2012

# Distributed Energy Resources, "Virtual Power Plants," and the Smart Grid

Joel B. Eisen
*University of Richmond*, jeisen@richmond.edu



## Recommended Citation

Joel B. Eisen, *Distributed Energy Resources, "Virtual Power Plants," and the Smart Grid*, 7 U. Hous. Envtl. & Energy L. & Pol'y J. 191 (2012; invited symposium issue).

# ARTICLE

## DISTRIBUTED ENERGY RESOURCES, "VIRTUAL POWER PLANTS," AND THE SMART GRID

*Joel B. Eisen*[*]

I. INTRODUCTION ........................................................................ 192

II. DEMAND RESPONSE AND SMART GRID TECHNOLOGIES ......... 197

III. THE SMART GRID, DR, AND DG INTEGRATION ..................... 201

IV. A MODEL FOR PROMOTING AGGREGATION AND INTEGRATION: THE "VIRTUAL POWER PLANT" ................... 205

V. CHALLENGES TO SCALING UP THE CONCEPT .......................... 208

VI. CONCLUSION ........................................................................ 212

* Professor of Law, University of Richmond School of Law. The author thanks the students and faculty of the University of Houston Law Center and the staff of the *Environmental & Energy Law & Policy Journal* for hosting an outstanding symposium on "American Energy Independence: An 'All of the Above' Strategy for Our Energy Policy." The author also thanks Jeff Ebihara of Consert and Michael Cassity of Mosaic BAS for their assistance and demonstration of the Consert VPP platform, and Richmond Law student Eric Wallace for invaluable research assistance.

*"The present electric power delivery infrastructure was not designed to meet the needs of a restructured electricity marketplace, . . . or the increased use of renewable power production."*[1]

## I. INTRODUCTION

Over the past 100 years, we have created an electric grid that is a complex network of large, fossil fuel-fired power plants located far from end users, with high-voltage transmission lines and lower voltage distribution lines carrying electricity to millions of consumers.[2] For decades, scholars, policymakers, and others have proposed a shift in electricity production from relying on central power stations to more use of a decentralized, or "distributed" generation (DG) of electricity.[3]

By refocusing on producing electricity (and reducing demand for it) with solutions deployed closer to consumers, DG represents a comprehensive paradigm shift in our nation's thinking about the electricity system.[4] The potential exists for an energy revolution that transforms end users from energy consumers into energy producers and managers. The term "distributed energy resources" ("DERs"), also known as "distributed resources,"[5]

---

1. C. GELLINGS ET AL., ELECTRIC POWER RESEARCH INSTITUTE, ESTIMATING THE COSTS AND BENEFITS OF THE SMART GRID: A PRELIMINARY ESTIMATE OF THE INVESTMENT REQUIREMENTS AND THE RESULTANT BENEFITS OF A FULLY FUNCTIONING SMART GRID 1-1 (2011) [HEREINAFTER EPRI 2011 TECHNICAL REPORT], *AVAILABLE AT* HTTP://IPU.MSU.EDU/PROGRAMS/MIGRID2011/PRESENTATIONS/PDFS/REFERENCE%20MATERIAL%20-%20ESTIMATING%20THE%20COSTS%20AND%20BENEFITS%20OF%20THE%20SMART%20GRID.PDF.

2. Joseph P. Tomain, *The Dominant Model of United States Energy Policy*, 61 U. COLO. L. REV. 355, 355 (1990)(stating that over the last one hundred years the U.S. government has developed energy policies).

3. AMORY LOVINS, SOFT ENERGY PATHS: TOWARD A DURABLE PEACE 25 (1977)(comparing two energy paths that are distinguished ultimately by their antithetical social implications, namely rapid expansion of centralized high technologies to increase supplies of energy and a commitment to efficient use of energy, rapid development of renewable energy sources matched in scale and energy quality to end use needs, and special transitional fossil fuel technologies).

4. AMORY LOVINS, MARVIN ODUM & JOHN ROWE, REINVENTING FIRE: BOLD SOLUTIONS FOR THE NEW ENERGY ERA (2011); Shannon Baker-Branstetter, *Distributed Renewable Generation: The Trifecta of Energy Solutions to Curb Carbon Emissions, Reduce Pollutants, and Empower Ratepayers*, 22 VILL. ENVTL. L.J. 1–3 (2011).

5. ANDRES CARVALLO & JOHN COOPER, THE ADVANCED SMART GRID: EDGE POWER DRIVING SUSTAINABILITY 14–15 (2011); Jon Wellinghoff & David L. Morenof, *Recognizing the Importance of Demand Response: The Second Half of the Wholesale Electric Market Equation*, 28 ENERGY L.J. 389, 392 (2007). For a description of "DER," *see* Dep't of Energy, *Distributed Energy Resource Basics*, Federal Energy Management Program, http://www1.eere.energy.gov/femp/technologies/derchp_derbasics.html (last

recognizes that distributed assets come in many forms. These include demand response (DR),[6] all forms of distributed generation, and even storage, if it could be proven at a reasonable cost and scaled up commercially. Greater reliance on DER would be a significant departure from the current structure of the electric industry.[7] Yet DERs are hardly a new phenomenon. Before the widespread deployment of alternating current, large-scale steam turbines, and long-distance transmission lines, electricity was generated at or near its point of use.

Making the electricity system more diverse, distributed, and renewable has widely known benefits. Given the urgency to address climate change,[8] DERs have become especially important as part of a portfolio of solutions to reduce fossil fuel use (and resulting GHG emissions) in the electricity sector of the economy and adapt to the changing climate.[9] The transition from reliance on large power plants to DERs must "occur rapidly to avert potentially catastrophic environmental effects."[10] DERs help the electric grid by increasing grid reliability and resilience, making the grid less vulnerable to prolonged power failures.[11] They can

---

visited Sept. 16, 2012).

6. The U.S. Department of Energy defines "demand response" as "Changes in electric usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized." FED. ENERGY REGULATORY COMM'N, ASSESSMENT OF DEMAND RESPONSE & ADVANCED METERING 5 (2006) [hereinafter FERC 2006 DR-AMI Report], *available at* http://www.ferc.gov/legal/staff-reports/demand-response.pdf. FERC's most recent annual report on DR activities in the United States is FED. ENERGY REGULATORY COMM'N, ASSESSMENT OF DEMAND RESPONSE & ADVANCED METERING (2011) [hereinafter FERC 2011 DR-AMI Report], *available at* http://www.ferc.gov/legal/staff-reports/11-07-11-demand-response.pdf.

7. *See, e.g.*, Nat'l Renewable Energy Lab., *Distributed Energy Basics*, http://www.nrel.gov/learning/eds_distributed_energy.html (last visited Sept. 16, 2012) [hereinafter *NREL Distributed Energy Basics*] (analogizing DER to "the historical evolution of computer systems [from] mainframe computers with outlying workstations [to] powerful servers networked with a larger number of desktop personal computers, all of which help to meet the information processing demands of the end users").

8. *See, e.g.*, Stephen Pacala & Robert Socolow, *Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies*, 305 SCIENCE 968, 968 (2004), *available at* http://www.sciencemag.org/content/305/5686/968.full(calling for a broad range of strategies to be taken immediately).

9. Lesley K. McAllister, *Adaptive Mitigation in the Electric Power Sector*, 2011 BYU L. REV. 2115, 2122 (2011).

10. DAVID J. HESS, TRANSITIONS, SOCIETAL CHANGE, AND COUNTERVAILING POWER: FINANCE, DEMOCRACY, AND GREEN ENERGY IN THE UNITED STATES 3 (2012) (review for publication with Global Environmental Change) (copy on file with author)

11. Amory B. Lovins, *A Farewell to Fossil Fuels: Answering the Energy Challenge*, 91 FOREIGN AFFAIRS 134, 142 (2012); MATTHEW KLIPPENSTEIN & NOORDIN

also reduce energy delivery losses, and reduce emissions of conventional pollutants.[12] Beyond the environmental and energy advantages, there are social benefits, such as widespread decentralized ownership of DG facilities to empower consumers.[13] Aggressive deployment of DG and DR is necessary to change the present landscape of generation dominated by fossil fuel sources.[14] This will be a tremendous challenge, given the enormous scale of existing electricity generation and distribution infrastructure, the comparatively small deployment of DERs, and the legal, political and financial structures that provide much greater incentives for fossil fuel fired plants than for DERs.[15]

In recent years, there has been another major game-changing trend in the electricity sector: the emergence of the "Smart Grid." There is no commonly accepted definition of the Smart Grid, [16] but it is generally understood as those "concepts, technologies, and operating practices intended to bring the electric grid into the 21st century."[17] Broadly speaking, this involves two different goals: using intelligent technologies to overhaul the electric system, and giving consumers new applications for making, using, and conserving electricity.[18]

---

NANJI, MCKINSEY & CO., ELECTRON-DEMOCRACY 4 (2009), *available at* http://www.ballard.com/files/PDF/White_Papers/Electron_Democracy_WP_-_FINAL.pdf (noting that, "a grid fed by a broad, physically dispersed heterogeneous mixture of power sources would provide robust protection against disruption"); Steven Ferrey, *Exit Strategy: State Legal Discretion to Environmentally Sculpt the Deregulating Electric Environment*, 26 HARV. ENVTL. L. REV. 109, 117 (2002) (a grid featuring more widespread deployment of DG is "less vulnerable to supply disruption from an overloaded system line, storm, or intentional disruption").

12. *See, e.g.* S.W. HADLEY ET AL., OAK RIDGE NATIONAL LABORATORY, QUANTITATIVE ASSESSMENT OF DISTRIBUTED ENERGY RESOURCE BENEFITS xii (2003), *available at* http://www.ornl.gov/~webworks/cppr/y2001/rpt/116227.pdf.

13. HESS, *supra* note 10, at 8; Baker-Branstetter, *supra* note 4, at 29.

14. Martin L. Hoffert, *Farewell to Fossil Fuels?,* 329 SCIENCE 1292, 1293 (2010)("Maintaining world economic growth and keeping atmospheric CO2 concentrations below 450 ppm, even with continuing improvements in energy intensity (the amount of CO2 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.").

15. *See generally* Joel B. Eisen, *Residential Renewable Energy: By Whom*?, 31 UTAH ENVTL. L. REV. 339, 346–348 (2011)(discussing the barriers to developing for infrastructure for delivering residential solar and supporting it).

16. JOHN G. KASSAKIAN ET AL., MASS. INST. TECH., THE FUTURE OF THE ELECTRIC GRID, 20 (2011)(noting that Section 1301 of the Energy Independence and Security Act of 2007 defines the Smart Grid in 13 different objectives that make up 'a broad collection of ambitious goals,'" citing 42 U.S.C. § 17381).

17. *See generally* Joel B. Eisen, *Smart Regulation and Federalism for the Smart Grid*, 37 HARV. ENVTL. L. REV. ___ (forthcoming 2013).

18. KASSAKIAN ET AL., *supra* note 16, at 109–10.

How do the two developments relate to one another? One answer is that Smart Grid advances are essential to encouraging greater deployment of DERs throughout the electric grid.[19] As MIT's Paul Joskow notes, "a smart grid may be needed if solar, wind, geothermal, and other renewable energy technologies are to make a sizable contribution to national electricity needs."[20]

Integrating more DERs into the electric grid will require many different technologies and profound regulatory changes. The relationship between the Smart Grid and DERs involve all domains of the electricity transmission and distribution system.[21] Investments in the distribution system can address physical challenges to connecting more DG to the electric grid.[22] Investments in the transmission system are essential for integrating power generated from renewable resources into the grid. As a recent report to FERC noted, "[t]he physical limits to the reliable integration of variable renewable generation are already well understood to be the transmission infrastructure required to deliver this generation to load."[23] The issue of stimulating the construction of new transmission capacity to more fully integrate new generation has attracted considerable attention.[24]

The specific focus of this Article is on the "virtual power plant" (VPP) concept, an intriguing idea that involves an

---

19. The U.S. Department of Energy believes that "the integration of distributed generation (DG), storage, and demand-side resources for participation in electricity system operation" is the "largest 'new frontier'" for the Smart Grid. U.S. DEP'T OF ENERGY, 2010 SMART GRID SYSTEM 3 (2012) [hereinafter 2010 DOE SMART GRID REPORT], *available at* http://energy.gov/sites/prod/files/2010%20Smart%20Grid%20System%20Report.pdf.

20. Paul L. Joskow, *Creating a Smarter U.S. Electricity Grid*, 26 J. ECON. PERSPECTIVES 29, 30 (2012).

21. *Id.*

22. *See generally* National Renewable Energy Laboratory, *Grid Interconnection*, http://www.nrel.gov/learning/eds_grid_interconnection.html (last visited Sept. 16, 2012).

23. JOSEPH H. ETO ET AL., LAWRENCE BERKELEY NATIONAL LABORATORY, USE OF FREQUENCY RESPONSE METRICS TO ASSESS THE PLANNING AND OPERATING REQUIREMENTS FOR RELIABLE INTEGRATION OF VARIABLE RENEWABLE GENERATION xxxi (2010) [hereinafter LBNL REGULATION REPORT], *available at* http://www.ferc.gov/industries/electric/indus-act/reliability/frequencyresponsemetrics-report.pdf.

24. Alexandra B. Klass, *Interstate Transmission Challenges for Renewable Energy: A Federalism Mismatch*, ___ VAND. L. REV. ___ (forthcoming 2012) (draft at 2) (noting that, "It is impossible to talk about developing renewable energy resources in the United States without also talking about developing electric transmission infrastructure.").

aggregation of DERs to provide a "fleet" of resources that can serve as the functional equivalent of a traditional power plant.[25] As the name suggests, this fleet of DERs can add up in the aggregate to the equivalent of a significant resource. Under certain conditions, this resource can be used on the grid (i.e., dispatched) much as a conventional power plant would be. This could reduce demand for fossil fuel-fired plants by enabling a utility to avoid generating electricity or purchasing it in wholesale markets. Increased availability of DR can also help with the integration of DG into the grid. If it is predictable and controllable, it can be called upon by a utility or wholesale market to facilitate DG integration by smoothing out the peaks and valleys of demand for electricity, counterbalancing the inherent variability of DG sources such as solar and wind.

Research and early pilot projects are testing the VPP concept, and several utilities are embarking on plans to deploy VPPs more broadly. This Article describes one such deployment, the VPP project underway at the San Antonio, Texas-based utility CPS Energy.[26] When complete, the CPS VPP will use the advanced technologies and two-way communications capabilities of the Smart Grid ("smart meters" and associated software and hardware) to link together up to 140,000 homes and provide DR equivalent to the output of a 250 megawatts (MW) power plant. The CPS Energy pilot and others will test the "fleet of resources" concept and may yield valuable information to guide its expansion elsewhere.

In Part II, this Article discusses the concept of demand response and its relationship to Smart Grid technologies. Part III discusses the specific challenges of integrating DERs into the grid, focusing on the potential for DR to help integrate the large number of DG sources expected to come on line in the future into the grid, and specifically on the concept of "regulation," or frequency control of the grid. Parts IV and V analyze the VPP concept, with specifics about the CPS Energy program, and a description of challenges facing the expansion of the VPP concept elsewhere.

---

25. *See infra* Part IV.
26. *See id.*

## II. DEMAND RESPONSE AND SMART GRID TECHNOLOGIES

"Demand response" (DR) is the name for strategies by which end-use customers reduce their use of electricity in response to emergency needs on the electric grid or price signals.[27] More widespread use of DR can minimize the strain on the grid, lessen the likelihood of power outages, and reduce emissions and the need to build new fossil fuel-fired power plants.[28] Recognizing DR's benefits, the Energy Policy Act of 2005 declared a national policy to encourage it.[29]

In emergency-based DR programs, consumers usually receive an incentive (typically monetary) and empower utilities or authorized third parties to decrease their electricity consumption over a specific time period in response to a signal to reduce demand.[30] Demand for electricity is not constant and spikes on many parts of the grid on several peak days of the year and at peak times. Emergency DR can help reduce demand at peak times by substituting negawatts for starting or using another power plant to meet peaking demand.[31] Historically, the primary use of DR has been reducing system demand in times of emergencies.[32]

Economic DR provides an incentive to customers or authorized third party providers to reduce consumption when electricity prices are high. At present, traditional utilities and wholesale markets have limited economic DR activity.[33] Research

---

27. FERC 2006 DR-AMI Report, *supra* note 6, at viii; *see also Demand Response – Policy*, U.S. DEPT. OF ENERGY, http://energy.gov/oe/electricity-policy-coordination-and-implementation/state-and-regional-policy-assistance/technic-1 (last visited Oct. 14, 2012). DR is one of the strategies available for "demand-side management," or "DSM," which also includes energy efficiency programs and incentives. James W. Moeller, *Electric Demand-Side Management Under Federal Law*, 13 VA. ENVTL. L.J. 57 (1993).

28. PETER FOX-PENNER, SMART POWER: CLIMATE CHANGE, THE SMART GRID, AND THE FUTURE OF ELECTRIC UTILITIES 46 (2011) (describing carbon-saving impacts of "aggressive DR"); FERC 2006 DR-AMI REPORT, *supra* note 6, at 12 (noting that, "demand response may provide environmental benefits by reducing generation plants' emissions during peak periods.").

29. 16 U.S.C. § 2642 (2005).

30. LBNL REGULATION REPORT, *supra* note 23, at 16.

31. FERC 2006 DR-AMI REPORT, *supra* note 6, at x. DR can be a substitute for new generation, or even for new transmission capacity to serve a specific area. *Id.*

32. PETER CAPPERS, CHARLES GOLDMAN, & DAVID KATHAN, DEMAND RESPONSE IN U.S. ELECTRICITY MARKETS: EMPIRICAL EVIDENCE 19 (2009), *available at* http://eetd.lbl.gov/ea/EMP/reports/lbnl-2124e.pdf

33. *Id.* at 16. For a summary of DR in one RTO, *see* PJM INTERCONNECTION, 2011 FINAL EMERGENCY LOAD MANAGEMENT (ILR/DR) AND ECONOMIC

has demonstrated, however, that there is enormous potential for DR beyond emergency curtailment activities. The nation's DR potential is well over 100 gigawatts (GW), and aggressive deployment of DR could reduce as much as 20% or more of existing demand.[34] One report identifies "residential and small commercial (i.e., mass market) customers" as having the greatest overall potential for increasing the size and scope of DR.[35]

Due to the structure of the electric utility industry, different regions have different types of DR providers.[36] In states with traditional vertically integrated utilities and cost of service regulation, these utilities offer time-based retail rates and incentive-based DR programs. In states with retail competition, competitive suppliers are also offering these programs.

In the parts of the nation with independent system operators and regional transmission organizations (ISO/RTOs) that manage transmission networks,[37] DR participates in the wholesale markets administered by ISOs and RTOs.[38] The PJM RTO, for example, allows deployment of DR as a resource in four different markets that it administers: the capacity, energy, reserve and regulation markets.[39] The Energy Policy Act of 2005 explicitly encouraged this, making it national policy that "unnecessary barriers to demand response participation in

---

DEMAND RESPONSE SUMMARY 2 (2011), *available at* http://www.pjm.com/markets-and-operations/demand-response/~/media/markets-ops/dsr/2011-final-energy-load-management-and-economic-demand-response-summary.ashx (providing statistics on emergency DR and noting that in 2011, "PJM had very limited Economic Demand Response activity").

34. FED. ENERGY REGULATORY COMM'N, A NATIONAL ASSESSMENT OF DEMAND RESPONSE POTENTIAL x–xii (2009) [hereinafter FERC 2009 DR POTENTIAL REPORT], *available at* http://www.ferc.gov/legal/staff-reports/06-09-demand-response.pdf.

35. PETER CAPPERS ET AL., MASS MARKET DEMAND RESPONSE AND VARIABLE GENERATION INTEGRATION ISSUES: A SCOPING STUDY 5 (2011) [hereinafter LBL 2011 DR-DG INTEGRATION SCOPING STUDY], *available at* http://eetd.lbl.gov/EA/emp/reports/lbnl-5063e-ppt.pdf.

36. *See id.*, at 8 (chart showing the variety of entities that are involved in DR deployment).

37. *See generally* David B. Spence, *Can Law Manage Competitive Energy Markets?*, 93 CORNELL L. REV. 765, 774 (2008)(noting that in the 1980s and 90s the FERC encouraged the formation of independent transmission-system operators to manage transmission systems resulting in the robust development of gas and electric wholesale markets in the United States by the twentieth century).

38. Wellinghoff & Morenof, *supra* note 5, at 395.

39. PJM Interconnection, *Demand Response*, *Markets & Operations*, http://www.pjm.com/markets-and-operations/demand-response.aspx (last visited Sept. 16, 2012). *See* Part II for a fuller discussion of the concept of regulation and the role of DR in providing regulation service.

energy, capacity and ancillary service markets shall be eliminated."[40] FERC implemented this statutory provision in part through its Order 719, which requires ISOs and RTOs that administer wholesale markets to allow DR market participation.[41] As implemented in PJM, for example, retail consumers cannot participate directly in the PJM markets, but do so through third parties called curtailment service providers (CSPs),[42] who bid DR into the various markets.[43]

The method of compensating DR in wholesale markets has attracted considerable recent attention. Wholesale market prices of electricity are based on locational marginal pricing (LMP)[44] that tracks instantaneous changes in costs of generation and demand through identification of precise locations where congestion leads to higher nodal prices. As FERC Chairman Jon Wellinghoff has noted, DR can therefore have a major impact on wholesale market prices because "even modest amounts of demand response can lead to significant reductions in wholesale prices at times of capacity constraints."[45] FERC's controversial Order 745, promulgated in 2011, established a uniform,

---

40. Act Aug. 8, 2005, P.L. 109-58, Title XII, Subtitle E, § 1252(e), (f), 119 Stat. 965 (corresponds to 16 U.S.C. § 2642 (2005)).

41. Non-Discriminatory Open Access Transmission Tariff, 18 C.F.R. § 35.28 (2012).

42. *See* CAPPERS, GOLDMAN, AND KATHAN, *supra* note 32, at 23–24 for a discussion of the evolution of DR from its provision by load serving entities (LSEs) to market participants including non-LSE CSPs. *See also* MARCY LOWE ET AL., CENTER ON GLOBALIZATION, GOVERNANCE & COMPETITIVENESS, U.S. SMART GRID: FINDING NEW WAYS TO CUT CARBON AND CREATE JOBS 18 (2011), *available at* http://cggc.duke.edu/pdfs/Lowe_US_Smart_Grid_CGGC_04-19-2011.pdf (naming leading CSP firms Comverge and EnerNOC). The CSPs authorized in the PJM market are listed at http://www.pjm.com/markets-and-operations/demand-response/csps.aspx.

43. This trend has intriguing potential. If DR is implemented on a widespread basis by third party providers without utilities' involvement, it is eventually possible that, "unregulated services could eventually create a 'virtual utility' that could largely or wholly bypass power companies, just as cell phones bypassed landline phone companies—a prospect that worries utility executives but excites venture capitalists." Lovins, *supra* note 11, at 142.

44. LMP is a marginal cost pricing mechanism under which "the price to withdraw electric power (whether bought in the exchange market or obtained through some other method) at each location in the grid at any given time reflects the cost of making available an additional unit of electric power for purchase at that location and time." ROBERT ALLEN ET AL., THE ELECTRIC ENERGY MARKET COMPETITION TASK FORCE, REPORT TO CONGRESS ON COMPETITION IN WHOLESALE AND RETAIL MARKETS FOR ELECTRIC ENERGY 58 (2006) [hereinafter TASK FORCE REPORT], *available at* http://www.ferc.gov/legal/fed-sta/ene-pol-act/epact-final-rpt.pdf. *See also* WILLIAM W. HOGAN, GETTING THE PRICES RIGHT IN PJM: ANALYSIS AND SUMMARY: APRIL 1998 THROUGH MARCH 1999 THE FIRST ANNIVERSARY OF FULL LOCATIONAL PRICING (1999), *available at* http://www.hks.harvard.edu/fs/whogan/pjm0399.pdf (early discussion of the LMP concept and its implementation in PJM by major academic proponent); *See* Hind Farag & Gary L. Hunt, *Don't Mess With Texas*, 144 No. 10 Fortnightly 12 (2006) (describing LMP's implementation as "nodal pricing" in Texas).

45. Wellinghoff & Morenof, *supra* note 5, at 395.

nationwide approach to compensating DR participating in wholesale markets, requiring that it receive the full LMP. ISOs and RTOs are beginning to take steps to comply with Order 745,[46] but even as implementation proceeds, a broad coalition of opponents has challenged the Order.[47]

For economic DR to become more widespread, time-based retail rates (the techniques collectively known as "dynamic pricing") must become more widely available to provide price signals to encourage demand reductions.[48] However, most residential and small commercial consumers do not receive finely detailed pricing signals, and typically pay a fixed price per unit of electricity consumption (usually a kilowatt-hour) that does not change to reflect short-term variations in the market price of electricity.[49] Making dynamic pricing more widely available is a major building block in the expansion of DR.[50]

Price signals cannot be made available to consumers without investments in advanced "smart meters" and other systems to support them. Most existing electric meters do not have two-way communications capabilities and only measure the amount of electricity consumed. Today's more advanced smart meters have capabilities for dynamic interaction between utilities and their customers.[51] For example, they can record consumption hourly or even more frequently[52] and can be turned on and off remotely.

---

46. ISOs and RTOs are filing with FERC to establish their versions of the "net benefits test" required under Order 745. *See* Energy Bar Association, *Report of the Demand-Side Resources & Smart Grid* Committee, 33 ENERGY L. J. 213, 223 (2012). *See, e.g.*, *PJM Implements FERC Order on DR Compensation*, SMART GRID TODAY (Apr. 3 2012), http://www.smartgridtoday.com/public/3888print.cfm (as of April 1, 2012, DR receives full LMP in the PJM energy market if it passes the net benefits test).

47. The petitions for review by major industry participants, including the Electric Power Supply Association, Edison Electric Institute, and others, are consolidated in the D.C. Circuit as Elec. Power Supply Ass'n v. FERC, Nos. 11-1486 et al. (D.C. Cir. filed Dec. 23, 2011).

48. SEVERIN BORENSTEIN, EFFECTIVE AND EQUITABLE ADOPTION OF OPT-IN RESIDENTIAL DYNAMIC ELECTRICITY PRICING 2 (2012), *available at* http://ei.haas.berkeley.edu/pdf/working_papers/WP229.pdf.

49. *Id.* at 4.

50. FERC 2011 DR-AMI REPORT, *supra* note 6, at 20.

51. LISA SCHWARTZ & PAUL SHEAFFER, REGULATORY ASSISTANCE PROJECT, IS IT SMART IF IT'S NOT CLEAN?: SMART GRID, CONSUMER ENERGY EFFICIENCY, AND DISTRIBUTED GENERATION 3 (2011).

52. FERC defines "Advanced metering" as "a metering system that records customer consumption [and possibly other parameters] hourly or more frequently and that provides for daily or more frequent transmittal of measurements over a communication network to a central collection point." FERC 2006 DR-AMI REPORT, *supra* note 6, at vi n. 2.

These technologies can have many benefits for utilities. The ability to communicate directly with smart meters, for example, can improve their outage and restoration capabilities.

By one estimate, utilities are expected to deploy about 65 million smart meters, reaching nearly half of American households, by 2015.[53] The smart meter is only one element in a utility's Smart Grid deployment, as updated communications, data analysis, billing and other systems are required as well.[54]

## III. THE SMART GRID, DR, AND DG INTEGRATION

One way in which DR may contribute to a more efficient and "smarter" grid is facilitating DG integration.[55] At present, the American electricity system is not built to handle large flows of DG. It is a one-way, left to right system that was not designed for bidirectional power flow between a utility and its customers.[56] Power is generated at power plants, transmitted over long distances, and distributed to end users, whose only "right to left" activity is typically mailing in monthly electric bills. To change this paradigm requires substantial changes to the grid.[57]

Expansion of DG, through incentives such as renewable portfolio standards, tax credits, and feed-in tariffs, promises to

53. AHMAD FARUQUI ET AL., INST. FOR ELEC. EFFICIENCY, THE COST AND BENEFITS OF SMART METERS FOR RESIDENTIAL CUSTOMERS 2 (2011), *available at* http://www.edisonfoundation.net/iee/Documents/IEE_BenefitsofSmartMeters_Final.pdf. As of September 2011, advanced meters made up 18.3% of all installed meters, for a total of 27.3 million smart meters. FERC 2011 DR-AMI REPORT, *supra* note 6, at 3. The U.S. Department of Energy's annual reports on the Smart Grid detail current and planned deployments of smart meters by individual utilities. 2010 DOE SMART GRID REPORT, *supra* note 19, at 22 (table listing current and planned deployments totaling 50.7 million meters).

54. Joskow, *supra* note 20, at 42.

55. NORTH AMERICAN ELEC. RELIABILITY CORP., ACCOMMODATING HIGH LEVELS OF VARIABLE GENERATION iii (2012) [hereinafter NERC 2012 Report], *available at* http://www.nerc.com/files/IVGTF_Report_041609.pdf. As noted above, this also relies on the availability of dynamic pricing. BORENSTEIN, *supra* note 48, at 5 (noting that, "Dynamic pricing makes it possible to more closely match demand fluctuations to the exogenous supply fluctuations and, thus, reduce the system costs of integrating these renewable energy sources.").

56. ELEC. POWER RESEARCH INST., NEEDED: A GRID OPERATING SYSTEM TO FACILITATE GRID TRANSFORMATION 4 (2012) [hereinafter EPRI GRID 3.0], *available at* http://www.nationalelectricityforum.org/pdfs/Needed_A_Grid_Operating_System_to_Facilitate_Grid_Transformation.pdf.

57. NERC 2012 REPORT., *supra* note 55, at i(terming this "one of the largest new resource integration efforts in the history of the electric industry"). *See also* GEORGE CRABTREE ET AL., AM. PHYSICAL SOC'Y, INTEGRATING RENEWABLE ELECTRICITY ON THE GRID 22 (2010), *available at* http://www.aps.org/policy/reports/popa-reports/upload/integratingelec.pdf ; EPRI GRID 3.0, *supra* note 56, at 5–6..

overhaul the grid's one-way nature.[58] Through added deployment of residential solar PV systems,[59] electric vehicles connected to the system in vehicle-to-grid (V2G) fashion[60] and other distributed resources, there may well be substantially more power being "added back" to the grid.

This poses many challenges, including the need to maintain the instantaneous balance between supply and demand on the grid. Because DG systems produce power intermittently,[61] they can lead to rapid and wide variations on the grid.[62] This variability creates a well-known macro-level problem of balance. Electricity is unique among all products in that it is "the ultimate 'just in time' manufacturing process, where supply must be produced to meet demand in real time."[63] No current technology provides large-scale, economical storage of electricity.[64] Therefore, system operators must constantly balance supply and demand in real time, and reliable operation of the grid depends on maintaining its frequency and other operating criteria within specific narrow limits.[65] Failure to maintain this balance can have extreme consequences, such as drops in voltage quality or blackouts, disruption to customers' equipment, and mandatory disconnection of power plants.[66]

---

58. CARVALLO & COOPER, *supra* note 5, at 18.

59. Eisen, *supra* note 15.

60. The vehicle-to-grid concept envisions that electricity stored in the batteries in electric vehicles could be "returned" to the grid when it is needed most. Steven E. Letendre & Willett Kempton, *The V2G Concept: A New Model for Power?*, PUB. UTIL. FORTNIGHTLY, Feb. 15, 2002, at 16, *available at* http://www.udel.edu/V2G/docs/V2G-PUF-LetendKemp2002.pdf.

61. CARVALLO & COOPER, *supra* note 5, at 18. Output of DG sources depends on a wide variety of factors. These include weather variables such as the amount of insolation (sun falling on a solar panel), technology variables such as the capacity factor of a wind turbine, and other variables (such as blockage of a solar panel by natural or man-made obstacles). NERC 2012 REPORT, *supra* note 53, at 15–27 (discussing the performance characteristics of wind and solar technologies); Joskow, *supra* note 20, at 36. *See generally* GAUTAM GOWRISANKARAN ET AL., INTERMITTENCY AND THE VALUE OF RENEWABLE ENERGY (2011), *available at* http://www.u.arizona.edu/~msamano/renewable_intermittency.pdf (attempting to quantify the intermittency).

62. *See generally* LBNL REGULATION REPORT, *supra* note 23 (discussing this challenge and strategies to address intermittency).

63. Joskow, *supra* note 20, at 33.

64. NERC 2012 REPORT, *supra* note 55, at i; AM. PHYS. SOC., *supra* note 55, at 3-4.

65. NERC 2010 REPORT., *supra* note 55, at i.

66. LBNL REGULATION REPORT, *supra* note 23, at 7.

System operators must respond quickly to rapid changes in power flows at different locations on the network. Their actions include primary frequency response (taking immediate action, often within seconds, to balance the grid) and secondary response (taking action that is not immediate), and these are collectively known as "regulation" of the grid.[67] Regulation is one of the "ancillary services" that "support the basic services of generating capacity, energy supply, and power delivery."[68] When frequency is above the scheduled value, system operators rely on generators to decrease their output, and when frequency is below the scheduled value, generators increase their output.[69] Their delicate balancing act monitors the amount of generation deployed at each point on the transmission grid, and uses reserves (both "spinning" and "non-spinning") that they can dispatch to keep supply and demand in balance. Frequency regulation service is an important resource on its own in wholesale electricity markets. Recognizing this, FERC issued Order 755 in 2011, which sets criteria for RTOs and ISOs to compensate providers of regulation service.[70]

The challenge of regulating the grid is exacerbated by the increasing overall stress on the aging grid. The primary frequency performance of the grid has been declining for many years.[71] A 2010 FERC-sponsored report[72] found that this trend was underway before the recent expansion of generators using renewable resources. However, the addition of more power with intermittent production characteristics could exacerbate this problem. The full extent of the challenge to system frequency regulation from increased deployment of renewable resources is only beginning to become known.[73] While most attention has

---

67. *Id.* at 9; Spence, *supra* note 37, at 770.

68. ERIC HIRST & BRENDAN KIRBY, ELECTRIC-POWER ANCILLARY SERVICES 6 (1996), *available at* http://www.consultkirby.com/files/con426_Ancillary_Services.pdf. *See, e.g.,* PJM Interconnection, *Ancillary Services*, *available at* http://www.pjm.com/markets-and-operations/ancillary-services.aspx (defining regulation as one of three ancillary services in PJM that "corrects for short-term changes in electricity use that might affect the stability of the power system").

69. LBNL REGULATION REPORT, *supra* note 23, at 7-8.

70. Fed. Energy Reg. Comm., Frequency Regulation Compensation in the Organized Wholesale Power Markets, 76 Fed. Reg. 67260 (2011)(to be codified at 18 C.F.R. pt. 35).

71. Richard Piwko et al., *Lessons Learned from Large-Scale Wind Power Integration*, IEEE PWR. & ENERGY, Mar./Apr. 2012, *available at* http://magazine.ieee-pes.org/marchapril-2012/penetrating-insights/

72. LBNL REGULATION REPORT, *supra* note 23.

73. *Id.*, at xvi (noting that, "Recent studies of renewables integration within the U.S. have focused on increased requirements for secondary frequency control (regulation and load following), but only to a limited extent if at all on requirements for

been devoted to larger generators such as wind farms, an expansion of DG may well present a similar challenge if it is large enough to increase overall system variability.[74]

DR could help meet the challenge of frequency regulation, by "smoothing out" the peaks and valleys associated with bringing more renewable resources online. The two different types of energy resource have different "production" characteristics. As Amory Lovins suggests in his recent article, "electric vehicles could recharge from or supply power to the electricity grid at times that compensate for variations in the output from wind and solar power."[75] That is, under the right circumstances, DR could provide regulation services.

FERC has identified expanded DR as a potential strategy to deal with the problem of regulation of the grid.[76] DR's production curve is technically different from that of other assets used as reserves on the grid, because it does not require the startup of a power plant.[77] If enough DR can be deployed predictably and readily, it may allow for integration of DG by enabling "grid operators to quickly respond to changes in variable generation output without placing undue strain on the power system."[78] However, in the case of DR aggregated from a number of mass-market consumers, that is a big "if." Not all DR is the same, as it varies in terms of how long it can be controlled and how much reduction in demand it provides.

Because there has not been an extensive amount of economic DR, more research and pilot projects are necessary to develop an understanding of the ability of DR to contribute to frequency regulation. Recent studies have examined the potential role of DR to address DG integration issues. However, most existing research deals with a "limited subset of bulk power operations," a "limited assessment of DR programs," and an "unrealistic view of how [DG] and DR will be integrated into the bulk power system

---

primary frequency control.").

74. AM. PHYS. SOC., *supra* note 57, at 3 ("As renewable generation grows it will ultimately overwhelm the ability of conventional resources to compensate renewable variability"); Piwko et al., *supra* note 69 (noting that, "the addition of large amounts of wind (or photovoltaic solar) generation could potentially exacerbate the problem [of frequency regulation]").

75. Lovins*, supra* note 11, at 136.

76. LBNL REGULATION REPORT, *supra* note 23, at xviii.

77. NERC 2012 REPORT, *supra* note 55, at iii.

78. *Id.*

in the near term (5-10 years)."[79] The last of these refers to the fact that research must model customer acceptance of and response to DR programs. Various pilot projects are being conducted to examine these issues.

## IV. A MODEL FOR PROMOTING AGGREGATION AND INTEGRATION: THE "VIRTUAL POWER PLANT"

The "virtual power plant" (VPP) has been proposed as one means to capture economic DR's potential benefits and to facilitate cost-efficient integration of DG into the electric grid. The term VPP lacks a single common definition,[80] but as the name implies, a VPP is not a bricks and mortar (or, perhaps more appropriately, boiler and machinery) power plant at all. Instead, it is an aggregation of resources, or, in one proposed definition, "a system that relies upon software systems to remotely and automatically dispatch and optimize generation, demand-side, or storage resources (including plug-in electric vehicles and bi-directional inverters) in a single, secure web-connected system."[81] Therefore, it is not a physical power plant, and is "virtual" in the sense that its central feature is the software and the hardware used to manage the different energy resources. As one explanation puts it, the VPP is "a power plant of the IT mind—a plant locked in the digital world that can shift from traditional generation to smart-grid-enabled renewables at will."[82]

A VPP could include any combination of DR and DG and could theoretically be dispatchable.[83] Indeed, as one researcher has put it the VPP's central feature is that it is an "aggregation of distributed resources that can be utilized in the same manner as conventional generation."[84] As another analysis puts it, the "essence" of the VPP is "the ability to tap resources in real time,

---

79. LBL 2011 DR-DG INTEGRATION SCOPING STUDY, *supra* note 35, at 7.

80. Peter Asmus, *Virtual Power Plants—What Are They?*, PIKE RES. BLOG, Nov. 16, 2011, *available at* http://www.pikeresearch.com/tag/virtual-power-plant

81. *Id.* (A bidirectional inverter can be operated in all four quadrants of the voltage/current regime hence may function as an inverter or as a rectifier by applying the proper drive signals).

82. Kathleen Davis, *Virtual Power Plants Set To Potentially Change Power Structure*, RENEWABLEENERGYWORLD.COM, Jan. 19, 2011, *available at* http://energystoragetrends.blogspot.com/2010/12/virtual-power-plants-set-to-potentially.html

83. *Id.* (stating that, "Ideally, the dispatch of the VPP would be fully integrated into utility system operations such that it would be transparent to the system operator.").

84. *Id.* (quoting Matt Wakefield of the Electric Power Research Institute).

and with enough granularity, to control the load profiles of customers, aggregate these resources, and put them up on a trader's desk."[85]

In this program, individual homes can become part of the system operator's electricity balancing process. Cycling off a single HVAC system does not by itself affect peak demand, but aggregating thousands of homes together may enable a system operator to cut demand in a measurable fashion and forego bringing a power plant online.[86] The design of the program is critical, because demand reductions must be controllable for the time period necessary for them to be relied upon by a utility or wholesale market.[87]

The VPP is comparable to a "microgrid," which also incorporates the idea of aggregating resources in an interconnected network that is distinctly different from the existing grid. The microgrid is a standalone, interconnected network of DERs that can function connected to, or separate from the grid.[88] A microgrid could include DR and DG in a small-scale version of the entire electricity system, with sophisticated load management controls.[89] If properly designed, a microgrid might be self-sustaining and would not need to connect to the electric grid. The VPP envisions a role for the resource in the portfolio of a utility and/or third party provider, by virtue of the connection to the grid infrastructure through smart meters.[90]

What makes the VPP "work"? There must be some sort of communication and interface among all of the different resources, and a link between the "power plant" and the system

---

85. Asmus, *supra* note 80.

86. *See, e.g.*, Katherine Tweed, *Texas Heat Wave: More Demand Response Needed*, GREENTECHGRID, Aug. 9, 2011, *available at* http://www.greentechmedia.com/articles/read/texas-heat-wave-more-demand-response-needed/ (noting that, "Single homes don't offer the load shed of large industrial customers, but there are meaningful megawatts that can be curbed through aggregation.").

87. CHARLES GOLDMAN, LAWRENCE BERKELEY NATL. LAB., USING DEMAND RESPONSE FOR INTEGRATING VARIABLE GENERATION 11 (2011), *available at* http://www.westgov.org/wieb/meetings/crepcfall2011/briefing/present/c_goldman2.pdf

88. *See generally* Sara C. Bronin, *Curbing Energy Sprawl with Microgrids*, 43 CONN. L. REV. 547 (2010); Lovins, *supra* note 11, at 142 (discussing "local 'microgrids,' which can stand alone if needed," and suggesting that "The Pentagon, concerned about its own reliance on the commercial grid, shares this goal of resilience and this path to achieving it.").

89. NREL DISTRIBUTED ENERGY BASICS, *supra* note 7.

90. Davis, *supra* note 82.

operator (a wholesale market or a traditional utility). These Smart Grid technologies include sophisticated smart meters, software that facilitates communication by reporting near real-time information to the DR provider and notifying customers of load curtailments or high prices, and technologies such as automatic sensors to control individual devices. Ideally, the suite of technologies would evaluate the combinations of DG and DR best suited to meet current grid needs, and make changes on a nearly instantaneous basis.

At the moment, VPPs have been deployed on a small scale with demonstrations and simulations. One notable project is a collaborative effort of the Electric Power Research Institute and the utility American Electric Power involving 10,000 customers in South Bend, Indiana to test a combination of community electric storage technologies and voltage control.[91]

In San Antonio, CPS Energy (CPS), the municipal utility that serves over 700,000 electric customers,[92] is implementing a technology solution from the startup company Consert to use smart meters to create a 250 MW virtual power plant.[93] The project goal is to install 140,000 systems, or 20% of CPS's total customer base, by 2014.[94] At each residence, utility technicians install two devices: a "gateway" for communicating to the utility, installed behind the glass in the smart meter; and a programmable communicating thermostat (PCT), installed inside the home.[95] Technicians also install device controllers on pool pumps, HVAC systems, and electric hot water heaters that communicate with the thermostat and gateway. Consert estimates that these three devices consume roughly 60% of the electricity in a typical home that has signed up for the program.[96]

Customers access the Consert secure online portal from any Web browser.[97] There, they can customize energy profiles (set on

---

91. *See* ELEC. PWR. RES. INST., EPRI SMART GRID DEMONSTRATION UPDATE (2011), *available at* http://smartgrid.epri.com/doc/EPRI%20Smart%20Grid%20Advisory%20Update%20-%2018-November-2011.pdf, for a description of project activities.

92. CPS Energy, *Who We Are*, http://www.cpsenergy.com/About_CPS_Energy/Who_We_Are/ (last visited Apr. 30, 2012).

93. Tweed, *supra* note 86; Sanford Nowlin, *Trends in Going Green in San Antonio*, SAN ANTONIO BUS. J., Feb. 10, 2012, at 22 (describing the CPS/Consert program).

94. *Id.*

95. *Id.*

96. Consert Inc., *Consert VPP*, 6 (2012) (copy on file with author).

97. *Id.*, at 9.

an initial basis through the response to a short survey) that have different settings to match personal habits. For example, the consumer can set a "Day" profile that sets the HVAC temperature higher when she is leaving for work during the day. An important aspect of this is that the consumer can use the profile to "opt out" of DR, which would typically happen by defining preferences that would override a demand reduction event. For example, once a setting that did not allow the air conditioning to exceed 78 degrees in the house was triggered, the consumer would no longer be part of the demand reduction event.

Information is communicated to CPS via a cellular company partner's wireless network, and company executives believe this provides sufficient reliability for the transmission of data. The utility can begin a demand reduction event within seconds and its secure portal shows the amount of load available on the system for demand reduction, and even which houses and devices are available. This system can be fine tuned to, for example, cycle off only those devices that have not been cycled off during the previous day, or cycle off all of a particular type of device (water heaters instead of HVAC systems in the middle of a hot day, for example). An important feature is that even if only 60-80% of the available load takes part in a demand reduction event, the utility can "hold" the reduction for a significant length of time, often for hours. This can make the amount of reduction more predictable and more reliable.

The utility and Consert estimate that at full deployment, the VPP would control a significant amount of load.[98] The 250 MW estimate puts the VPP at a size comparable to that of many fossil fuel-fired plants.

## V. CHALLENGES TO SCALING UP THE CONCEPT

There are numerous barriers to more widespread deployment of DR.[99] Scaling up a VPP faces considerable challenges. For one, the 20% target participation rate of the CPS/Consert program is a tacit recognition that homes that do not have all three electric appliances that can currently be

98 *Id.*

99. FERC 2009 DR POTENTIAL REPORT, *supra* note 34, at xiv-xvi (describing and listing the principal obstacles); *compare* REG. ASSIST. PROJ,, *supra* note 49, at 7 (listing similar barriers to wider deployment of energy efficiency programs).

controlled (a home with a gas water heater, for example) are less viable candidates for the program.

Another challenge is behavioral: motivating larger numbers of customers to accept a VPP's demand reduction program. Much excellent work has gone into studying the behavioral dimension of prompting consumers to curb their demand for electricity.[100] The 2010 "National Action Plan on Demand Response," promulgated by FERC in response to a mandate in the Energy Independence and Security Act of 2007, calls in part for strategies and activities to improve communication with customers.[101]

Early indications are that consumers save about 15% of electricity usage in the CPS Energy VPP.[102] Some of this undoubtedly comes from increased awareness of energy management techniques through education tools made available on the website, and some comes from savings achieved during demand reduction events. The VPP design (and particularly the feature that gives consumers control over ending participation in DR events) may allow CPS to avoid the customer resistance that other utilities have encountered when they have implemented direct load control programs.[103] Preliminary surveys show that consumers are satisfied with the level of comfort maintained during DR events, and are also enthusiastic about the energy savings achieved in the VPP. However, the information about customer satisfaction in pilot projects is from early adopters. Data about customer satisfaction may look less encouraging for a broader cross-section of homeowners with different attitudes about reducing energy use, not to mention different types of appliances, sizes of homes, weather conditions, incomes, and electricity consumption rates.[104]

---

100. *See, e.g.*, Amanda R. Carrico et al., *Energy and Climate Change: Key Lessons for Implementing the Behavioral Wedge*, 1 J. ENERGY AND ENVTL. L. 61, 61 (2011) (addressing one of the obstacles to achieving a behavioral wedge of individual household emissions reductions).

101. FED. ENERGY REG. COMM., NATIONAL ACTION PLAN ON DEMAND RESPONSE (2010), *available at* http://www.ferc.gov/legal/staff-reports/06-17-10-demand-response.pdf

102. *Nowlin*, *supra* note 93, at 22.

103. *See, e.g.*, Liz F. Kay and Julie Baughman, *Consumer advocates call for review of BGE program*, BALT. SUN, July 25, 2011 (detailing thousands of consumer complaints about the BGE "Peak Rewards" program).

104. Joskow, *supra* note 20, at 42.

In general, researchers have found that better communication is necessary to improve consumer response to DR program availability. A recent report by the American Council for an Energy-Efficient Economy (ACEEE) found that in nine pilot projects it studied in the United States, United Kingdom and Ireland, homeowners achieved only a 3.8% overall savings of electricity use.[105] The ACEEE did find, however, that a small percentage of households saved up to 25% because they were the most responsive to feedback from an in-home display.[106] The report suggests that more consumer education is necessary. In the case of the VPP concept, more targeted efforts will be necessary to determine whether consumers will accept it, and how it should be designed and marketed to accomplish its objectives.

Among the many other challenges is securing increased support for exposing mass-market customers to dynamic pricing, as there has been opposition to it from some constituencies, and state regulators have been unwilling in some instances to allow utilities to implement it.[107] The success of pilot projects could help make the case for broader implementation of dynamic pricing. However, the CPS/Consert program does not include it, and it is therefore not an optimal model for assessing the likelihood of success of a broader DR program featuring it.

As for utilities, the disincentives for them to adopt DR programs (in effect, to "anti sell" their own product) are well known and documented.[108] State public utility commissions should consider broader use of "decoupling" policies[109] that

---

105. AM. COUNCIL FOR AN ENERGY EFFICIENT ECON., RESULTS FROM RECENT REAL-TIME FEEDBACK STUDIES (2012), *available at* http://www.aceee.org/research-report/b122

106. *Id.*

107. BORENSTEIN, *supra* note 48, at 5–6, discusses the reasons for this opposition; *see also* Michael P. Vandenbergh and Jim Rossi, *Good for You, Bad for Us: The Financial Disincentive for Net Demand Reduction*, ___ VAND. L. REV. ___ (forthcoming 2012)(copy on file with author, at 14)(observing that, "people often have limited or incorrect information about what activities use the most electricity, suggesting that responses to variable or dynamic pricing will often be disappointing or counterproductive.").

108 FERC 2006 DR-AMI Report, *supra* note 6, at 126.

109. *See* REG. ASSIST. PROJECT, REVENUE REGULATION AND DECOUPLING: A GUIDE TO THEORY AND APPLICATION (2011), *available at* http://raponline.org/document/download/id/902 and JOSEPH P. TOMAIN, ENDING DIRTY ENERGY POLICY: PRELUDE TO CLIMATE CHANGE 175–79 (2011) for explanations of the various rate designs involved in decoupling initiatives. NATL. RENEWABLE ENERGY LAB., DECOUPLING POLICIES: OPTIONS TO ENCOURAGE ENERGY EFFICIENCY POLICIES FOR

reward utilities for DR investments. These incentives may prompt utilities to invest in the software, hardware and services to create a dispatchable portfolio of DR resources, or partner with (or acquire) third-party providers that have already made substantial inroads in the DR market.

Standardization of the technologies necessary for more widespread use of DR is also important.[110] Many different vendors are vying for a piece of the smart grid market, and moving beyond demonstrations and pilots to broader DR incorporation in wholesale markets will require standards that address smart meter functionalities and communications protocols. The technical standards development effort led by the National Institute of Standards and Technology (NIST), working in conjunction with FERC and the private sector, has identified DR as one of eight priority areas for immediate attention.[111] The NIST-led "Priority Action Plan" PAP09 is devoted to establishing technical standards such as "an automated mechanism for announcing, configuring, and removing devices."[112] As NIST has observed, "lack of widely accepted signals across the entire DR signaling and validation chain hinders widespread deployment of these technologies," and standards developed in the NIST process "will allow further automation and improve DR capabilities across the grid."[113]

Another issue that must be addressed in deploying large-scale DR more widely is the relationship of state PUCs and third-party aggregators seeking to provide DR in wholesale markets.[114]

---

UTILITIES 6 (2009), *available at* http://www.nrel.gov/docs/fy10osti/46606.pdf, features a map showing the status of decoupling programs in the U.S.

110. *See generally* Eisen, *supra* note 17.

111. NAT'L INST. OF STDS. AND TECH., NIST FRAMEWORK AND ROADMAP FOR SMART GRID INTEROPERABILITY STANDARDS, RELEASE 1.0 8, 20 (2010) (hereinafter "NIST STANDARDS FRAMEWORK 1.0"; Eisen, *supra* note 17 (discussing the NIST Framework process).

112. NAT'L INST. OF STDS. AND TECH., SMART GRID INTEROPERABILITY PANEL, PAP09: STANDARD DR AND DER SIGNALS, *available at* http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/PAP09DRDER.

A set of communication protocols known collectively as "OpenADR" is the basis of much of PAP09. The first OpenADR 2.0 products were tested in April, 2012 and expected to become more widely available by the end of the year. Marianne Hedin, *OpenADR 2.0 Standard Will Fuel Automated Demand Response*, PIKE RESEARCH BLOG, Apr. 27, 2012, *available at* http://www.pikeresearch.com/blog/openadr-2-0-standard-will-fuel-automated-demand-response

113. NIST STANDARDS FRAMEWORK 1.0, *supra* note 111, at 82.

114. FERC 2011 DR-AMI REPORT, *supra* note 6, at 19 (noting that, "a number of states and local jurisdictions have either prohibited third-party aggregation of customer demand response into organized RTO or ISO wholesale markets or have ongoing

FERC's Order 719 required ISOs and RTOs to grant access to their markets to third-party "aggregators of retail customers" (ARCs), except where "the laws or regulations of the relevant electric retail regulatory authority do not permit the customers aggregated [by the ARC] to participate."[115] When PJM revised its Open Access Transmission Tariff to accommodate the requirements of Order 719, the Indiana Utility Regulatory Commission (IURC) issued an order enjoining retail customers in Indiana from selling DR in PJM's wholesale markets without the IURC's prior approval.[116] The IURC believed "allowing retail customers to aggregate demand response for sale through PJM 'would at least partially bypass' the IURC's oversight of the retail market."[117] In a 2012 decision, the D.C. Circuit ruled against the IURC,[118] without directly addressing the underlying issue of whether FERC had interfered with Indiana's exclusive jurisdiction over retail electric service. Other states have been active in regulating increased deployment of third-party DR,[119] and may well continue to challenge FERC's DR policies as an affront to their jurisdiction over retail sales of electricity.[120]

## VI. CONCLUSION

DERs present a number of challenges to the existing electric grid, due to their location at its "edge."[121] The challenge of integrating resources that provide output on a variable basis,[122] and send electricity back to the grid in large amounts, "is no longer just a theoretical question to debate [but] becoming a real challenge in several countries,"[123] including the United States. The "virtual power plant"

---

proceedings examining third-party aggregation").

115. FERC Order 719, *supra* note 39, at ¶ 155. An example of one utility's program for customers and aggregators is PG&E, *Aggregator Programs*, http://www.pge.com/mybusiness/energysavingsrebates/demandresponse/largecommercialindustrialaggregator/index.shtml (last visited May 1, 2012).

116. Ind. Util. Reg. Comm. v. FERC, 668 F.3d 735 (D.C. Cir. 2012).

117. *Id.* at 738.

118. *Id.* at 741.

119. *See, e.g.*, Md. Pub. Serv. Comm., Order No. 84275, In the Matter of an Investigation of the Regulation of Curtailment Service Providers, No. 9241 (2011) (Maryland PSC order requiring curtailment service providers operating in PJM to register with the PSC).

120. CAPPERS ET AL., *supra* note 32, at 26 (noting that states limit participation in their markets by aggregators because PUCs are "concerned about the erosion of their authority to regulate the business and operations of incumbent monopoly utilities and its infrastructure.").

121. CARVALLO & COOPER, *supra* note 5, at 16.

122. Joskow, *supra* note 20, at 36.

123. Michael Levi, *The Clean Energy Ministerial: What I Learned about Solar PV and Global Governance*, CFR ENERGY, SECURITY AND CLIMATE, Apr. 26, 2012,

idea holds promise for its ability to address that variability, but for more VPPs to be deployed on the grid, the promise of the Smart Grid must become more widely realized and the many other challenges to more widespread third-party DR solutions must be addressed.

---

*available at* http://blogs.cfr.org/levi/2012/04/26/the-clean-energy-ministerial-what-i-learned-about-solar-pv-and-global-governance/.