Chapter Five

To Begin the World Anew: Smart Grids and the Need for a Comprehensive U.S. Energy Policy

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The United States is in the midst of a monumental transformation of its electric power system. Advances in information and communication technologies and grid measurement and control devices have initiated the transition toward a more resilient, sustainable and efficient future power grid. Deployment of these technologies is being driven by policies encouraging the shift to a greener and more secure grid, incorporating clean and low carbon energy as well as rising consumer demand for smarter ways to use existing resources.

While the passage of the Energy Independence and Security Act (EISA) in 2007 and the 2009 American Recovery and Reinvestment Act (ARRA) accelerated U.S. investment in a "smart grid" sufficiently flexible to accommodate technological and societal changes associated with transition in the nature of the electric generating fleet, the U.S. is not alone in its grid transformation. Countries across the globe have and continue to invest billions in their electricity transmission and distribution systems in an effort to adjust to the challenges of rising demand, constrained resources and growing environmental consciousness. In its effort to modernize its grid and create a large-capacity interconnected transmission backbone, China spent more than $7.3 billion on smart grid stimulus investments in 2010.[1] Efforts under way in the European Union (EU) also warrant a closer look. In 2010, Italy alone had about three times the amount of smart meters installed

[1] SmartGridnews.com (2010, January 27), Smart Grid Snapshot: China Tops Stimulus-Funding, SmartGridNews.com, available at: http://www.smartgridnews.com/artman/publish/Stimulus_News_Digest_Products/Smart-Grid-snapshot-China-Tops-Stimulus-Funding-1827.html, accessed August 2011.

compared to the U.S.[2] EU wide, there are more than 45 million smart meters installed, keeping the continent on track to fulfilling one of the European Commission's smart grid deployment goals—structured smart grid deployment milestones the United States does not have.[3] Even so, the U.S. has recently established 99 smart grid investment grant programs across the nation, spending $3.4 billion and unleashing more than that in private sector investments.[4]

This chapter explains the differing motivations behind smart grid deployment in the United States and Europe. It will also aim to examine the progress made in the United States, give an overview of recent smart grid-related research and outline policy recommendations for further deployment. Lastly, it suggests areas of transatlantic cooperation that would help both the United States and countries in the EU accelerate smart grid deployment.

What is the Smart Grid?

The smart grid is a network of transmission lines, interactive equipment, and new technologies working together to help consumers and producers of energy save economic and environmental resources. This digitization of the power system delivers sensing, communications and controls across the system from transmission to distribution to the consumer, delivering a two-way flow of energy and communications that provide real-time system transparency to operators and consumers alike.

[2] Zhang, Zhen. "Smart Grid in America and Europe—Similar desires, different approaches, Part II" *Public Utilities Fortnightly*, February 2011, p. 33.

[3] Giordano, Vincenzo, et al. "Smart Grid projects in Europe: lessons learned and current developments," *European Commission Joint Research Centre Institute for Energy*, p. 13.

[4] "Follow the Money: Stimulus Funding Begins to Flow Into Smart Grid Sector," available at: http://www.kema.com/services/ges/smart-grid/AI/follow-the-money-stimulus-funding-begins-to-flow-into-smart-grid-section.aspx.

Smart Grids of Necessity, Smart Grids of Choice

Both the United States and the EU are moving in the direction of the smart grid, yet at a varying pace and for often different reasons. One similar characteristic of this movement is that progress in the United States and in Europe is not homogeneous, but differs internally depending on regulatory, policy, regional and cultural variables.

There are a multitude of stakeholders involved in generating, transmitting, distributing, and regulating electricity in the U.S. In 2007, there were 9,554 utilities across the nation, of which 1,934 were generating electricity.[5] Policy is made by a combination of federal and state entities. For example, the U.S. Department of Energy oversees technology research and development, and has a role in examining certain policy issues such as transmission siting. However, the Federal Energy Regulatory Commission (FERC) oversees regulatory questions relevant to wholesale power markets and interstate transmission, including grid reliability. The Environmental Protection Agency (EPA), meanwhile, administers the Clean Air Act, which impacts emissions-related requirements associated with electric generation. If the alphabet's soup of federal entities were not enough, it is in fact State boards and commissions—some appointed by Governors, others elected by popular ballot—that regulate retail sales and the distribution of electricity to customers.

Moreover, it is important to appreciate that the U.S. electricity sector is highly differentiated on the state level as well. Texas has a deregulated retail market for electricity, unlike any of its neighboring states, allowing most of its residents to select their retail electric provider from a list of utilities.[6] Restructuring of electricity markets is currently on hold in a number of jurisdictions in the aftermath of the western electricity crisis of 2000-2001, which was widely perceived as an economic disaster driven by a combination of bad actors, bad weather and poor market design in California.[7] Meantime, the

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[5] U.S. Census Bureau, "2007 Economic Census." Available at www.census.gov/compendia/statab/2012/tables/12s0923.pdf, accessed October 2011.

[6] See http://www.powertochoose.org/.

[7] "Adressing the 2000-2001 Western Energy Crisis," available at http://www.ferc.gov/industries/electric/indus-act/wec/chron.asp.

debate about restructuring has gone completely dormant in a majority of states.[8]

In the EU, the situation is similar in terms of comparing member states' electricity sectors. Countries within the EU have differing electricity markets, ranging from the centrally organized and fully nationalized electricity market in France to the United Kingdom's competition-based system.[9] While the EU does not have a central regulatory authority equivalent to FERC, it does have political mechanisms that can direct changes to the continent's electricity sector through decisions by the European parliament and resulting directives from the European Commission. One of the recent milestones here is the "Third Energy Package," the tenets of which include an 80% penetration of smart meters in European households by 2020.[10] The EU has also tied smart grid to its general goal of unbundling transmission systems operation, building a liberalized internal market for electricity, incorporating renewable energy and reducing carbon emissions.[11] Article 3, section 11 in chapter 2 from the above mentioned legislation calls on member states to develop "innovative pricing formulas," and introduce "intelligent metering systems or smart grids."[12] Reading the plans and directives suggests that incorporating renewable energy and reducing the continent's carbon footprint are the EU's main drivers of advancing smart grid deployment. An April 2011 report from the European Commission calls the smart grid the "backbone of the future decarbonised power system," which will "enable the integration of vast amounts of both on-shore and off-shore renewable energy."[13] EU pol-

8 "Status of Electricity Restructuring by State," Energy Information Administration, available at http://www.eia.gov/cneaf/electricity/page/restructuring/restructure_elect.html.

9 Von Danwitz, Thomas, "Regulation and Liberalization of the European Electricity Market—A German View," *Energy Law Journal*, Volume 27, p. 423.

10 Electricity Directive (2009/72/EC).

11 Directive 2009/72/EC, available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32009L0072:EN:NOT.

12 Supra 8.

13 "Smart Grids: From Innovation To Deployment" Communication From The Commission To The European Parliament, The Council, The European Economic And Social Committee And The Committee Of The Regions, available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0202:FIN:EN:PDF.

icy also states that the smart grid will "significantly reduce the environmental impact of the whole electricity supply system."[14] Along the same lines, the Strategic Deployment Document for Europe's Electricity Networks picked smart grid to become an essential enabler for the continents 20/20/20 goals, cutting emissions and increasing renewable energy by 2020.[15]

Beyond directives by the European Commission determining many of the smart grid's features, the EU's smart grid policy is guided by several plans and initiatives, including the SmartGrids European Technology Platform for the Electricity Networks of the Future (SmartGrids ETP), the European Electricity Grid Initiative (EEGI) Roadmap and Implementation Plan, the EU Framework Program, and the European Strategic Energy Technology Plan (SET Plan).[16] These plans and initiatives prioritize deployment strategies, outline specific milestones and determine funding levels for smart grid research.

But while it is arguably the case that environmental outcomes have animated EU policy in relation to the smart grid, U.S. entities—driven by public/private partnerships—significantly accelerated efforts in the areas of advanced technology development and deployment as a result of the Northeast/Midwest blackout of August 2003. The blackout left more than 50 million people in cities including New York City, Detroit, Cleveland and Toronto without electricity for up to four days, drove policymakers to adopt federal legislation putting in place mandatory reliability standards governing the electric utility industry, and reinvigorated research on technologies designed to provide enhanced visibility over grid systems.

In addition, peak demand, a spike in electricity consumption usually occurring in the afternoon and early evening hours of the winter and summer months, is challenging grid operators and has been another prime motivator for smart grid deployment. Over the last few decades,

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[14]The SmartGrids European Technology Platform, available at http://www.smartgrids.eu/node/81.

[15] "Strategic Deployment Document for Europe's Electricity Networks," *European Technology PlatformSmartGrids*, p. 6.

[16]Zhang, Zhen. "Smart Grid in America and Europe—Similar desires, different approaches, Part I." *Public Utilities Fortnightly*, January 2011, p. 48.

end-use consumption of electricity has grown faster than that of petroleum or natural gas.[17] The residential sector has, driven by the growth of air-conditioners in housing from 68% in 1993 to 87% in 2009, as well as the proliferation of consumer electronics, outpaced both commercial and industrial users.[18]

For generators of electricity, peak demand translates into a vexing challenge: during most of the year, about 50% of the country's generation capacity is fully used. However, for 5% of the time, or about 400 hours every year, more than 90% of the capacity is used.[19] These hours are crunch times for grid operators, typically occurring during the hottest days of summer when customers turn on their air conditioners, televisions and other electronic appliances. Until now, utilities reaction has been to "build to peak;" building new peak generation plants and then firing them up in times of need. Back-up generation through peak generators is, however, the least economic- and most emissions-intensive generation; utilities pay hundreds of millions of dollars every year just to provide electricity during these few hours.

Informed by these events and developments, the EISA of 2007 stated that the main purpose of a smart grid was to "maintain a reliable and secure electricity infrastructure that can meet future demand growth."[20] Delaying or removing the need for expensive generation capacity expansion by addressing the problem of peak demand is thus a prime policy objective.

Comparing the motivations behind U.S. and EU smart grid deployment thus illustrates a distinct characteristic. While the nature of the U.S. power grid has led to a policy focus on reliability, interoperability and advanced research and development—with deployment

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[17]Joskow, Paul; "Challenges for Creating a Comprehensive National Electricity Policy," Speech at Technology Policy Institute, September 26, 2008.

[18]2009 Residential Energy Consumption Survey 2009, Energy Information Administration, available at http://www.eia.gov/consumption/residential/reports/air_conditioning09.cfm and http://www.eia.gov/consumption/residential/reports/electronics.cfm.

[19]Lightner,Eric,Widergren, Steven."An Orderly Transition to a TransformedElectricity System." *IEEE Transactions On Smart Grid*, Vol. 1, No. 1, June 2010, p. 4.

[20]"Energy Independence and Security Act of 2007, Title XIII, Section 1301, available at http://energy.senate.gov/public/_files/getdoc1.pdf.

driven by Federal matching funds for utility smart grid investments—EU policymakers have also deemed smart grid as an enabler for the liberalization of electricity markets and a means to address climate change.[21]

Benefits of the Smart Grid

While reliability and peak demand issues have been primary, initial drivers of smart grid deployment in the United States, there is increasing recognition that building additional intelligence into grid infrastructure can help achieve a number of additional energy policy goals, including reducing U.S. dependence on foreign oil, lowering the emissions profile of the electric generating fleet, decarbonizing transportation and enhancing the resilience of infrastructure critical to economic and national security.

Renewables Integration

In the United States, 24 states plus the District of Columbia currently have a Renewable Portfolio Standard (RPS).[22] These standards mandate energy providers selling energy within a state to produce or purchase a specific amount of renewable energy by a determined date. Together with State Renewable Energy credits and Federal Production Tax Credits (which, depending on the form of energy, are bound to expire by December 2012 and 2013[23]), RPSs have contributed to a rapid growth of renewable energy across the nation. In 2009, more than 60% of total renewable electric generation additions came from wind power alone.[24]

While the growth in wind power and other renewables is supporting President Obama's goal of generating 80% of electricity from

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[21]Supra 19, Section 1304-06.

[22]Five other states, North Dakota, South Dakota, Utah, Virginia, and Vermont, have nonbinding goals for adoption of renewable energy instead of an RPS. http://apps1.eere.energy.gov/states/maps/renewable_portfolio_states.cfm.

[23]See American Recovery and Reinvestment Act of 2009, H.R. 1 (Div. B, Section 1101 & 1102) available at http://thomas.loc.gov/home/h1/Recovery_Bill_Div_B.pdf .

[24]Electric Power Industry 2009: Year in Review, Energy Information Agency, (Washington, D.C., November 2010, updated January 2011 & April 2011).

clean sources by 2035, the intermittent character of such generation is creating headaches for grid operators worried about fluctuations in electricity generation. Here, smart grid technologies such as near real-time sensor and monitoring technologies will mitigate many of the existing uncertainties by combining energy storage, better forecasting and access to resources generated outside a control area.[25]

Electric Mobility

Recent research in electricity fueled transportation points toward additional benefits for grid operators and customers coming from battery storage in plug-in electric vehicles used as balancing tools for growing amounts of renewable energy. Scientists at my laboratory examined a decentralized control scheme called Grid Friendly Charging, which varies the charging rates for electric vehicles (EV) depending on the state of the grid. At night, when abundant wind power is available, the Smart Charger would allow EVs to absorb surplus energy and recharge their batteries, using the additional renewable power. During peak load times, this technology would postpone EV charging, and use stored electricity from EV batteries to strengthen the grid.[26]Grid Friendly Charging will support electricity operators' goals of having a more predictable load by balancing demand for electricity. In combination with real time pricing, which regulators across the United States are now testing in select regions, smart charging would bolster the business case for electric vehicles and the smart grid itself by allowing customers to charge their vehicles at the most economic rate and, where possible, even sell surplus electricity back to the grid. Lastly, substituting more transportation fuels away from fossil sources to domestically produced renewable energy would address a key policy goal- reducing their dependency on foreign fuel and curbing the transportation sector's carbon footprint.

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[25]Imhoff, Carl. "Grid 2050—Shaping Grid Transformation," *Public Utilities Fortnightly*, August 2011, p. 32.

[26]Tuffner, F. K., Kintner-Meyer, M, "Using Electric Vehicles to Mitigate Imbalance Requirements Associated with an Increased Penetration of Wind Generation," IEEE Power and Energy Society General Meeting 2011, p .7.

CO_2

In addition to supporting the integration of renewable energy and clean transportation, a fully deployed smart grid by itself could also reduce CO_2. During the next twenty years, smart grid could lower the U.S. carbon emissions and energy use of the electric sector by up to 12%.[27] By combining smart grid technologies, such as consumer information and feedback systems, conservation voltage reduction, and building diagnostics, the grid of the future would create significant efficiency gains and demand reductions. In emissions terms, these savings would result in the United States preventing the equivalent of 442 million metric tons, or 66 typical coal power plants' worth, of carbon emissions from entering the atmosphere each year. In energy terms, these 66 power plants produce the equivalent amount of electricity needed to power 70 million of today's homes.

While the United States appears far from managing its carbon emissions by means of a carbon tax or installing a cap-and-trade system, its emissions-reducing character would make the smart grid an even more attractive investment driving CO2 reduction, if and when carbon management schemes were to be introduced.

Smart Grid—Strong Economy

Smart Grid will allow the United States to grow a domestic industry around energy provision, delivery and demand management. Recent private and public smart grid investments in the United States alone are estimated to directly create more than 280,000 jobs between 2009 and 2012, of which half are expected to be retained as permanent, high-skilled jobs.[28] These jobs will bring several economic benefits to communities across the United States. In West Virginia, for example, the job creation through deployed smart grid is estimated to provide annual benefits of $215 million to the U.S. economy.[29] As

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[27] Pratt, R. et al. "The Smart Grid: An Estimation of the Energy and CO_2 Benefits," Pacific Northwest National Laboratory, January 2010, p. vi.

[28] The U.S. Smart Grid Revolution—Smart Grid Workforce Trends 2011, GridWise Alliance, 2011.

[29] NETL (National Energy Technology Laboratory) (2010), *West Virginia Smart Grid Implementation Plan—Roadmap Framework*, U.S. Department of Energy (DOE), prepared for GridWeek 2010, October 18 2010, Washington, DC, available at

businesses in smart grid-related manufacturing, services and software development are located in diverse locations from California to North Carolina to Texas, similar job-related economic benefits can be expected across the United States.[30]

The transition to smart grid will, however, increase the training and skill requirements of workers in the energy sector. This transition is paralleled in all sectors of the labor market, which demands new skill sets to manage the ever growing complexities of everyday work. In the energy sector, the rising reliance on information and communication technology, as well as advanced diagnostics and measuring devices, translates into a shift towards a highly trained workforce, able to design, install, maintain and service smart grid infrastructure and technology.

Federally Funded Smart Grid Investments in the United States—An Overview

To spur deployment of the smart grid, the U.S. has passed two important pieces of legislation in recent years. In 2007, Congress laid out a roadmap for grid modernization policy as part of the Energy Independence Act (EISA). In addition to charting general policy trajectory (including the aforementioned focus on reliability and protection of grid infrastructure) EISA's Section 1306 created the Smart Grid Investment Matching Grant Program, designed to provide up to 20 percent of the costs for utilities and other stakeholders that invest in deployment of certain smart grid-related equipment. Less than 18 months later, the ARRA of 2009 not only reaffirmed the political commitment to smart grid, but also augmented EISA's financial support by providing full matching grants for smart grid projects. About $4.5 billion in federally-funded awards to utilities, research organizations, private companies, manufacturers, cities and others spurred more than $8 billion of public-private smart grid investments. The 99 recipients receiving ARRA grants gave ongoing US smart grid deployments an

http://www.smartgrid.gov/sites/default/files/pdfs/10182010_gw_wv_sgip.pdf, accessed August 2011.

[30]Lowe, Marcy, et al. "U.S. Smart Grid—Finding new ways to cut carbon and create jobs," Center on Globalization, Governance & Competitiveness, Duke University, April 2011, p. 25.

essential boost in the midst of the 2008–2009 recession. Some highlights of these grants include:

- ARRA funded the deployment of 877 phasor measurement units (PMUs), expanding the prior nationwide network of 200 by more than 400 percent.[31]
- Federal grant awards for advanced metering infrastructure (AMI) deployments under ARRA total $812.6 million to date, with total project values reaching more than $2 billion.[32]
- ARRA includes a $2.4 billion program designed to establish 30 manufacturing facilities for electric vehicle batteries and components. This funding is in addition to the aforementioned $4.5 billion in awards made under ARRA.
- ARRA funded the Center for the Commercialization of Electric Technologies (CCET) Smart Grid Demonstration Project, a demonstration-scale micro grid project in Texas.

ARRA also continued funding for the Advanced Research Projects Agency-Energy (ARPA-E) to conduct smart grid R&D projects, and the Energy Information Administration (EIA) to collect data from the 14 ongoing smart grid demonstration projects. These demonstration projects are allowing both policy makers and electricity operators to lower costs and quantify the benefits of wider smart grid deployment. Indeed, the 16 ongoing demonstration projects are designed to test technologies in a systems context and help chart the business case for further smart grid deployments, for utilities, electricity providers and grid operators alike. Taking into account the regulatory and energy portfolio characteristics of different regions of the U.S., the demonstrations test everything from time of use pricing to interoperability.

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[31]Overholt P. 2010. "North American SynchroPhasor Initiative (NASPI) and DOE's Smart Grid Investment Grants." Presented at the EEI Transmission, Distribution and Metering Conference. April 11-14, 2010, Arlington, Virginia. Accessed October 8, 2011 at http://www.eei.org/meetings/Meeting%20Documents/2010-04-TDM-Tuesday-4-Overholt-Philip.pdf.

[32]U.S. Department of Energy. 2010a. "Recovery Act Selections for Smart Grid Investment Grant Awards—By Category." U.S. Department of Energy, Washington, D.C. Accessed March 22, 2011 at http://www.oe.energy.gov/DocumentsandMedia/Combined_SGIG_Selections_Category-12-16-10.pdf (undated webpage).

For example, the largest, regional ongoing demonstration, the Pacific Northwest Smart Grid Demonstration Project, is occurring in a geographical area with a significant amount of renewable energy penetration. The Pacific Northwest does not, however, have any dynamic pricing for consumers available. Consequently, this demonstration is focusing on integrating renewable energy and developing a "transactive control" system, which will translate the grid's supply and demand of electricity into a signal that is received by responsive assets, such as smart water heaters and electric vehicles. Those assets will automatically react to and shift demand away from the grid during current peak times.[33]

Implications for Future Federal Energy Policy Deliberations

ARRA and preceding legislations allowed smart grid deployment in the United States to progress rapidly in a very short amount of time. The funds made available through EISA and ARRA allowed utilities, private energy services companies, research organizations, and manufacturers to test smart grid technology and inform their decisions how to proceed. While federal funding for smart grid R&D continues with approximately $30 million per year, the government is gradually reducing its involvement in financing large scale smart grid deployment across the nation. As the federal government is slowly stepping back, the question of what mechanisms might guide further investments and planning for smart grid deployment remain. This is especially important given the hopes and expectations pinned to the electric power system. Yet while smart grid holds the promise of reducing dependence on foreign fuels, decarbonizing transportation, building a more resilient grid and strengthening the domestic economy, the realization of these promises is by no means a given. The U.S. electricity sector in general is lacking a guiding policy that could drive the transformation towards the grid of the 21st century.

[33]Previous demonstrations using transactive control, such as the Olympic Peninsula Test Bed, achieved peak load reductions of up to 20%. See Hammerstrom, D, et. al, Pacific Northwest GridWise(tm) TestbedDemonstration Projects, Part I. Olympic Peninsula Project, Pacific Northwest National Laboratory, October 2007.

Stuck in a limbo of structural fragmentation, cautious approaches to restructuring and decades-old regulatory paradigms, the electricity sector would benefit from a national debate framing the needs and the policy goals for this transformation. As with other successful transformative changes to vital areas of national interest, a national policy and regulatory reform is needed. Be it the natural gas industry or the telecommunications sector, successful changes in these areas historically have been driven by federal initiatives.[34] But the electricity sector is, in the words of Paul Joskow, former dean of the MIT Sloan School of Business, "the last reform holdout."[35]

What could these reforms look like? Just as smart grid is blurring the lines between generation, transmission, distribution and end use, a new regulatory framework might be informed by emerging technology capabilities that blur existing jurisdictional lines. Surely, there will be no "one size fits all" solution to the highly diverse grid of the Unites States. Yet as the smart grid is changing the grid landscape, regulatory paradigms need to adapt accordingly to capture achievable benefits.

Looking at four sectors of potential regulatory involvement should illustrate areas where regulatory changes could bolster smart grid deployment and secure several important policy goals. Developing a holistic plan addressing electricity regulation jurisdictions, transmission lines, spreading the benefits and costs of deployment, as well as developing tools to maximize the benefits for the labor market resulting from grid evolution is essential to fulfill smart grid's promises. The following four examples are by no means exclusive to successful regulatory involvement. Yet they illustrate the positive impact regulation could have in ensuring successful smart grid deployment.

Expanding Control Areas

To square the circle of providing an abundant supply of reliable energy and integrating vast amounts of renewable and intermittent energy, control areas need to consolidate or at least vastly increase their coordination. Without consolidation or coordination, using the

[34]Supra 14, p. 4-6.

[35]Supra 14, p. 7.

wider area's generation diversity and access to existing assets in surrounding control areas will not be possible and thus hinder successful and efficient deployment of renewable energy. One study analyzing the integration of renewable energy into regional power grids has concluded that there is a need to "substantially increase balancing area cooperation or consolidation," and, "enable coordinated commitment and economic dispatch of generation over wider regions."[36] Another study focusing on wind energy alone states that "large operating areas—in terms of load, generating units, and geography—combined with adequate transmission, are the most effective measures for managing wind generation."

Apart from supporting the integration of renewable energy, expanding operating areas brings along further benefits for the electricity sector, such as saving money. One previous study concluded that "operating separately and locally, individual [balancing authorities] would have to purchase more expensive balancing reserves to accommodate the variability and uncertainty from high penetration of [variable generation] in the future."[37] There are other examples of existing and potential savings resulting from the consolidation of control areas. The PJM Interconnection, a regional transmission organization that coordinates the movement of wholesale electricity in 13 states and the District of Columbia, is one example where consolidation between control areas has led to efficiency gains, cost savings and growth in power flows.[38] Upcoming studies by Pacific Northwest National Laboratory and the National Renewable Energy Laboratory calculate significant economic savings, exceeding $250 million, resulting from greater coordination and consolidation.[39]

Getting large amounts of renewable energy online also will require expanding the existing transmission grid significantly. Research shows

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[36]"Western Wind and Solar Integration Study," GE Energy, May 2010.

[37]Y. V. Makarov, N. Zhou, P. Etingov, N. Samaan, J. Ma, R. Diao, and R.T. Guttromson "Analyzing of Balancing Authorities Cooperation Methods with High Variable Generation Penetration," *Proc. 9th International Workshop on Large-Scale Integration of Wind Power into Power Systems as well as on Transmission Networks for Offshore Wind Power Plants*, Québec City, Québec, Canada, October 18-19, 2010.

[38]Supra 14, p. 11.

[39]Supra 26, p. 33.

that without enhancing transmission lines, "substantial curtailment (shutting down) of wind generation would be required."[40] Clearly, this scenario would not be desirable given the capital intensive nature of renewable investments.

The 2011 announcement by the White House to fast track seven transmission projects in both the western and eastern interconnection is a great step forward.[41] This measure will both support the electrical grid's reliability and ability to integrate renewable energy, while it is also setting an example for fast tracking the procedural steps of coordinating with various grid stakeholders on statutory reviews, permits, and regulation in general.

Beyond Smart Meters—Grid Operators' Smart Grid Planning

In an emerging age of constrained resources, new environmental benchmarks and rapidly changing grid technology, grid operators are reexamining their approach to electricity delivery. In a smarter grid, the general notion of finding supply-side solutions for growing demand is now balanced with consideration of mechanisms that can incentivize demand side changes, such as transactive control enabling smart appliances at home or grid friendly charging for electric vehicles. With this new operational strategy comes the potential for a new culture of business and new opportunities for revenue on the demand side.

Instead of creating incentives that solely reward cost efficiency by means of reducing operating costs, regulation should motivate operators to embrace the next generation of smart grid technology. A good example here is the wide-scale deployment of advanced metering infrastructure (AMI). Utilities across the United States have modernized their operational area by installing smart meters. While AMI is an important technology, it is not an end in itself. Utilities see smart meters as a tool to reduce operating costs by reducing meter readings and non-technical energy losses. Yet smart meters are also key enablers once combined with other smart grid technologies, such as

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[40] Eastern Wind Integration and Transmission Study, EnerNex Corporation, Revised Feb. 2011, p. 27

[41] Interagency Rapid Response Team for Transmission, The White House Council on Environmental Quality, available at http://www.whitehouse.gov/administration/eop/ceq/initiatives/interagency-rapid-response-team-for-transmission.

demand response applications. To help move the smart grid to the next level, regulators should work with utilities to identify how to leverage investments for multiple consumer value streams that are likely to emerge over the next decade. This way, regulators could ensure that smart grid technology will benefit consumers and utilities alike for a range of potential benefits long into the future. Additionally, sensible regulation in this area can bolster the ongoing changes in utilities' operational culture. These regulatory innovations for smart grid must look across the entire system, from transmission (today's PMU upgrades) to distribution (distribution automation) and the consumer interface (AMI, HEMS, smart charging) and consider new value streams that accrue from leveraging information across these traditional boundaries! Another example of a cultural change for operators is the new role utilities are playing at the consumer level. Previously, a utility's role ended at the front door or the electric meter. Now, with demand response through smart water heaters, clothes dryers and thermostats coming from within the house, utilities need to address the new responsibilities coming from their expanded reach. Regulators should encourage utilities to be creative with their consumer incentive programs to provide more customer-oriented services, beyond just energy delivery. Discussions focusing on alternative revenue streams through efficiency gains and quality of service instead of volumes delivered are helpful here.

Alternatively, regulators could incentivize utilities to use outside contractors to manage some of these new business areas. Just as U.S. utilities have started outsourcing ancillary services, such as tree cutting, to contractors, outside vendors can manage the in home activities for utilities which in this case stay focused on their core business. Either way, regulation has a role to play to help utilities in this changing environment.

As the integration of renewable energy is a key policy goal of the Obama Administration and the majority of U.S. states, regulators should examine the role utilities can play to support the transition to clean and homegrown energy. Yet there are still utilities across the U.S. that do not offer their customers options to select renewable energy as a source for their electricity. Additionally, too often, consumers are not even aware of the renewable choices they have. A recent survey of 10,000 energy consumers across 15 countries found that more than half of the respondents did not know whether their energy provider had a green energy program or not.[42] Without these green options available or known, the goal of increasing the amount of renewable energy becomes harder to obtain.

Utilities provide the most immediate, interactive opportunity with customers. They are often the first and only stop for consumers to receive information about energy use, clean and green energy options and general knowledge. Utilities also build and manage the last mile in energy delivery infrastructure and for that reason they harbor the key to unlocking effective policy. It is important for regulators to establish goals that highlight a easy and clear path for all utilities offering customers renewable energy purchasing options, and offering utilities ideas for informing their customers about these options.

Keeping the Customer Satisfied—Spreading Smart Grid Benefits to Rate Payers

Grid operators can also be a key leveraging tool to get one of the smart grids most important assets involved: the well-informed customer. Customers' participation is crucial to realize several of the demand response strategies that will help fulfill many of the smart grid's efficiency promises. Recent surveys explain that a well-informed customer was more likely to have a positive opinion of local smart grid deployment programs underway or proposed[43]—a fact vital for operators confronted with opposition to, for example, smart meters in California or new transmission lines in Germany.[44] Informed consumers furthermore equate smart grid deployment with energy benefits for their families and are more likely to change their energy usage patterns to meet specific goals. Yet customers are still not treated as a part

[42]IBM 2011 Global Utility Consumer Survey.

[43]Supra 43.

[44]Barringer, Felicity. "New Electricity Meters Stir Fears," *The New York Times*, January 30, 2011, available at http://www.nytimes.com/2011/01/31/science/earth/31meters.html?pagewanted=all, and Diehl, Joerg, "Die Trassen-Brecher, Spiegel Online, July 18, 2011. Available at http://www.spiegel.de/wirtschaft/unternehmen/0,1518,772586,00.html.

of the solution to issues of constrained resources, rising demand and environmental concerns, let alone informed enough.

An easy way for regulators to address these discrepancies would be highlighting best practices among utilities. Falling short of demanding standards, regulators could showcase utilities offering their customers choices of renewable energy (where available), free energy efficiency consulting, high amounts of reimbursement for demand response, and information campaigns to keep rate payers informed and knowledgeable about the smart grid. Similarly to Japan's "Top Runner"[45] standard for appliances, which pegs efficiency standards to the most energy efficient product commercially available in a given appliance category, this "Smartest Utility" would set the benchmark for other utilities and allow customers to see what is available at a given time.

While informing rate payers about choices available is important, saving money is still one of the highest motivators for consumers considering changes to their energy usage behavior.[46] Yet as it stands, FERC has no power to regulate retail pricing for consumers and until now, there has been sporadic movement from state PUCs to introduce retail pricing. Adding financial incentives through measures such as real time pricing (RTP) will get a wider range of consumers involved and move some of smart grid's benefits within rate payers' reach. RTP will help smart grid deployment on many levels. It will allow customers to become active participants in the smart grid, paying attention to the dynamics of demand and supply and, with the help of smart appliances and measurement devices, adjusting their energy behavior accordingly. All eyes are currently on Ohio, where the state's Public Utilities Commission approved the nation's first trial residential real time price rate that automates consumer equipment response to RTP signals being tested under the ongoing AEP Ohio's gridSMART program.[47] Using transactive control, participating consumers' home

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[45]See Komiyamaa, Ryoichi; Marnay, Chris. "Japan's Residential Energy Demand Outlook to 2030—Considering Energy Efficiency Standards 'Top-Runner Approach,'" Lawrence Berkeley National Laboratory, Berkeley, CA, May, 2008, available at http://eetd.lbl.gov/ea/emp/reports/lbnl-292e.pdf.

[46]Supra 43.

[47]Frequently Asked Questions, AEP Ohio gridSMART Demonstration Project, available at https://www.aepohio.com/save/SmartMeters/FAQ.aspx#4.

energy management systems will be linked with AEP's market-based dispatch system to communicate a cleared market price every five minutes.

Beyond engaging consumers, RTP is an essential enabler for vendors looking to help consumers make smarter energy choices through grid friendly appliances and home energy monitoring displays, among others. Without a price signal there will be no business case for these appliances and information management companies waiting to get involved.

On a larger level, RTP also is necessary to support the integration of renewable energy and make energy storage projects financially viable. Without a clear price signal that would allow cheap night-time wind energy to be stored and then sold at peak times during the day, these costly investments in renewables and large scale energy storage will not take place.

Smart Grid and the Workforce

Smart Grid has the potential to support the growth of a strong, highly skilled workforce in the United States. Recent private and public smart grid investments in the United States are estimated to directly create more than 280,000 jobs between 2009 and 2012, of which half are expected to be retained as permanent, high-skilled jobs.[48]

Yet without taking appropriate measures on the policy making level, there will be a severe disconnect between the specialization required and the skills available. First, there is the challenge of retaining the meter reader, or better yet, turning her into a meter technician. The experience of the electricity sector in countries in the EU-15, where 250,000 jobs have been lost since 1995, highlights the need for proactive measures.[49] Policymakers need to ensure that technological advances go hand in hand with educational excellence, leading to

[48]Supra 29.

[49]European Foundation for the Improvement of Living and Working Conditions (EUROFUND) (2008), *Trends and drivers of change in the European energy sector: Mapping report*, available at http://www.eurofound.europa.eu/pubdocs/2008/12/en/1/ef0812en.pdf, accessed August 2011.

the development of a smart grid-savvy labor force. Support for work force development, through vocational and on the job training and incentives for students choosing, for example, electrical engineering programs will be necessary to bridge the widening skills gap. Given the importance of involving consumers, incorporating a more customer centric approach into curricula for energy sector jobs also is advisable.

A second challenge that utilities across the nation face is a graying workforce. With an average age of 48 years, the US utility worker is five years older than the average worker. Worse still, between 25-35% of utilities' technical workforce is bound to retire during the next five years.[50] Given the prospects of thousands of engineers and technicians needed to manage the upcoming smart grid, these numbers are daunting.

There are examples of utilities and the government working together to mitigate these challenges. In 2010, the Obama Administration set aside about $2 billion for funding community colleges. Utilities, such as California's Pacific Gas & Electric (PG&E) are working with community colleges to develop curricula that support targeted workforce training across the Golden State. PG&E's PowerPathway program has helped 200 students to complete training in community colleges and subsequently hired half of those enrolled.[51]

As this example illustrates, the labor market impact of deploying smart grid needs to be a part of a new, holistic federal energy policy. Policymakers need to address these challenges by working with energy operators and educational institutions to realize smart grid's jobs potential. Without targeted collaboration, the intergenerational transfer of knowledge, and the transformation to a highly trained workforce, able to design, install, maintain and service smart grid infrastructure and technology will remain incomplete.

Further Steps

Further cooperation between the public and private sector is necessary to realize several of the smart grid's promises. Neither the gov-

[50] Supra 3, p.47.

[51] "Workers (and business) unite!," *The Economist*, Aug 27th 2011, p. 28.

ernment nor the energy operators alone can manage the expense associated with addressing the under investments in the U.S. power grid, where the average age of power transformers in service is more than 40 years.[52]

Policymakers can further budding public-private partnerships across the energy sector by examining areas where unbundling, restructuring and/or deregulation might unleash new markets that ultimately bolster the business case for smart grid.

As stated, smart grid in the United States is already blurring the previously clearly defined delineations between transmission and distribution. Reexamining the areas of state vs. federal regulation also could help utilities and grid operators with cost recovery while ensuring a wider deployment of smart grid. Regulatory innovation might, for example, help to level the playing in between states whose individual regulatory entities are currently using differing methods of review cost recovery for smart grid investments at the distribution level.[53] There is a need to examine if and how deregulation of the retail market can support smart grid deployment targets. And we need to explore new innovative regulatory approaches in unstructured markets that capture the flexibility of smart grid innovations in the current regulatory framework. While the Quadrennial Technology Review of the U.S. Department of Energy acknowledges that "deficient market structures" were one of the barriers to the deployment of energy storage technologies,[54] other studies of competitive markets have shown that unstructured markets "encourage the introduction of new products and services unavailable in more traditional electric markets."[55]

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[52]Hill, Edwin; "New Challenges Demand New Solutions,"*EnergyBiz*September/October 2007, p. 14. http://energycentral.fileburst.com/EnergyBizOnline/2007-5-sep-oct/Financial_Front_New_Challenges.pdf.

[53]Supra 10, 38.

[54]Report on the First Quadrennial Technology Review, U.S. Department of Energy, September 2011, p.90. Available at http://energy.gov/downloads/report-first-quadrennial-technology-review.

[55] "Electricity "deregulation" inches forward, new report reveals," Smartgridnews.com, December 7, 2010, available athttp://www.smartgridnews.com/artman/publish/Business_Markets_Pricing/Electricity-deregulation-inches-forward-new-report-reveals-3349.html.

Why Cooperate?

While initial motivations about the smart grid's raison d'être are different in the United States and Europe, there are several overlaps in technological and regulatory challenges that call for closer cooperation. Both the United States and Europe are using the same technology and are tackling similar problems on the road to smart grid. Both could benefit from lessons learned so far, especially given the substantial investments in the United States following the 2009 stimulus funding. And, given the current economic situation in the United States and Europe, both can benefit from burden sharing in select areas of capacity building.

As the United States is examining its path towards smart grid, countries in the EU are confronted with several, similar policy choices that warrant a look at the benefits of transatlantic smart grid cooperation. On the topic of deregulation, countries in the EU and states within the US have experienced varying degrees of liberalized and deregulated electricity markets. In the United States, there are 14 states plus the District of Columbia with restructured electricity sectors.[56] States such as Texas are at the forefront of deregulating, allowing consumers to choose their electricity service from a variety of retail electric providers. The same is true for countries in the European Union, such as the United Kingdom. Comparing the experiences can help U.S. states with pending deregulation as well as European countries beginning the prescribed liberalization process to formulate and apply best practices. Deregulation is especially interesting to examine in light of ongoing smart grid technology deployments. Questions such as how deregulation affects smart grid deployment could be answered by looking at the experiences and challenges taking place on the other continent.

One challenge both the United States and Europe face is in the area of grid modeling. The smart grid of the future will employ millions of smart devices, smart loads and distributed renewable generation. The growth in smart sensors alone will create yet unseen volumes of data that need to be analyzed. At the same time, the forecasted expansion of intermittent renewable energy, especially from

[56]Supra 5.

small wind turbine and roof-top photovoltaic panels, will add a tremendous degree of uncertainty to planning and operating the grid as we know it.

While research[57] investigating future concepts and tools for grid operation and planning is underway, closer cooperation to tackle these challenges is needed. Researchers at Pacific Northwest National Laboratory have developed open-source simulation software called "GridLAB-D," which allows power systems planners and operators from the United States, Europe, and beyond to simulate the interplay of assets, control strategies, and communication devices over a time series and examine how a virtual smart grid would operate before money is spent on deployment.[58] These facilities allow for best practices to be shared while advancing the understanding of technologies and their impact.

There are several further areas of cooperation. Both the United States and Europe are staking great hopes in the promise of low-carbon electric vehicles. With plans to deploy millions of EVs across the continents, there are lessons to be learned in areas of grid friendly charging, electric vehicles as grid balancers through vehicle to grid technology, and much more.

Both the United States and Europe also are trying to integrate vast amounts of renewable energy coming online. Here, closer comparison between areas with substantial renewable energy in the electricity sector, such as the U.S. Pacific Northwest and EU countries Sweden, Denmark or Germany would be opportune to save grid operators from reinventing the wheel.

One area where cooperation already is successfully taking place is in the field of standards and interoperability. Under the helm of the Institute of Electrical and Electronics Engineers (IEEE), internationally harmonized data standards have benefitted vendors in both the United States and Europe to build applicable technology. Transferring IEEE's experience to smart grid specific applications, such as technology interfaces and communication needs could espouse similar positive outcomes. An organization that could spearhead this cooperation is the Smart Grid Interoperability Panel (SGIP), which coordinates

[57]See Future Power Grid Initiative, http://gridoptics.pnnl.gov/.

[58]http://www.gridlabd.org/.

standards development in the United States. Broadening SGIP's scope and including European standard organizations could create a forum to exchange and align ideas.

There already are several vehicles of EU-U.S. cooperation in place. The U.S.-EU Energy Council has two working groups on energy policy and energy technology RD&D that could be expanded upon to include lessons learned from EV deployment and renewable integration. As mentioned, the Smart Grid Interoperability Panel would be a prime location to include EU standards and interoperability discussions to facilitate smart grid deployment.

Comparing the policy driving smart grid in both the EU and the U.S. highlights the activist role the European Commission and Parliament are playing in defining smart grid and its deployment. While efforts by Brussels are often delayed and/or watered down, a key difference between the U.S. and the EU is that the EU actually has a smart grid deployment plan. Judging by the rapid and early deployment of smart meters and the incorporation of smart grid into larger political goals, such as emission reduction and electricity sector liberalization, the EU's smart grid outlook seems more concrete than in the United States at present. Taking a page out of the EU's playbook and developing a comprehensive approach to formulate smart grid deployment plans would benefit the grid modernization efforts in the United States.

The United States is well on its way to modernize its electric grid. Efforts driven by the legislative framework created by EISA and ARRA (and resulting funding) have tremendously helped to accelerate deployments of smart grid technology and infrastructure. Yet as recent evolutions in technology and societal demands for a more sustainable grid have changed the needs and characteristics of the power system, there is considerable room for regulatory and policy-making involvement to ensure the transition to a more efficient, resilient and smarter grid. This is especially important given the lessons learned from the progress made over the last four years.

While countries in the EU are undergoing a similar transformation, the U.S. experience in deployment and the resulting need to revisit the existing regulatory compact can provide vital insights to

European policy makers. At the same time, the United States, in its effort to formulate a forward looking federal energy policy, can learn from the progress that is being made in the EU, as well as the EU's efforts to establish guidelines to smart grid deployment across its 27 country-wide territory. Examining the others' experience especially in times of constrained resources will benefit both the United States and Europe. Mutual learning and further cooperation in smart grid deployment brings the promise of advancing the transatlantic relationship as both continents adapt to a new era of advanced technology, constrained resources and rising demand for energy.