011), *available at* http://www.eia.gov/analysis/requests/subsidy/pdf/subsidy.pdf.

7. PEW CHARITABLE TRUSTS, WHO'S WINNING THE CLEAN ENERGY RACE 4 (2010), *available at* http://www.pewtrusts.org/uploadedFiles/wwwpewtrustsorg/Reports/Global_warming/G-20%20Report.pdf.

newable energy investment is strongly linked to government support.[8] The U.S. Department of Energy reports a significant growth in government subsidies to renewable fuels between 2007 and 2010.[9] While remaining a relatively small portion of total United States energy generation (10.3 percent), renewable fuels received more than half of total subsidies (55.3 percent).[10] Of the total renewable energy subsidies, wind received the largest share (42 percent).[11] The future may hold reduced investment in renewable energy, as the U.S. Congress has extended the production tax credit for wind only until the end of 2012.[12]

B. Defining the Grid

Modern economies require a constant and reliable flow of electricity. The electric power system has three functions: (1) generation, (2) transmission, and (3) distribution. The term "grid" refers to the transmission portion of the electric power system. Poor power quality, as characterized by loss or fluctuations in power, has been estimated to cost commercial and industrial users between US$15 billion and US$35 billion annually.[13] Wind and solar power, while clean and renewable, are not constant or reliable.[14] Sudden shifts in wind patterns or sunlight intensity can create surges or lulls in power generation. These fluctuations spell trouble for the transmission part of the electric power system, which is designed to deliver a steady flow of electricity. To maintain the stable operation of the electric system, the system must instantaneously balance the amount of generation supplied and the demand from users ("the load"). If the generation and load are not in balance, brownouts or blackouts may occur.[15] Traditional fossil energy sources can be accessed on demand. The grid operator can simply call for more coal or more gas if greater load requires more generation. Energy from renewable sources such as wind and solar is nondispatchable, that is, it cannot be accessed

---

8. U.S. ENERGY INFO. ADMIN., U.S. DEP'T OF ENERGY, ANNUAL ENERGY OUTLOOK 2011, at 10, 21 (2011) (indicating that extending renewable energy tax credits would lead to more rapid growth in renewable energy generation).

9. U.S. ENERGY INFORMATION ADMINISTRATION, *supra* note 6, at xvii.

10. *Id.*

11. *Id.* at xviii.

12. American Taxpayer Relief Act of 2012, Pub. L. No. 112-240, § 407, 126 Stat. 2340 (2013)*; see also* KPMG INT'L, KPMG'S 2011 ENERGY SURVEY 5 (2012).

13. U.S. DEP'T OF ENERGY, SMART GRID SYSTEM REPORT 32 (2009), *available at* http://www.smartgrid.gov/sites/default/files/resources/systems_report.pdf.

14. Yang et al., *supra* note 62, at 15 ("During the day, wind power can be a few GW in some moments and only a few MW and even zero in others. Similarly, solar power is generated only in the daytime and varies when clouds pass by.").

15. *Id.* at 91.

on demand. The grid operator cannot command the wind to blow or the sun to shine. Accordingly, as the generation mix includes more wind and solar, the balancing task of grid operators becomes more difficult.[16] A serious system imbalance can trigger an automatic emergency shutdown of generation and cause a blackout.[17]

The existing transmission grid was not designed and built for renewable energy generation.[18] It was built for energy on demand, supplied by fossil fuels or large hydroelectric projects.[19] The United States does not have a national power grid, per se. The continental United States is divided into three synchronized transmission networks: the Eastern Interconnection, the Western Interconnection, and the Electric Reliability Council of Texas (ERCOT) network.[20] In 2008, the electric power system in the United States consisted of over 9,200 generating plants with more than a million megawatts of electrical capacity connected to more than 300,000 miles of transmission lines, creating an electrical flow managed by around 150 control centers.[21] It sounds impressive, but electricity infrastructure has not changed much since the 1900s.[22]

The grid is tired and old.[23] The existing power grids in the United States function with technology developed in the 1950s or earlier. About

---

16. U.S. DEP'T OF ENERGY, DOE/GO-102008-2567, 20% WIND ENERGY BY 2030: INCREASING WIND ENERGY'S CONTRIBUTION TO U.S. ELECTRICITY SUPPLY 75 (July 2008), *available at* http://www.nrel.gov/docs/fy08osti/41869.pdf.

17. *Id.*

18. *See* STAN MARK KAPLAN, CONG. RES. SERV. R40511, ELECTRIC POWER TRANSMISSION: BACKGROUND AND POLICY ISSUES 7 (2009); *see also* GLOBAL ENV'T FUND, THE ELECTRICITY ECONOMY 21 (2008), *available at* http://www.globalenvironmentfund.com/data/uploads/The%2520Electricity%2520Economy.pdf; U.S. ENERGY INFO. ADMIN., U.S. DEP'T OF ENERGY, DOE/EIA-0384, ANNUAL ENERGY REVIEW 2011, at 233 (2012), *available at* http://www.eia.gov/totalenergy/data/annual/pdf/aer.pdf (showing no measurable wind or solar power until 1989).

19. KAPLAN, *supra* note 18, at 7.

20. CHI-JEN YANG, ELECTRICAL TRANSMISSION: BARRIERS AND POLICY SOLUTIONS 11 (CCPP Technology Policy Brief Series 2009), *available at* http://www.nicholas.duke.edu/ccpp/ccpp_pdfs/transmission.pdf. New Mexico is in the Western Interconnection.

21. AMY ABEL, CONG. RESEARCH SERV., RL34288, SMART GRID PROVISIONS IN H.R. 6, 110TH CONGRESS 2 (2008).

22. NAT'L SCI. & TECH. COUNCIL, EXECUTIVE OFFICE OF THE PRESIDENT, A POLICY FRAMEWORK FOR THE 21ST CENTURY GRID: ENABLING OUR SECURE ENERGY FUTURE, at v (2011), *available at* http://www.whitehouse.gov/sites/default/files/microsites/ostp/nstc-smart-grid-june2011.pdf.

23. MASS. INST. TECH., THE FUTURE OF THE ELECTRIC GRID 7 (2011) ("The U.S. grid is often referred to as 'antiquated' or 'broken' . . . International comparisons or even comparisons within the U.S. are difficult because of differing geography, rates of growth, and definitions of performance measures.")."

70 percent of all transmission lines and power transformers are twenty-five years old or older, and 60 percent of all circuit breakers are more than thirty years old.[24] Not only is energy different today, energy markets are different. When the grid was designed, utilities were highly regulated and served a local market.[25] Today, many utilities are less regulated and purchase power on competitive wholesale markets serving large areas.[26] The existing power grid system does not have the flexibility to cope with these changes. According to Bill Richardson, former New Mexico Governor and U.S. Energy Secretary under President Bill Clinton, "the United States is a superpower with a Third-World Grid."[27] Moreover, while power generation has increased, the capacity of the transmission grid has not kept up due to lack of investment. From 1975 to 1998, a period that experienced a 40 percent growth in generation capacity, transmission investments barely covered maintenance costs.[28] Since 1982, growth in peak demand for electricity has exceeded transmission growth by almost 25 percent every year.[29] With expected increasing demand for electricity, pressure on the grid will increase.[30] The DOE expects an annual increase of 0.7 percent in primary energy consumption through 2035.[31]

Furthermore, the grid is inefficient: for coal plants, more than two thirds of the power generated is lost to heat; for the most efficient combined cycle natural gas plants, over half the power generated is lost to heat.[32] An additional 7 percent of the power is lost in transmission.[33]

---

24. AMER. SOC. CIV. ENG., FAILURE TO ACT: THE ECONOMIC IMPACT OF CURRENT INVESTMENT TRENDS IN ELECTRICITY INFRASTRUCTURE 19 (2011), *available at* http://www.asce.org/uploadedFiles/Infrastructure/Failure_to_Act/energy_report_FINAL2.pdf.

25. MASSACHUSETTS INSTITUTE OF TECHNOLOGY, *supra* note 23, at 235.

26. YANG, *supra* note 20, at 11.

27. *Id.* at 6.

28. *Id.* at 6–7.

29. U.S. DEP'T OF ENERGY, THE SMART GRID: AN INTRODUCTION 6 (2008), *available at* http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/DOE_SG_Book_Single_Pages%281%29.pdf.

30. W. BREUER ET AL., WORLD ENERGY COUNCIL, PROSPECTS OF SMART GRID TECHNOLOGIES FOR A SUSTAINABLE AND SECURE POWER SUPPLY 2 (2007), *available at* http://www.worldenergy.org/documents/p001546.pdf.

31. U.S. ENERGY INFORMATION ADMINISTRATION, *supra* note 8, at 63–64.

32. To express the efficiency of a generator or power plant as a percentage, divide the equivalent Btu content of a kWh of electricity (which is 3,412 Btu) by the heat rate. U.S. ENERGY INFO. ADMIN., U.S. DEP'T OF ENERGY, ELECTRIC POWER ANNUAL 2010, at 51 (2011), *available at* http://www.eia.gov/electricity/annual/pdf/epa.pdf.

33. To calculate transmission and distribution (T&D) losses as a percentage, divide Estimated Losses by the result of Total Disposition minus Direct Use. Direct Use electricity is electricity that is generated at facilities that is not put onto the electricity

When energy sources are inexpensive, that is not a big problem. But with rising costs and environmental concerns, this is a shocking statistic. The grid is congested; using the System Average Interruption Duration Index (SAIDI), "an index of the average outage duration for each customer served and a common reliability indicator for electric power systems," the United States' best value (70 minutes) is significantly worse than the European average (under 50 minutes) and far behind the world's best practice (under 10 minutes in Singapore and Hong Kong).[34]

At times, the grid is underused. The electrical power system is designed to support peak demand loads, which are much higher than average loads.[35] While electricity users need a steady and constant flow of electricity, taken as a whole, users do not use electricity in a steady and constant way.[36] During the middle of the night, residential energy demand is low.[37] When the weather is hot, everyone turns up the air conditioner. Accordingly, the power system operates at full capacity for only a few hundred hours each year.[38] "Utilities spend billions of dollars a year to build, maintain, and operate peaking plants that are used only rarely, typically driven by extreme temperatures or unplanned emergencies."[39]

One way to reduce the requirement for peaking plants is by increasing long-distance transmission capacity. Although energy losses increase with the distance traveled because of resistance, long-distance transmission uses higher voltage (500kVor greater vs. 120V for standard residential wiring), which minimizes transmission energy losses.[40] More long-distance transmission capacity could also allow more renewable energy

---

transmission and distribution grid, and therefore does not contribute to T&D losses. For 2010, the estimated T&D losses are 6.5%. U.S. ENERGY INFO. ADMIN, U.S. DEP'T OF ENERGY, DOE/EIA-0348(01)/2, STATE ELECTRICITY PROFILES 2010, at 6 (2012), *available at* http://www.eia.gov/electricity/state/pdf/sep2010.pdf.

34. YANG, *supra* note 20, at 6.

35. MASSACHUSETTS INSTITUTE OF TECHNOLOGY, *supra* note 23, at 150.

36. *See, e.g.*, U.S. ENERGY INFO. ADMIN., U.S. DEP'T OF ENERGY, DEMAND FOR ELECTRICITY CHANGES DURING THE DAY (2011), *available at* http://www.eia.gov/todayinenergy/detail.cfm?id=830.

37. *See, e.g.*, *Voluntary time-of-use*, CON EDISON CUSTOMER CENTRAL, http://www.coned.com/customercentral/energyresvoluntary.asp.

38. MICHAEL KINTNER-MEYER, KEVIN SCHNEIDER & ROBERT PRATT, IMPACTS ASSESSMENT OF PLUG-IN HYBRID VEHICLES ON ELECTRIC UTILITIES AND REGIONAL U.S. POWER GRIDS PART 1: TECHNICAL ANALYSIS, PACIFIC NORTHWEST NAT'L LAB 2 (2007), *available at* http://www.ferc.gov/about/com-mem/wellinghoff/5-24-07-technical-analy-wellinghoff.pdf.

39. NATIONAL SCIENCE & TECHNOLOGY COUNCIL, *supra* note 22, at 4.

40. Lara Wong, *A Review of Transmission Losses in Planning Studies*, CAL. ENERGY COMM'N, CEC-200-2011-009, at 6–8 (2011), *available at* http://www.energy.ca.gov/2011publications/CEC-200-2011-009/CEC-200-2011-009.pdf.

into the electrical generation mix.[41] Intermittent power generation is not as much of a problem if the grid can spread power over a larger area, because the unsynchronized peaks and troughs characteristic of wind and solar power can then cancel each other out.[42] "For example, the wind may suddenly stop blowing in either Texas, North Dakota, offshore Massachusetts, or on the Great Lakes, but the chances of the wind stopping in all of these places at the same time is very low."[43] More long-distance transmission capacity also facilitates remote backup capacity or storage facilities, thereby reducing the need for and cost of redundant standby capacity from peak capacity plants.[44] However, there are many barriers to building additional long-distance transmission capacity. A 2008 study estimated that about US$300 billion of transmission investment would be needed from 2010 to 2030.[45] Utilities and electricity generators within regional transmission organizations (RTOs) are generally responsible for initial funding of transmission construction.[46] Investors seek a high return on their investment in transmission lines because jurisdiction over transmission projects is fragmented between state and local jurisdictions, causing delays in the time to obtain necessary permissions.[47] Each state has the ability to determine for itself whether the line should be permitted and the route it should take; this process has likely already inhibited the building of new transmission lines.[48] Citizens tend to object to having power lines built through their backyards or in wilderness areas.[49] Moreover, there is a disconnect (no pun intended) between the financing needs of renewable energy projects and those of transmission projects. Renewable energy projects typically are built in phases over a period of years, but it is not economically feasible to build transmission lines in phases—rather, transmission lines should be built to full capacity even though the power generation may not be at full capacity for a number of years.[50] Regulatory complexity, lack of financial capital, and local opposition will

---

41. YANG, *supra* note 20, at 3.

42. *Id.* at 10–11.

43. *Id.*

44. *Id.*

45. MARC W. CHUPKA ET AL., TRANSFORMING AMERICA'S POWER INDUSTRY: THE INVESTMENT CHALLENGE 2010-2030, at 37 (2008), *available at* http://www.brattle.com/_documents/uploadlibrary/upload725.pdf.

46. YANG, *supra* note 20, at 18.

47. *Id.* at 13–17.

48. KAPLAN, *supra* note 18, at 15.

49. WARREN CAUSEY, *Transmission Strains: A Matter of Keeping the Lights On*, ENERGYBIZ MAGAZINE 18 (2010), *available at* http://www.energybiz.com/magazine/issue/106956/energybiz-magazine-januaryfebruary-2010.

50. KAPLAN, *supra* note 48, at 19.

make it hard to expand the transmission system. These "connectivity challenges" will be discussed in more detail in a subsequent section.

C. Why the Smart Grid?

Investing in smart grid technology may be a lower cost alternative to building more costly transmission lines. The smart grid will give utilities and customers information about timing of energy consumption, and allow utilities to create incentives for customers to shift consumption away from times when the costs of providing electricity are high.[51] By smoothing energy use during highest demand periods, such as a very hot summer day, smart grid technologies could save billions of dollars by reducing utility operating costs.[52] Smart grid technologies can also smooth the peaks and valleys due to renewable energy generation.[53] Potential benefits of the smart grid include avoiding costly blackouts, improving the security and reliability of electrical distribution, facilitating renewable energy development, and reducing the need for new power plant construction.[54]

What are the elements of the smart grid? Definitions vary. According to the U.S. Congress, key elements include:

> (1) Increased use of digital information and controls technology to improve reliability, security, and efficiency of the electric grid; (2) Dynamic optimization of grid operations and resources, with full cyber-security; (3) Deployment and integration of distributed resources and generation, including renewable resources; (4) Development and incorporation of demand response, demand-side resources, and energy-efficiency resources; (5) Deployment of 'smart' technologies (real-time, automated, interactive technologies that optimize the physical operation of appliances and consumer devices) for metering, communications concerning grid operations and status, and distribution automation; (6) Integration of 'smart' appliances and consumer devices; (7) Deployment and integration of advanced electricity storage and peak-shaving technologies, including plug-in electric and hybrid electric vehicles, and thermal-storage air conditioning; (8) Provision to consumers of timely information and control options; (9) Development of standards for communication and interoperability of appliances and equipment connected to the electric grid,

51. NATIONAL SCIENCE & TECHNOLOGY COUNCIL, *supra* note 22, at 4.
52. *Id.*
53. INTERNATIONAL ENERGY AGENCY, *supra* note 4, at 11.
54. AM. COUNCIL FOR AN ENERGY-EFFICIENT ECON., SMART GRID (2009), *available at* http://www.aceee.org/files/pdf/smartgrid_policyposition0809.pdf.

> including the infrastructure serving the grid; and (10) Identification and lowering of unreasonable or unnecessary barriers to adoption of smart grid technologies, practices, and services.[55]

The Department of Energy (DOE) notes that the smart grid will incorporate existing technologies like advanced metering infrastructure (AMI) that relay price signals to "smart" home controllers or end-user consumer devices such as dishwashers or refrigerators and grid visualization that integrates weather, geographical, and user sensor information to avoid potential problems like blackouts. The smart grid will allow grid operators to manage and shift power loads to improve the efficiency of the electric power system. The DOE estimates that smart grid enhancements will ease congestion and deliver between 50 percent and 300 percent more electricity through existing energy corridors.[56] According to the DOE, "the Smart Grid holds the potential to be the most affordable alternative to 'building out' by building less, and saving more energy." Over twenty years, between US$46 billion and US$117 billion in avoided costs from power plant and transmission construction could be saved through smart grid enhancements.[57] While smart grid approaches cannot completely avoid the need to build new infrastructure, they will permit deferring or avoiding some level of investment by incorporating demand response—enabling and incentivizing consumers to shift their electricity usage to off-peak periods. Current grids, backed up by fossil-burning peak plants, can handle some level of renewable power generation.[58] However, when intermittent renewable generation reaches a certain level, the grid becomes unreliable.[59] A study of the Western Interconnection showed no adverse impact on the existing grid with up to 20 percent wind and solar generation.[60] The existing grid can accommodate 30 percent wind and solar generation, but only if weather forecasts are perfect, which seems unlikely.[61] Other studies indicate the limits of renewable

---

55. Energy Independence and Security Act of 2007, Pub. L. No. 110-140, § 1301, 121 Stat. 1492, 1783 (2007).

56. U.S. Department of Energy, *supra* note 29, at 17.

57. U.S. Dep't of Energy, What a Smart Grid Means to the Nation's Future, at 5 (2009), *available at* http://www.smartgrid.gov/sites/default/files/pdfs/sg_policymakers.pdf.

58. Yang et al., *supra* note 2, at 15.

59. *Id.*

60. Debra Lew, Dick Piwko, Nick Miller, Gary Jordan, Kara Clark & Lavelle Freeman, Nat'l Renewable Energy Lab., NREL/TP-5500-50067, How Do High Levels of Wind and Solar Impact the Grid? The Western Wind and Solar Integration Study, at 6 (2010), *available at* http://www.nrel.gov/docs/fy11osti/50057.pdf.

61. *Id.* at 7.

generation range from 10 percent to 20 percent, depending on the size of the grid and the types of renewable generation included.[62]

Shortly after the 2008 election, President-elect Obama announced the goal of 10 percent renewable electricity generation by 2012, and 25 percent by 2025.[63] In his 2011 State of the Union address, President Obama stated a new goal: "By 2035, 80 percent of America's electricity will come from clean energy sources."[64] This level of renewable energy generation will challenge today's grid resources. Tax policy fostered and grew the nascent oil industry in the early twentieth century.[65] As the next section will illustrate, tax policy has played a key role in the development of renewable energy in the early twenty-first century.

II. U.S. TAX INCENTIVES FOR RENEWABLE ENERGY

A tax expenditure is a subsidy delivered through the tax system.[66] Tax expenditures, also called tax incentives, are economic instruments that operate to change the cost of a particular activity by reducing the tax burden on taxpayers engaging in the favored activity. Thus, renewable energy tax incentives operate by reducing the cost of generating electricity using renewable sources. Renewable fuels accounted for 10.3 percent of total electricity generation and received 55.3 percent of total federal support for energy, including tax expenditures and direct subsidies.[67] The DOE estimated total electricity-related federal subsidies for 2010 to be US$11.9 billion, up from US$7.7 billion in 2007.[68] Tax expenditures made up more than 28 percent of the total federal subsidies and support related to electricity production.[69]

---

62. Yang et al., *supra* note 62, at 15.

63. OFFICE OF THE PRESIDENT-ELECT, THE OBAMA-BIDEN PLAN (2009), http://change.gov/agenda/energy_and_environment_agenda/.

64. President Barack Obama, Remarks by the President in State of Union Address (Jan. 25, 2011), *available at* http://www.whitehouse.gov/the-press-office/2011/01/25/remarks-president-state-union-address.

65. *See* Mona Hymel, The United States' Experience with Energy-Based Tax Incentives: The Evidence Supporting Tax Incentives for Renewable Energy, 38 LOY. U. CHI. L.J. 43 (2006).

66. STANLEY S. SURREY, PATHWAYS TO TAX REFORM: THE CONCEPT OF TAX EXPENDITURES 6 (1973); *see also* JOINT COMM. ON TAXATION, JCX-15-11, BACKGROUND INFORMATION ON TAX EXPENDITURE ANALYSIS AND HISTORICAL SURVEY OF TAX EXPENDITURE ESTIMATES 6 (2011).

67. U.S. ENERGY INFORMATION ADMINISTRATION, *supra* note 6, at xvii.

68. *Id.*

69. *Id.*

Renewable energy enjoys federal tax benefits primarily through the production tax credit (PTC)[70] and the investment tax credit (ITC).[71] The PTC provides a tax credit based on the amount of energy generated by a qualifying source.[72] For example, the New Mexico Wind Energy Center, constructed in 2003, a 200 MW rated plant, generates about 594,000 MWh of electricity each year.[73] In 2011, the PTC provided 2.2 cents per kWh generated.[74] A MWh (megawatt hour) is 1,000 times a kWh (kilowatt hour). Thus, the New Mexico Wind Energy Center should have received a PTC in 2011 of about US$13 million. The facility will receive the PTC each year for ten years after it is placed in service. The PTC reduces tax liability over the ten-year period after the project begins producing electricity based on the amount of electricity produced, rather than on the cost of the property.[75] Thus, the amount of the PTC will vary depending on the actual energy generated by the plant.

The ITC provides a tax credit based on the amount invested in the project. The ITC provides a tax credit of 30 percent of the project cost for an "energy property."[76] Energy property includes property that generates electricity by solar, wind, closed-loop biomass, open-loop biomass, geothermal, landfill gas, trash, hydropower, or marine and hydrokinetic renewable energy.[77] For example, NRG Energy completed a 20 MW rated solar generating plant in southern New Mexico in 2011, called the Roadrunner Solar Generating Facility.[78] Assuming the cost of the project was US$120 million, the ITC would provide a tax credit of 30 percent of the cost of the project, or US$36 million.[79] In contrast to the PTC, which is

---

70. *See* I.R.C. § 45(a) (2012).

71. *See* I.R.C. § 48 (2012).

72. I.R.C. § 45(a) (2012).

73. *New Mexico Wind Energy Center Facts*, PNM, http://www.pnm.com/systems/nmwec_facts.htm (last visited Nov. 6, 2012).

74. Internal Revenue Serv., U.S. Dep't of the Treasury, Notice 2011-40, Internal Revenue Bulletin 2011-2012: Credit for Renewable Electricity Production, Refined Coal Production, and Indian Coal Production, and Publication of Inflation Adjustment Factors and References Prices for Calendar Year 2011 (2011).

75. I.R.C. § 45(a) (2012).

76. I.R.C. § 48(a)(2) (2012).

77. *Id.*

78. *Roadrunner Solar Generating Facility Fact Sheet*, NRG Energy, Inc., http://www.nrgenergy.com/nrgsolar/roadrunner.html (last updated Aug. 31, 2011).

79. While the cost of building the Roadrunner Solar Generating Plant is not readily available, the DOE estimates the cost to build small solar generating plants to be approximately US$6,000 per kWh. U.S. Energy Info. Admin., Updated Capital Costs for Electricity Generation Plants 7 (2010), *available at* http://www.eia.gov/oiaf/beck_plantcosts/pdf/updatedplantcosts.pdf.

paid over the first ten years of the project, the ITC provides up-front tax benefits: all the tax benefits of the ITC occur as soon the project is placed in service.[80] When a project is placed in service depends on a number of factors, but generally means when a project is ready to perform its specifically designed function, i.e., generating electricity.[81] However, if the project is sold within five years, the ITC must be recaptured.[82] Recapture means that the taxpayer's taxable income will increase in the amount of the ITC previously taken. Moreover, unlike the PTC, the ITC is not dependent on the amount of electricity generated by the project. The depreciable basis of a project must be reduced by half the value of the ITC.[83] As most business property may be fully depreciated (i.e., the owner may deduct the full cost of the property over time), this may reduce the overall tax benefit from the project.[84] In the Roadrunner Solar Generating Facility example above, the potential depreciation deductions over the life of the project are reduced by US$18 million, half of the ITC of US$36 million.

Solar electric projects are no longer eligible for the PTC.[85] The relative financial value of the tax incentive—whether it be the PTC or the ITC—depends on "two project-specific factors: installed project costs and expected capacity factor (i.e., production)."[86] Projects with higher capacity factors and lower installed costs would prefer the PTC to the ITC because more capacity means more production, "while lower installed costs mean that the value of those PTCs will add up to a higher percentage of installed costs."[87] For example, a 100 MW plant that cost US$25 million and generated 300,000 MW of electricity each year would receive either a US$7.5 million ITC in the first year of operation or US$6.6 million each year for ten years. If the plant cost US$100 million and generated 100,000 MW of electricity each year, it would receive either a US$30 million ITC in the first year of operation or a US$2.2 million PTC each year for ten years. The first plant should choose the PTC, because its low

80. I.R.C. § 48(a) (2012).

81. *See, e.g.*, I.R.S. Priv. Ltr. Rul. 2003-34-031 (May 19, 2003).

82. I.R.C. § 50 (2012); *see also* Treas. Reg. § 1.47-6(a)(2) (2009) (providing that recapture will apply if a partner in a partnership that owns the facility reduces its interest in the partnership by more than a third).

83. I.R.C. § 50(c)(3) (2012).

84. *See* I.R.C. § 167 (2012); I.R.C. § 168 (2012).

85. I.R.C. § 45(d)(4) (2012) (cross-referencing section 48(a)(3) (2012)).

86. *See* Mark Bolinger et al., Lawrence Berkeley Nat'l Lab. Report, LBNL-1642E, PTC, ITC, or Cash Grant?: An Analysis of the Choice Facing Renewable Power Projects in the United States 4 (2009), *available at* http://eetd.lbl.gov/ea/emp/reports/lbnl-1642e.pdf.

87. *Id.* at 6.

construction cost and high productivity makes the PTC a better choice. The second plant should choose the ITC.

Renewable energy accounted for 55.3 percent of all electricity-related tax expenditures in 2010, mostly because of wind power projects receiving the PTC or ITC.[88] This number is likely to decline after 2013 because of the expiration of the PTC for wind.[89] The ITC and the PTC created financing options for renewable energy projects via "tax equity investors," investors who bought into the projects through complex partnership and lease transactions to reap the tax benefits. The number of tax equity investors active in the renewable power market declined precipitously because of the financial crisis that began in the summer of 2008. For a limited time, from 2009 to 2011, federal law allowed ITC-eligible renewable power projects to receive a cash grant of equivalent value instead of the ITC.[90] The energy grant program, which was designed as a more flexible financing alternative to the PTC and ITC in a challenging economic climate, paid out US$4.2 billion in 2010, 84 percent going to wind projects and 11 percent to solar projects.[91]

Wind power development has been driven by tax expenditures. In 2008, researchers describing wind investment as a "boom-and-bust cycle" due to the repeated expiration and subsequent short-term extensions of the PTC, expressed concern about continued growth in the wind industry without a long-term extension of the PTC.[92] The PTC for wind was extended in 2008 and is now scheduled to expire at the end of 2013.[93] De-

---

88. U.S. ENERGY INFORMATION ADMINISTRATION, *supra* note 6, at xvii.

89. RYAN WISER & MARK BOLINGER, 2011 WIND TECHNOLOGIES MARKET REPORT 3 (2012), *available at* http://www1.eere.energy.gov/wind/pdfs/2011_wind_technologies_market_report.pdf.

90. American Recovery and Reinvestment Act of 2009, Pub. L. No. 111-5, § 1603, 123 Stat. 115, 364 (2009), *extended by* Tax Relief, Unemployment Insurance Reauthorization, and Job Creation Act of 2010, Pub. L. No. 111-312, § 707, 124 Stat. 3296 (2010); *see also* Janet E. Milne, *Climate Change Tax Expenditures in the U.S. Tax Code: A Tax Expenditure Microcosm with Environmental Dimensions*, *in* TAX EXPENDITURES: THE STATE OF THE ART 7 (Lisa Philipps, Neil Brooks & Jinyan Li eds., 2011) (describing policy differences between the grant program and the tax credits).

91. U.S. ENERGY INFORMATION ADMINISTRATION, *supra* note 6, at xv.

92. RYAN WISER & MARK BOLINGER, U.S. DEP'T OF ENERGY, DOE/GO-102008-2590, ANNUAL REPORT ON U.S. WIND POWER INSTALLATION, COST, AND PERFORMANCE TRENDS: 2007, at 4 (2008), *available at* http://www.nrel.gov/docs/fy08osti/43025.pdf.

93. American Taxpayer Relief Act of 2012, Pub. L. No. 112-240, § 407, 126 Stat. 2340 (2013) (extending the PTC for wind projects "the construction of which begins before January 1, 2014."); Energy Improvement and Extension Act of 2008, Pub. L. No. 110-343, § 101, 122 Stat. 3765, 3808 (2008) (extending the placed-in-service date for the PTC through December 31, 2009 (one year) for wind by amending Section 45

spite the "boom-and-bust" years, the amount of electricity generated by wind in the U.S. increased by more than 16-fold from 2000 to 2010.[94] The DOE credited the PTC with significant contributions to the expansion of the wind industry since 1998, noting that wind capacity has grown by an average of more than 25 percent per year.[95] In 2010, wind power provided 2.3 percent of total U.S. electricity generation.[96]

Tax policy has also significantly influenced solar power generation. Researchers at the Lawrence Berkeley National Laboratory found that financial incentives provided through utility, state, and federal programs, including federal and state ITCs, have been "a major driving force for the photovoltaic (PV) market in the United States."[97] As a result of these financial incentives, the average installed cost of a PV system declined by almost 30 percent since 1998.[98] The report indicates that tax incentives for solar energy are having the desired effect: reducing the cost of generating electricity using solar power.[99] The Internal Revenue Code contains separate incentives for commercial solar energy and for residential solar energy. The ITC for residential solar energy systems is a non-refundable personal tax credit of 30 percent of the cost of qualified solar electric property, defined as property that uses solar energy to generate electricity for use in a dwelling unit used as a residence.[100] While commercial PV systems costs remained level from 2008 to 2009, the after-tax cost of residential PV fell to historic lows in 2009, largely as a result of legislation in

---

of the Code); American Recovery and Reinvestment Act of 2009, Pub. L. No. 111-5, § 1101, 123 Stat. 115, 319 (2009) (extending the eligibility dates for the credit for wind through January 1, 2013).

94. U.S. ENERGY INFORMATION ADMINISTRATION, *supra* note 6, at 13 tbl.4.

95. U.S. ENERGY INFO. ADMIN., U.S. DEP'T OF ENERGY, DOE/EIA-0383(2009), ANNUAL ENERGY OUTLOOK 2009, at 47 (Mar. 2011), *available at* http://www.eia.gov/oiaf/aeo/pdf/0383(2009).pdf.

96. U.S. ENERGY INFORMATION ADMINISTRATION, *supra* note 6, at 12.

97. GALEN BARBOSE ET AL., LAWRENCE BERKELEY NAT'L LAB. REPORT, LBNL-4121E, TRACKING THE SUN III: THE INSTALLED COST OF PHOTOVOLTAICS IN THE U.S. FROM 1998-2009, at 4 (2010), *available at* http://eetd.lbl.gov/ea/emp/reports/lbnl-4121e.pdf.

98. *See* Galen Barbose et al., *Installed PV Costs Plummet in 2010*, SOLAR TODAY (Feb.24, 2011), http://www.ases.org/index.php?option=com_content&view=article&id=1356&Itemid=23.

99. BARBOSE ET AL., *supra* note 97, at 35 ("The number of photovoltaic systems installed in the United States has been growing at a rapid pace in recent years, driven in large measure by government incentives. Given the relatively high historical cost of PV, a key goal of these policies has been to encourage cost reductions over time.").

100. *See* I.R.C. § 25D (2012); *see also* S. JOINT COMM. ON TAXATION, JCX-25-09, TAX EXPENDITURES FOR ENERGY PRODUCTION AND CONSERVATION 50 (2009).

2009 that lifted the US$2,000 cap on the federal ITC for residential PV systems.[101]

Tax incentives are critical to the development of the renewable energy market, driving down costs and making clean energy competitive with traditional fossil fuel energy sources. The author does not intend to suggest that tax incentives are the only or the best means of encouraging the development of renewable energy.[102] In particular, using tax incentives for renewable energy generally requires complex transactions, as the renewable energy developer frequently does not have sufficient tax liability to benefit from the incentives.[103]

Imposing consumption taxes, such as a carbon tax, on environmentally damaging goods would more efficiently encourage alternatives to fossil fuel use.[104] However, the United States has not embraced the idea of pollution taxes, preferring instead the path of least legislative resistance: tax incentives. From a budgetary perspective, most tax expenditures are comparable to mandatory spending for entitlement programs, in that no further action is required to provide resources for tax expenditures.[105] If Congress continues to spend taxpayer money on growing renewable energy, the pressure on the transmission grid will increase. Those connectivity challenges are examined in the next section.

III. RENEWABLE ENERGY CONNECTIVITY CHALLENGES

Renewable energy poses two distinct connectivity challenges. First, these renewable energy sources are not only nondispatchable, they may be inconveniently located. Renewable energy sources may be located far away from the energy users, and as noted before, adequate transmission facilities may be lacking.[106] Second, most solar generation is "distributed generation," located on rooftops scattered throughout an urban area. It

---

101. *See* I.R.C. § 25D, *amended by* American Recovery and Reinvestment Act of 2009, Pub. L. No. 111-5, § 1122, 123 Stat. 115, 364; *see also* BARBOSE ET AL., *supra* note 97, at 31.

102. *See* Roberta F. Mann, *Back to the Future: Recommendations and Predictions for Greener Tax Policy*, 88 OR. L. REV. 355, 401 (2010).

103. *See* Roberta F. Mann & E. Margaret Rowe, *Taxation*, *in* THE LAW OF CLEAN ENERGY: EFFICIENCY AND RENEWABLE 146 (Michael B. Gerrard, ed., 2011).

104. See Roberta F. Mann, *The Case for the Carbon Tax: How to Overcome Politics and Find Our Green Destiny*, 39 ENVTL. L. REP. NEWS & ANALYSIS 10118, 10123 (2009).

105. *See* U.S. GOV'T ACCOUNTABILITY OFFICE, TAX EXPENDITURES REPRESENT A SUBSTANTIAL FEDERAL COMMITMENT AND NEED TO BE REEXAMINED 4-6 (2005), *available at* http://www.gao.gov/new.items/d05690.pdf.

106. *Id.* at 75.

has been shown that the current grid can accommodate no more than 20 percent renewable generation.[107]

A. Transmission Capacity for Renewable Energy

There is an inevitable collision between increasing renewable energy generation and stagnant transmission capacity. Signs of this collision are already appearing. Researchers found lack of transmission availability to be a "primary barrier to wind development," noting a "mismatch between the short lead time needed to develop a wind project and a lengthier time often needed to develop new transmission lines."[108] The spring of 2011 in the Northwest exemplified these conflicts.

In May 2011, the Bonneville Power Administration (BPA), put wind farms on notice of a shutdown.[109] The reason: rainy spring weather that followed a winter with heavy snow in the mountains feeding the Columbia River basin. BPA could not send water around the generating turbines because of the harm it would cause to endangered salmon. BPA could not store the excess water and did not want to sell surplus electricity at below market rates. Wind farms relying on PTC-based financing were in trouble, because the tax credit is based on the amount of power generated by the facility. Less power generated meant a smaller tax credit. Congressman Earl Blumenauer of Oregon estimated that the shutoffs cost wind power generators millions of dollars, noting that "[t]here's a disconnect between Bonneville's short-term actions and (the Obama) administration's long-term stated goals' supporting wind energy."[110] This conflict illustrates the mismatch described above: Bonneville spokesman Michael Milstein noted "the reason we are in this situation is that we connected wind to our system as fast as any utility in the country."[111] In 2009, Congress provided the Bonneville Power Administration with US$3.25 billion in new borrowing authority to expand their transmission

---

107. *See generally* Yang et al., *supra* note 2; *see also*, LEW ET AL., *supra* note 60; *see also supra* text accompanying notes 43-45.

108. WISER & BOLINGER, *supra* note 92, at 27.

109. *See NW Power Surplus May Halt Wind Energy*, KGW.COM (News Channel 8, Portland, Or.), May 14, 2011, http://www.kgw.com/news/local/NW-has-too-much-dam-power-plans-wind-power-halt-121832839.html.

110. Jeff Barnard, *Wind Industry Demands Solution to Grid Overload*, REGISTER-GUARD (Eugene, Or.) (May 24, 2011), http://www.registerguard.com/web/newslocal news/26286565-41/power-wind-energy-bonneville-northwest.html.csp (citation omitted).

111. *Id.* This is not an isolated incident: Idaho has experienced similar problems. Rocky Barker, *Idaho Power says adding more wind to its system will create costs someone will has to pay*, IDAHO STATESMAN (July 12, 2012), http://www.idahostatesman.com/2012/07/12/2186557/cost-of-managing-wind-power-increases.html.

systems to better accommodate renewable sources of electricity supply.[112] BPA has plans to develop more than 200 additional miles of transmission, but that may be too little and come too late.[113]

The U.S. power grid was built for the central station model where large power plants in relatively remote locations generate electricity, which is then transmitted long distances over high-voltage transmission lines before being stepped down in voltage for use in local distribution systems.[114] As noted above, wind resources and certain types of solar resources are also remote from the users, however, the difference between "traditional" central station power plants and the "new" renewable wind and concentrated solar plants is that renewable energy development has not been accompanied by the increased spending on transmission lines that accompanied all other phases in the development of the electrical grid.[115] Federal hydropower developments of the 1930s, 1940s, and 1950s, included the installation of integral long-distance transmission lines owned by the federal government.[116] Grid integration of large-scale nuclear and coal plants in the 1960s and 1970s included new high-voltage interstate transmission lines.[117] However, the average level of transmission investment for the last half of the 1990s was under US$3 billion per year, down from investments of approximately US$5.5 billion per year in the 1970s (adjusted for inflation), lagging substantially behind that of previous decades because of uncertainty about the outcome of electricity restructuring.[118] Before the late 1980s, the electricity industry was composed primarily of vertically integrated utilities with regulated, geographic monopolies.[119] In the late 1980s, the Federal Energy Regulatory Commission (FERC) and several states began to develop restructuring and regulatory reform programs with a goal of promoting competition in the supply of electricity and to create wholesale power markets.[120] In the wake of Cali-

112. U.S. Energy Information Administration, *supra* note 6, at xv.

113. *See* Bonneville Power Administration, How BPA Supports Wind (May 26, 2011), http://www.bpa.gov/corporate/AgencyTopics/ColumbiaRiverHighWaterMgmnt/How%20BPA%20supports%20wind%20-%20May%202011.pdf.

114. *See* Frederick R. Fucci, *Distributed Generation*, *in* The Law of Clean Energy (Michael Gerrard, ed., 2011).

115. Yang, *supra* note 20, at 6-7.

116. *See* U.S. Department of Energy, *supra* note 16, at 93.

117. *Id.*

118. *Id*. at 94.

119. *See* Massachusetts Institute of Technology, *supra* note 23, at 258.

120. Id. at 236-39.

fornia's electricity market "meltdown" in 2000,[121] and stunned by high electricity prices,[122] many states backed away from plans to deregulate their electricity markets.[123] After passing the Electrical Utility Restructuring Act of 1999, New Mexico reversed course and repealed the act in 2003.[124] While transmission investment has been increasing since the late 1990s, investment has not caught up with changing energy distribution needs.[125] Government subsidies and tax expenditures are driving renewable generation, but subsidies for transmission investment are declining.[126]

B. Interconnection Issues for Renewable Energy

Even when the renewable energy sources are close to the consumers, transmission can be difficult. Residential solar PV and small wind generators may be widely distributed close to the load (distributed generation). The majority of solar generated electricity is distributed generation—as of mid 2008, global installed concentrated solar power (CSP) was 431 MW (million watts), while solar PV was 10 GW (billion watts).[127] As noted previously, the power grid was designed around the central station model. When generation is spread over separate rooftops across an entire city, different transmission strategies are required. Net metering, described below, is the usual method.

Net metering generally means that customers can get credit on their utility bill for energy produced by their solar system in excess of the

---

121. *See generally* Paul L. Joskow, *California's Energy Crisis* (Nat'l Bureau of Economic Research, Working Paper No. 8442, 2001), *available at* http://www.nber.org/papers/w8442.pdf?new_window=1.

122. *See* Paul Davidson, *Shocking electricity prices follow deregulation*, USA TODAY, Aug. 10, 2007, http://usatoday30.usatoday.com/money/industries/energy/2007-08-09-power-prices_n.htm.

123. *See* U.S. ENERGY INFO. ADMIN., STATUS OF ELECTRICITY RESTRUCTURING BY STATE (2010), *available at* http://www.eia.gov/cneaf/electricity/page/restructuring/restructure_elect.html.

124. *See* U.S. ENERGY INFO. ADMIN., NEW MEXICO RESTRUCTURING SUSPENDED (2008), *available at* http://www.eia.gov/cneaf/electricity/page/restructuring/new_mexico.html.

125. *See* U.S. DEPARTMENT OF ENERGY, *supra* note 29, at 6.

126. U.S. ENERGY INFORMATION ADMINISTRATION, *supra* note 6, at xvii (""While fuel and technology-related electricity subsidies grew 66 percent between 2007 and 2010, transmission and distribution system-related subsidies actually declined.").

127. Concentrating Solar Power (CSP) refers to methods for focusing sunlight on a fluid to produce steam and drive a turbine to produce electricity. *See generally* PEW CENTER FOR CLIMATE CHANGE, CLIMATE TECHBOOK: SOLAR POWER 1-34 (2012), *available at* http://www.pewclimate.org/docUploads/Solar-FactSheet.pdf.

amount of electricity used.[128] Net metering rules, which vary from state to state, usually provide restrictions on the amount of electricity that can be sold to the utility and the rate at which the utility will purchase the electricity. New Mexico has a typical net metering rule: net metered customers are credited or paid for any monthly excess generation.[129] Regulatory structure plays a large role in the ease or difficulty of integrating renewable energy into the power system. The Federal Energy Regulatory Commission (FERC) regulates all interstate transmissions of electricity in the United States.[130] Since the majority of solar energy facilities are small PV units that will be interconnected to their local utilities' grid, the facilities will also be subject to the jurisdiction of FERC.

Despite the Federal oversight created by FERC, each state may develop its own interconnection standards.[131] Each utility within each state establishes its own procedures and requirements in approving a generating facility for interconnection.[132] Although there are multiple layers of federal, state and local regulations faced by participants in the power system, there is no single agency in the United States with the mission of addressing the need for electricity delivery on a national scale, with the goal of promoting low-carbon energy.[133] Until there is coordinated oversight and a national plan for improving transmission, "smart" grid systems could provide a solution for inflexible, overused, outdated power grids. The next section explores smart grid solutions, and identifies potential problems that could arise with a smarter grid.

---

128. LAUREL VARNADO & MICHAEL SHEEHAN, INTERSTATE RENEWABLE ENERGY COUNCIL, CONNECTING TO THE GRID: A GUIDE TO DISTRIBUTED GENERATION INTERCONNECTION ISSUES 11 (6th ed. 2009).

129. *See* 17.9.570 NMAC; *see also* NMSA 1978, §§ 8-8-15, 62-6-4, 62-6-19, 62-6-24, 62-8-2 (2012).

130. *See* 16 U.S.C. § 824 (West 2012); *see also*; *What FERC Does*, FED. ENERGY REGULATORY COMM'N, http://www.ferc.gov/about/ferc-does.asp (last updated Feb. 3, 2012)

131. 16 U.S.C. § 2621 (2006); RUSTY HAYNES & CHUCK WHITAKER, CONNECTING TO THE GRID: A GUIDE TO DISTRIBUTED GENERATION INTERCONNECTION ISSUES 7 (5th ed. 2007), *available at* http://www.okcommerce.gov/Libraries/Documents/Connecting_to_the_Grid_A_Guide_to_Distributed_Generation_Int_2008072240.pdf.

132. FERC has issued standard interconnection agreements and procedures for generators greater than 20 MW and less than 20 MW. *Generator Interconnection*, FED. ENERGY REGULATORY COMM'N, http://www.ferc.gov/industries/electric/indus-act/gi.asp(last updated Nov. 13, 2012).

133. YANG, *supra* note 20, at 18.

IV. POTENTIAL GRID SOLUTIONS

The smart grid uses technology to monitor electrical flows and enhance planning and load shifting opportunities. A report commissioned by President Obama divides these technologies into three basic categories: "(1) advanced information and communications technologies (including sensors and automation capabilities) that improve the operation of transmission and distribution systems; (2) advanced metering solutions, which improve on or replace legacy metering infrastructure; and (3) technologies, devices, and services that access and leverage energy usage information, such as smart appliances that can use energy data to turn on when energy is cheaper or renewable energy is available."[134] The success of the technology depends in large part on customer response, because a large part of the smart grid strategy is to reduce and time demand for electricity. The DOE estimates that up to 52 percent of the peak electricity demand growth between 2008 and 2030 could be offset through a combination of energy efficiency and demand-response programs.[135] The number of utilities offering demand-response (DR) programs is increasing, and DR potential for peak load reduction has increased 10 percent from 2006 to 2009.[136] The existing DR resource potential ranges from 3 to 9 percent of a region's summer peak demand in most regions of the U.S.[137]

A. Feedback and the Smart Grid

Research shows that feedback that taps into social norms and compares consumers' electrical use to local average use can help consumers effectively reduce energy costs.[138] Effective feedback can help consumers make decisions by comparing their present consumption to their historical consumption or showing that an old appliance uses far more energy than a new one.[139] Social environments can have a large influence on energy use by individual customers. "Knowing what social norms influence their decisions, what social networks allow them to influence others, and what sources they consider credible can change the approaches efficiency

---

134. National Science & Technology Council, *supra* note 22, at 1.

135. U.S. Department of Energy, *supra* note 13, at 17.

136. Peter Cappers et al., Demand Response in U.S. Electricity Markets: Empirical Evidence 27 (2009), *available at* http://eetd.lbl.gov/ea/EMP/reports/lbnl-2124e.pdf.

137. *Id.*

138. National Science & Technology Council, *supra* note 22, at 45.

139. *Id.*

programs take."[140] However, feedback mechanisms like smart meters do not offer a panacea to the electrical system's woes. One group of researchers noted "in promoting energy efficiency, there is often a dogged insistence that consumers 'should' appreciate energy efficiency products and that if they do not, they need to be educated to do so."[141] The researchers commented "[t]hese arguments do not always make sociological sense. For example, considering the residential sector, for many energy-relevant investments, monetary savings may be a few dollars per year or less, too small to bother with and hardly detectable, given the variability of energy usage from billing cycle to billing cycle."[142] Moreover, consumers may not understand smart meters and actively resist their installation. A letter to the editor of my local newspaper illustrates this lack of understanding, stating that smart meters create an "information glut [that] will not create a 'smart' electric grid—unless you mean the kind of grid smart enough to charge you more for peak electrical use."[143] The writer is correct, in a way: the point of demand response technology is to put a higher price on peak electricity, which is more costly to produce. The writer continued, "Such a deal: Consumers get zapped constantly by microwaves, and excessive use of electricity during peak time is punished by a higher electric rate."[144] The writer's first point is simply incorrect. A recent report by the non-profit California Council on Science and Technology (CCST) found that the electromagnetic frequency emissions from a smart meter is almost seventy times less than the Federal Communications Commission (FCC) limit and 3,500 times less than the demonstrated hazard level.[145] Cell phone use produces between five and twenty-five times the exposure of a smart meter.[146] Nonetheless, after customer complaints, Pacific Gas & Electric Company allowed smart meter

140. KATHERINE FRIEDRICH ET AL., VISIBLE AND CONCRETE SAVINGS: CASE STUDIES OF EFFECTIVE BEHAVIORAL APPROACHES TO IMPROVING CUSTOMER ENERGY EFFICIENCY, at x (2010), *available at* http://www.greenbiz.com/sites/default/files/e108.pdf.

141. MITHRA MOEZZI ET AL., BEHAVIORAL ASSUMPTIONS IN ENERGY EFFICIENCY POTENTIAL STUDIES 34 (2009), *available at* http://uc-ciee.org/downloads/energyefficiency.pdf.

142. *Id.* at 35. (citation omitted).

143. Michael A. Lee, Letter to the Editor, REGISTER-GUARD (Eugene, Or.), Aug. 9, 2011, at A10.

144. *Id.*

145. CAL. COUNCIL ON SCI. AND TECH., HEALTH IMPACTS OF RADIO FREQUENCY EXPOSURE FROM SMART METERS 18 (Apr. 2011), *available at* http://www.ccst.us/publications/2011/2011smart-final.pdf.

146. *Id.* at 21.

customers to elect to turn off the wireless signal.[147] However, "[t]hose who opt out must pay more partly because their consumption will not be transmitted automatically and meter readers will have to gather the information. . . ."[148] It should be noted that a large number of smart meters are not used for demand response activities. In 2008, slightly over 1 percent of customers received a "dynamic pricing tariff."[149] In conclusion, smart meters have a lot of potential to increase the efficiency of the grid, but consumer resistance may be a barrier to adoption.

B. Smart Appliances and the Smart Grid

Smart grid technology is not dependent on consumer action. Smart grid technology can directly interact with smart appliances to save energy and spare the grid congestion.[150] Smart appliances, such as thermostats, microwaves, space heaters, refrigerators, clothes washers and dryers, and hot water heaters can be fitted with signaling software that enables the device to communicate with other components of a smart grid.[151] These technologies will allow the customer and/or the utility or other authorized third parties to control the device's energy consumption based on energy prices and grid conditions. A BPA pilot project would install special devices on the hot water heaters of participating homeowners.[152] The devices communicate with the grid and can shut the appliance on or off, based on conditions of the regional electrical system and the amount of renewable energy available.[153] The program is specifically designed to help accommodate wind energy. The program allows homeowners to override the water heater device at any time.[154] BPA predicted that "with modern insulated water heaters, it is unlikely they will even notice a change in water temperature."[155]

C. Privacy and the Smart Grid

Some are concerned about the privacy and security implications of the smart grid. In Germany, plans for expanding the smart grid have

---

147. Felicity Barringer, *PG&E Offers Critics Option to Turn Off Smart Meters*, N.Y. Times, Mar. 24, 2011, at B5.

148. *Id.*

149. U.S. Department of Energy, *supra* note 13, at vi.

150. *Id.* at 28.

151. *Id.*

152. *Smart grid project will let wind farms 'talk' to appliances*, Bonneville Power Admin. (Aug. 12, 2010), http://www.bpa.gov/news/newsroom/Pages/Smart-grid-project-will-let-wind-farms-talk-to-appliances.aspx.

153. *Id.*

154. *Id.*

155. *Id.*

faced opposition on privacy and security grounds. Security concerns include vulnerability to hackers who could potentially control the grid or power plants ("cybersecurity threats"). Others are more concerned about privacy.

> "For me as a data subject, the threats can come from outside the grid, but that isn't very likely," said Karg, of the Independent Center for Privacy Protection. "It's rather that my energy supplier will try to find out more about my use of resources. In Germany, we are talking about smart metering being used for gas, water, heat as well as electricity, being measured every quarter of an hour."[156]

In the United States, one of the Congressional goals in developing the smart grid is cybersecurity.[157] The Obama Administration is also concerned about privacy, noting that "[w]hile providing consumers timely access to energy usage data in an understandable form can be a valuable tool for achieving energy savings, the data needs to be protected to safeguard consumers' privacy."[158] The administration supports a shared responsibility approach in which governmental agencies, utilities, energy industry organizations, consumer groups, and researchers would work to implement privacy rules specific to the smart grid context.[159]

D. Electric Vehicles—a Challenge and an Opportunity

One potential challenge for the grid can become a solution. President Obama announced his goal of having a million electric vehicles (EVs) on the road by 2015.[160] Charging a million new EVs will increase the demand on the grid, but EVs may enable greater use of intermittent renewable power generation.[161] As of 2009, only 0.02 percent of light-duty vehicles (LDVs) were grid-connected, but most forecasts estimate ultimate penetration of this market at 8 to 16 percent, with some aggressive estimates at 37 percent, by 2020.[162] LDVs today are the largest energy

---

156. Jabeen Bhatti, *German Plans for Smart Grid Expansion Bump Up Against Privacy, Security Concerns*, BNA World Climate Change Report, May 9, 2011, http://climate.bna.com/climate/summary_news.aspx?ID=162390.

157. Energy Independence and Security Act of 2007, Pub. L. No. 110-140, § 1301, 121 Stat. 1492, 1783 (2007).

158. National Science & Technology Council, *supra* note 22, at 45.

159. *Id.* at 46.

160. *Id.* at 1.

161. *Id.* at 15.

162. U.S. Department of Energy, *supra* note 13, at 27.

consumers in the transportation sector,[163] which is the most significant sector of the economy that relies on some form of energy other than electricity.[164] In 2009, the United States consumed about 3.7 trillion kWh of electric power.[165] If 150 million grid-enabled LDVs each consume 8 kWh of power a day, that would represent an additional 440 billion kWh of power consumed each year.[166] A group of researchers investigating EV and plug-in electric vehicle (PHEV) expansion in the Pacific Northwest found that more than 70 percent of the energy for the U.S. LDV fleet could be supplied without building additional generation or transmission—if their charging times are carefully managed to strictly avoid charging during peak load hours.[167] Smart grid technologies can manage the charging time period and shift the additional load from EVs into off-peak times.[168] The Northwest researchers found that "smart charging raises the share of electric [vehicle miles traveled] by 9 percentage points from 64 percent to 73 percent of the LDV fleet. This allows the grid to support 18 million more PHEVs and EVs beyond the 140 million supportable with *unmanaged* charging."[169] With the proper integrating technology, EVs could offer energy storage and frequency regulation through vehicle-to-grid (V2G) interfaces, thus reducing the need for peak generation.[170] V2G could also aid the integration of variable renewable resources by scheduling charging when excess, off-peak renewable energy is available.[171] Adding smart grid managed EVs may even save electric customers on their utility bills. The Electrification Coalition found that "by flattening the load curve and increasing the utilization rates of existing power generating plants, utilities should be able to spread their fixed costs over a greater volume of power and reduce maintenance costs, perhaps lowering costs for all of their customers."[172] Studies show that imple-

---

163. LDVs are by far the greatest transportation energy user and accounted for 59 percent of transportation energy consumption. U.S. ENERGY INFORMATION ADMINISTRATION, *supra* note 8, at 130 tbl.A7.

164. *Id.* at 118.

165. *Id.* at 73.

166. REPORT OF THE ALTERNATIVE FUEL VEHICLE INFRASTRUCTURE WORKING GROUP 15 (2010), *available at* http://psrc.org/assets/3751/W_OregonReport_2010.pdf.

167. KEVIN SCHNEIDER ET AL., PACIFIC NORTHWEST NAT'L LAB., IMPACT ASSESSMENT OF PLUG-IN HYBRID VEHICLES ON PACIFIC NORTHWEST DISTRIBUTION SYSTEMS 1 (2008).

168. NATIONAL SCIENCE & TECHNOLOGY COUNCIL, *supra* note 22, at 15.

169. SCHNEIDER ET AL., *supra* note 167, at 3.25.

170. REPORT OF THE ALTERNATIVE FUEL VEHICLE INFRASTRUCTURE WORKING GROUP, *supra* note 166, at 15-16.

171. NATIONAL SCIENCE & TECHNOLOGY COUNCIL, *supra* note 22, at 15.

172. ELECTRIFICATION COALITION, ELECTRIFICATION ROADMAP: REVOLUTIONIZING TRANSPORTATION AND ACHIEVING ENERGY SECURITY 15 (2009), *available at*

menting a smart grid would cost less than building new physical infrastructure to upgrade the grid. One study estimated that it would cost US$1.5 trillion to update the grid by 2030, in comparison to less than US$100 billion to implement a smart grid.[173] In order to deploy the smart grid at the household level, meters must be replaced, wiring retrofitted, and appliances replaced in every household. The estimated cost for smart metering per household is in the range of US$200–US$700, resulting in nationwide investment of US$20–US$70 billion with approximately 100 million households across the country.[174]

E. Financing the Smart Grid

Who should pay for smart grid implementation? The government? Utilities? Consumers? Venture capitalists? One issue is whether costs should be allocated between smart grid technologies' impact on the wholesale transmission system and retail distribution system. If FERC and the states cannot determine which costs should be considered transmission related (federally regulated) and which should be considered distribution related (state regulated), utilities may be reluctant to make large investments in smart grid technologies.[175] Utilities may also be reluctant to be first adopters of evolving smart grid technologies; the first adopters may end up with the most expensive and least sophisticated technologies. A cautious utility industry may want to bide its time until it can learn from first adopters' experiences and mistakes. If utilities are reluctant to purchase smart grid technology, then venture capital to develop smart grid capacity will be hard to find. Smart grid investments are also complex. The DOE notes that "smart-grid investments are often capital intensive, expensive, and include multiple jurisdictions within a utility's service area."[176] "While smart-grid investments can enable numerous new products (e.g., advanced meters, solar panels, electric vehicles, and smart appliances) and operational efficiencies (e.g., reduced meter reading costs, fewer field visits, enhanced billing accuracy, improved cash flow, and enhanced response to outages), such benefits may be difficult to quantify and to build into business cases given the nascent stages in which these technologies often exist, and the lack of industry standards and best practices for integrating smart-grid technologies."[177]

---

http://www.electrificationcoalition.org/sites/default/files/SAF_1213_EC-Roadmap_v12_Online.pdf.

173. U.S. Department of Energy, *supra* note 13, at viii.

174. Yang, *supra* note 20, at 24–25.

175. Abel, *supra* note 21, at 3.

176. U.S. Department of Energy, *supra* note 13, at 24.

177. U.S. Department of Energy, *supra* note 13, at 24.

The International Energy Agency urges government involvement to reduce risk, stimulate deployment and bring down costs, stating: "[g]overnments will need to intervene on an unprecedented level in the next decade to avoid the lock-in of high-emitting, inefficient technologies. They must take swift action to implement a range of technology policies that target the cost-competitiveness gap," including smart grid technologies.[178] As shown by the tax incentives discussion in Section 2 above, tax policy is an effective way for government to encourage innovation and ease market entry for low-carbon technologies. The following section will discuss how tax policy has been used to help the power grid, and how it could be better used in the future.

V. USING TAX POLICY TO ENCOURAGE GRID SOLUTIONS

A. Existing Provisions

The Internal Revenue Code (IRC) contains a number of provisions that could facilitate expansion of a smarter grid. First, public utility customers are not taxed on the value of energy conservation measures provided by a public utility.[179] The Internal Revenue Service (IRS) has ruled that advanced metering infrastructure qualifies as an energy conservation measure excludible from gross income.[180] This provision does not help the utility find financing to fund smart grid improvements, but at least it removes one potential cause of customer reluctance to accept smart meters. For example, a customer might be distressed at receiving a US$300 tax bill after having a smart meter installed. Because of this provision, tax liability for the customer is not an issue.

Second, a broad provision allowing contributions to the capital of corporations without triggering tax liability has been used, in conjunction with some IRS rulings, to lower the tax cost of interconnectivity.[181] The IRS ruled that a utility may exclude from gross income a payment made by a "qualified facility" (QF) for purposes of interconnection so that the QF could sell electricity to the utility. The QF could be a consumer with rooftop solar panels, although that cannot be determined from the private letter ruling (PLR). The IRS held that the deemed contribution of the intertie by the QF to the utility qualified as a tax-free contribution to capital.[182] PLRs have no precedential value,[183] so it is unclear whether the

178. INTERNATIONAL ENERGY AGENCY, *supra* note 4, at 6–7.
179. I.R.C. § 136(a) (2012).
180. I.R.S. Priv. Ltr. Rul. 201046013 (Nov. 19, 2010).
181. I.R.C. § 118 (2012).
182. I.R.S. Priv. Ltr. Rul. 201122005 (Mar. 2, 2011).
183. I.R.C. § 6110(k)(3) (2012).

IRS would view contributions to capital to fund smart grid investments in the same way.

Third, the IRC contains tax credits for the purchase of PHEVs and EVs. Owners or lessors of PHEVs acquired after December 31, 2009, are eligible for a tax credit of up to US$7,500.[184] A qualified plug-in electric drive vehicle is a motor vehicle that has at least four wheels, is manufactured for use on public roads, meets certain emissions standards, draws propulsion using a traction battery with at least four kilowatt-hours of capacity, and is capable of being recharged from an external source of electricity.[185] The base amount of the credit is US$2,500, plus US$417 for each kilowatt-hour of battery capacity in excess of four kilowatt-hours.[186] The credit for plug-in vehicles is phased out as each manufacturer sells its 200,000th vehicle.[187] The IRC also provided a 10 percent tax credit for the cost of converting any motor vehicle to a plug-in electric.[188] The credit was capped at US$4,000, and the conversion must have been completed by December 31, 2011.[189]

Certain EV vehicles are eligible for a 10 percent tax credit, capped at US$2,500.[190] Purchasers or lessors of new electric-drive motorcycles and three-wheeled vehicles could receive a 10 percent tax credit, capped at US$2,500.[191] The vehicle must be acquired after December 31, 2011, and before January 1, 2014.[192] The Joint Committee on Taxation estimated the cost of the PHEV and EV credits to be US$300 million from 2009 to 2013. The DOE noted that the cost of PHEVs is lower than it would have been without the credit, and moreover that even after the credit has expired, "incentivizing the purchase of PHEVs in the near term will allow both battery and battery-system manufacturers to achieve earlier economies of scale through greater initial sales, thus allowing battery and systems costs to decline more quickly than would have been the case without the tax credit."[193] The DOE identified cost of PHEV vehicles as a problem both now and in the future.[194] A car buyer would likely balk at the prospect of purchasing a PHEV if the incremental cost of the vehicle exceeded the anticipated savings from future fuel expenditures. The DOE

184. I.R.C. § 30D(b)(2–3) (2012).
185. I.R.C. § 30D(d) (2012).
186. I.R.C. § 30D(b)(2–3) (2012).
187. I.R.C. § 30D(e) (2012).
188. I.R.C. § 30B(i) (2012).
189. *Id.*
190. I.R.C. § 30D(g) (2012).
191. *Id.*
192. *Id.*
193. U.S. Energy Information Administration, *supra* note 95, at 33.
194. *Id.* at 34.

found that "in 2030, the additional cost of a PHEV is projected to be higher than total fuel savings unless gasoline prices are around US$6 per gallon."[195] Furthermore, if consumers do not buy PHEVs due to these cost concerns, then PHEV sales volumes will be insufficient to create economies of scale for PHEV manufacturing.[196]

In 2009, Congress allocated US$2.3 billion for the tax credit for advanced energy property.[197] A 30 percent tax credit is available to a certified project that re-equips, expands, or establishes a manufacturing facility for the production of advanced energy equipment.[198] Qualifying advanced energy property includes equipment for renewable energy generation as well as for energy conservation technologies.[199] The Secretary of the Treasury, acting in consultation with the Secretary of Energy, must certify the property.[200] The selection criteria include: domestic job creation; greenhouse gas reduction; potential for technological innovation and commercial deployment; lowest leveled cost of generated or stored energy; and shortest time from certification to completion.[201] Projects selected to receive the advanced energy property tax credit included residential smart meters.[202]

B. New Ideas

While the provisions listed above give some support to smart grid development, Congress could provide more targeted help. Senator Amy Klobucher of Minnesota introduced a bill providing a "renewable electricity integration credit," designed to promote wind and solar energy production and improve the reliability and strength of the U.S. energy grid.[203] The credit, targeted toward utilities, would be larger (up to 0.6 cents per kilowatt hour) for utilities that generate more of their energy from intermittent renewable sources, like wind and solar, and smaller for utilities that generate less of their energy from these intermittent

---

195. *Id.*
196. *Id.*
197. I.R.C. § 48C (2012).
198. *Id.*
199. *Id.*
200. *Id.*
201. *Id.*
202. Press Release, White House, Fact Sheet: $2.3 Billion in New Clean Energy Tax Credits, (Jan. 8, 2010), *available at* http://www.whitehouse.gov/the-press-office/fact-sheet-23-billion-new-clean-energy-manufacturing-tax-credits. Approximately US$36 million of the total US$2.3 billion tax credits available were awarded to smart grid projects.
203. S. 559, 112th Cong. § 401 (2011).

sources.[204] The credit would also phase out over time unless utilities continue to increase their renewable portfolio.[205] Installation of smart meters and other smart grid technology is capital intensive. Adding an ITC providing up front funding for smart grid technologies could facilitate their more rapid deployment.

Manufacturers of energy-efficient appliances are eligible for a myriad of credits, which vary in amount depending on the type and energy efficiency of the appliance.[206] The eligible appliances are dishwashers, clothes washers, and refrigerators.[207] In future legislation extending these credits, Congress could limit the credit to appliances with "smart grid" capability, thereby encouraging the technology.

VI. CONCLUSION

The United States' economy faces many challenges: a polarized political situation, large budget deficits, high unemployment. Smart grid technology could facilitate a shift to a clean energy economy with significant use of renewable energy, distributed energy resources, electric vehicles, and electric storage and create an electricity infrastructure that saves consumers money through greater energy efficiency, as well as supporting the more reliable delivery of electricity.[208] Reliable electricity and technological innovation will help create jobs of the future. Tax policy is only one way the government can lead the way in renewable energy. It has proven effective in encouraging development of renewable energy electricity generation. However, if the existing power grid cannot accommodate more renewable electricity, the renewable revolution will stall. The federal government should protect their investment in renewable technology by helping the grid to modernize. Smart grid technology is less costly and avoids the pitfalls of developing physical transmission capacity. In a constrained economy, the government needs to be careful about spending money. Smart grid technology is cost-efficient and encourages energy efficiency. It's smart to provide smart incentives for the smart grid.

---

204. *Id.*

205. *Id.*

206. I.R.C. § 45M. (2012) (expiration date extended by the American Taxpayer Relief Act of 2012, Pub. L. No. 112-240, § 408, 126 Stat. 2340 (2013)).

207. *Id.*

208. National Science & Technology Council, *supra* note 22, at 1.