Promoting Clean Reliable Energy Through Smart Technologies and Policies: Lessons from Three Distributed Energy Case Studies

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ABSTRACT

Following the blackout of the electric grid in the 1965 it was hypothesized that large central generation would lead to continued reliability problems. More recently, following Hurricane Sandy, there have been additional criticisms of the risks that large centralized electric systems face in terms of system restoration following catastrophic storms.

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Together these concerns have led some in the electric industry to conclude that bigger is not always better. In 2007, with the passage of the Energy Independence and Security Act, Congress initiated policy support for a smarter more distributed grid. Since then, utilities have begun to experiment with more distributed, micro-scale projects that allow sections of the grid to "island" and serve customers locally during catastrophic power outages. This paper examines three very different approaches to explore the benefits of distributed energy technologies as well as the public policies necessary to promote their vibrant future.

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I. INTRODUCTION

In their 1982 book Brittle Power, Amory and Hunter Lovins observed that, "[t]he United States has for decades been undermining the foundations of its own strength. It has gradually built up an energy system prone to sudden, massive failures with catastrophic consequences."[1] In this classic book, the authors explain how the electric grid's centralized system architecture makes it inherently prone to the instability we have for

1. AMORY B. LOVINS & L. HUNTER LOVINS, BRITTLE POWER: ENERGY STRATEGY FOR NATIONAL SECURITY 1 (Jack Howell & Nancy Irwin eds., 1982).

decades.[2] A notable example of this instability is the November 9, 1965 blackout, when "'[w]ithin eight minutes 50 million people across eight states and two Canadian provinces had been blacked out.'"[3] Nearly forty-four thousand megawatts, twenty-three percent of the total peak demand, was lost.[4]

Accordingly, on June 1, 1968, the electric utility industry created the North American Electric Reliability Council (NERC) to promote the reliability and adequacy of Bulk Electric System of North America.[5] NERC is a not-for-profit regulatory authority whose mission is to assure the reliability of the Bulk Electric System in the U.S., Canada and the northern portion of Baja California, Mexico.[6] The Federal Energy Regulatory Commission (FERC) approved NERC to be the designated electric reliability organization, and as such the FERC maintains oversight and approval authority for the Reliability Standards NERC creates, and assesses penalties for Reliability Standard violations.[7]

However, even with NERC's best efforts, on August 14, 2003, approximately 50 million people in the U.S. and Canada lost approximately 61,800 megawatts (MW) of electric power.[8] The cascading power outage struck the states of Ohio, Michigan, Pennsylvania, New York, Vermont, Massachusetts, Connecticut, New Jersey and the Canadian province of Ontario.[9] Power was not restored for four days in some parts of the United States.[10] The total estimated cost of damages in the U.S. associated with this blackout falls between $4 and 10 billion dollars.[11]

The U.S. continues to rely on centralized generation, bulk transmission systems, and analog electronic signals to keep huge machines rotating

2. *Id*. at 1–4.
3. Alison C. Graab, *The Smart Grid: A Solution to a Complicated Problem*, 52 WM. & MARY L. REV. 2051, 2052 (2011).
4. Lovins & Lovins, *supra* note 1, at 51.
5. NERC was originally created by voluntary industry agreement. *See History of NERC*, N. AM. ELEC. RELIABILITY CO., http://www.nerc.com/AboutNERC/Documents/History%20AUG13.pdf.
6. *About NERC*, N. AM. ELEC. RELIABILITY CO., http://www.nerc.com/AboutNERC/Pages/default.aspx (last visited Feb. 5, 2015).
7. *Id.*
8. U.S.-Canada Power System Outage Task Force, *Final Report on the August 14, 2003 Blackout in the United States and Canada: Causes and Recommendations*, at 1 (Apr. 2004), http://www.nerc.com/docs/docs/blackout/ch1-3.pdf.
9. *Id.*
10. *Id.*
11. *Id.*

synchronously from hundreds of miles away.[12] The historic economic impact of power outages is difficult to calculate but one study estimated the annual cost of outages across all U.S. business sectors between $104 billion and $164 billion in 2001.[13] The causes of major disturbances on the electric grid are dominated by weather related events.[14] Annual cost estimates for weather related events ranged from $20 billion to $55 billion.[15]

In addition to the traditional reliability challenges of a centralized grid that often relies on technology that could be described as "antique," today's grid is facing new and additional challenges from extreme weather events such as Hurricane Sandy and the Polar Vortex. The U.S. Department of Energy (DOE) explored the impacts that increasing temperatures, decreasing water availability, increasing storms, flooding, and sea level rise create for the energy sector.[16] The DOE noted that the electric grid becomes more vulnerable as increasing storms cause sea levels to rise.[17] Storm surges may harm coastal thermoelectric facilities. For example, the increasing intensity and frequency of flooding pose risks to inland thermoelectric facilities. Also, the increasing intensity of storm events increases the risks to electric transmission and distribution lines.[18] According to the DOE, smart grid and distributed technologies present some of the major opportunities for action in response to increased severe weather events.[19]

A different but equally important concern with the traditional grid is that the electric power sector is the largest source of carbon dioxide (CO_2) emissions in the United States.[20] This is primarily due to a heavy dependence on fossil fuels, which account for about 87% of the energy consumed in the United States.[21] As a result, CO_2 emissions from the

12. *Id.* at 5–6.

13. *See* Richard J. Campbell, *Weather Related Power Outages and Electric System Resiliency*, CONG. RESEARCH SERV. at 8 (Aug. 28, 2012), http://fas.org/sgp/crs/misc/R42696.pdf.

14. *Id.* at 2–6.

15. *Id.* at 8.

16. *U.S. Energy Sector Vulnerabilities to Climate Change and Extreme Weather,* U.S. Dep't of Energy i (2013), *available at* http://energy.gov/sites/prod/files/2013/07/f2/20130716-Energy%20Sector%20Vulnerabilities%20Report.pdf.

17. *Id.* at 35.

18. *Id.* at 34.

19. *Id.* at 43.

20. *U.S. Envtl. Prot. Agency, Inventory of U.S. Greenhouse Gas Emission and Sinks: 1990–2011* at 2–4 (2013), *available at* http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2013-Main-Text.pdf.

21. *Id.* at 2–9.

electric power sector make up a third of the U.S. economy's total greenhouse gas emissions and about 8% of global CO_2 emissions.[22]

The traditional centralized grid raises concerns about both its increasing environmental footprint and the reliability of today's Bulk Electric System. In 2001, NERC advised Congress that the grid was not originally designed for the way in which it is currently being used.[23] While the grid was originally intended to transfer power over short distances, the grid now carries millions of watts over long distances.[24]

The Article begins by exploring the advantages to smart distributed technologies. Second, an overview of the legal and policy incentives that have spurred growth in smart grid investment is discussed. Next, three utilities: an investor owned utility, a municipal utility and a cooperative utility, and their smart grid investments, are detailed in different case studies. Each utility's section begins with an introduction to the organizational structure and unique aspects of each entity, project specifications, and the unique aspects each project offers to the surrounding communities. Finally, the commonalities and differences between all three projects are explored, and then the current status of smart distributed technologies as well as future opportunities is discussed.

II. THE EVOLUTION OF FEDERAL SMART GRID POLICY

While the states are often considered the laboratories of policy in the United States, it is the Federal Government that initially spurred Smart Grid investment and innovation. The first major congressional effort to support the Smart Grid was with the Energy Independence and Security Act of 2007 (EISA). The Federal Energy Regulatory Commission (FERC) released its Smart Grid Policy in 2009. In an effort to recover from the Great Recession, Congress appropriated funds for Smart Grid projects in

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22. *Id.* at 2–22 (U.S. calculations are based on a ten-year trend between 2000 and 2010); *see also* U.S. ENERGY INFO. ADMIN., ANN. ENERGY REV. 309 (2011), *available at http://www.eia.gov/totalenergy/data/annual/pdf/aer.pdf*; *see also* Carbon Dioxide Info Analysis Center, *Global Fossil-Fuel CO_2 Emissions* (last visited Dec. 1, 2014), *available at* http://cdiac.ornl.gov/trends/emis/tre_glob.html (based on a ten-year average between 2000 and 2010).

23. *David N. Cook, Gen. Counsel, N. Am. Elec. Reliability Council, Hearing Before the United States Senate Committee on Energy and Natural Resources* (May 15, 2001), *available at* http://www.gpo.gov/fdsys/pkg/CHRG-107shrg75190/html/CHRG-107shrg75190.htm.

24. *Id.*

the American Reinvestment and Recovery Act (ARRA) in 2009. In 2011, the White House released the Smart Grid Framework, which solidified Smart Grid Investment as Federal Policy.[25] In July 2014, the U.S. Department of Agriculture announced a combined $263.3 million in loans to eight states to modernize and improve the reliability of the grid in rural areas.[26] The National Institute of Science and Technology (NIST) released the third version of Smart Grid Interoperability Standards in October 2014.[27] At the end of 2014, the federal government announced that it would allocate more than $3.5 million "to help communities deploy pre-commercial and commercial Smart Grid technologies and tools that will help decision makers and resource managers to improve the recovery of electricity delivery services in their communities."[28]

A. The Energy Independence and Security Act

Congress supported the development of the "Smart Grid" in the Energy Independence and Security Act of 2007 (EISA or "the Act") in response to growing concerns about the reliability and security of the grid.[29] According to the EISA, "[i]t is the policy of the United States to support the modernization of the Nation's electricity transmission and distribution system to maintain a reliable and secure electricity infrastructure that can meet future demand growth."[30] By passing the EISA, Congress further defined a series of goals for grid modernization that the Act characterized as the "Smart Grid." Congress defined the goals of a Smart Grid to include:[31]

- Increased use of digital information and controls technology;
- Dynamic optimization of grid operations and resources with full cyber security;
- Deployment and integration of distributed resources and generation, including renewable resources;

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25. *A Policy Framework for the 21st Century Grid: Enabling Our Secure Energy Future*, EXEC. OFFICE OF THE PRESIDENT, *available at* http://www.whitehouse.gov/sites/default/files/microsites/ostp/nstc-smart-grid-june2011.pdf.

26. U.S. DEP'T OF AGRICULTURE, http://www.usda.gov/wps/portal/usda/usdahome?contentid=2014/07/0148.xml (July 16, 2014).

27. Press Release, THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY, http://www.nist.gov/el/smartgrid-100114.cfm (Oct. 1, 2014).

28. *Fact Sheet: 16 U.S. Communities Recognized as Climate Action Champions for Leadership on Climate Change*, THE WHITE HOUSE (Dec. 3, 2014), *available at* http://www.whitehouse.gov/the-press-office/2014/12/03/fact-sheet-16-us-communities-recognized-climate-action-champions-leaders.

29. *See* ENERGY INDEPENDENCE AND SECURITY ACT OF 2007, Pub. L. No. 110-140, 121 Stat. 1492 (codified as amended at 42 U.S.C. §§ 17381–17386 (2012)).

30. *Id.*

31. *Id.*

- Development and incorporation of demand side resources and energy efficiency;
- Deployment of "smart" technologies for metering, communications concerning grid operation and status, and distribution automation;
- Integration of "smart appliances" and consumer devices;
- Deployment and integration of advanced electricity storage and peak-shaving technologies, including plug-in electric and hybrid electric vehicles, and thermal-storage air conditioning;
- Provision to consumers of timely information and control options;
- Development of standards for communication and interoperability of appliances and equipment connected to the grid; and
- Identification and lowering of unnecessary barriers to the Smart Grid.

Congress's comprehensive list of policies for grid modernization failed to mention general expansion of the nation's Bulk Electric System. While this omission does not suggest that federal policy for grid modernization does not include expansion of the Bulk Electric System, it does suggest that it is a separate and distinct policy from those characterized as a Smart Grid under the EISA.[32]

In addition to defining the goals of the Smart Grid, Title XIII of the EISA defined some federal policies intended to meet these goals. The Act required the Secretary of Energy to regularly report to Congress on the status of Smart Grid deployments and any regulatory or government

32. *See* MEMORANDUM OF UNDERSTANDING AMONG THE U.S. DEPARTMENT OF AGRICULTURE, DEPARTMENT OF COMMERCE, DEPARTMENT OF DEFENSE, DEPARTMENT OF ENERGY, ENVIRONMENTAL PROTECTION AGENCY, THE COUNCIL ON ENVIRONMENTAL QUALITY, THE FEDERAL ENERGY REGULATORY COMMISSION, THE ADVISORY COUNCIL ON HISTORIC PRESERVATION, AND DEPARTMENT OF THE INTERIOR, REGARDING COORDINATION IN FEDERAL AGENCY REVIEW OF ELECTRIC TRANSMISSION FACILITIES ON FEDERAL LAND, at 2 (Oct. 23, 2009) ("Expanding and modernizing the transmission grid by siting proposed electric transmission facilities will help to accommodate additional electricity generation capacity over the next several decades, including new renewable generation as well as improve reliability and reduce congestion), *available at* http://www.whitehouse.gov/files/documents/ceq/Transmission%20Siting%20on%20Federal%20Lands%20MOU.pdf.

barriers to continued deployment.[33] Congress also established a federal Smart Grid Advisory Committee and a Smart Grid Task Force.[34] The Smart Grid Advisory Committee was established by the Secretary of Energy, and is composed of nine members who have sufficient experience to represent the full range of Smart Grid technologies and services.[35] The mission of this Advisory Committee is to advise relevant federal officials concerning the development of Smart Grid technologies, the progress on transition to these Smart Grid technologies and services, and the evolution of standards and protocols for interoperability of Smart Grid devices.[36]

The Assistant Secretary of the Office of Electricity Delivery and Energy Reliability, under the Department of Energy (DOE), established the Smart Grid Task Force.[37] It was intended to be an internal DOE coordination team from various divisions who have responsibilities related to Smart Grid technologies and practices with members also designated by the Chair of the Federal Energy Regulatory Commission (FERC) and the Director of the National Institute of Standards and Technology (NIST).[38] According to the Act, the mission of the Smart Grid Task Force is to "ensure awareness, coordination, and integration of the diverse activities of the Office and others in the Federal Government related to Smart Grid technologies, practices, and services."[39] The Smart Grid Task Force was also given responsibility for the coordination function between Smart Grid technologies and practices to "infrastructure development, system reliability and security, and the relationship of Smart Grid technologies and practices to other facets of electricity supply, demand, transmission, distribution, and policy."[40] Thus the task force was established to be a link between the federal Smart Grid policy and related policies, such as expansion of the transmission system.[41]

Another key provision of the EISA was its delegation of authority to the Director of NIST to coordinate the development of a Smart Grid interoperability framework that includes protocols and model standards to achieve interoperability of Smart Grid devices and systems.[42] The director

33. *Id*. § 1302.
34. *Id*. § 1303.
35. *Id.*
36. *Id.*
37. *Id.*
38. Energy Independence and Security Act (EISA) tit. 13, § 1303(b)(1), 42 U.S.C. § 17383(b)(1), http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/EISA_Title_XIII_Smart_Grid.pdf.
39. *Id*. § 1303(b)(2), 42 U.S.C. § 17383(b)(2).
40. *Id.*
41. *Id.*
42. *Id*. § 1305(a), 42 U.S.C. § 17385(a).

was advised to seek input from the FERC, the DOE (including its Smart Grid Task Force and Advisory Committee), and other state, federal, and private entities. NIST was directed to issue an initial progress report on recommended standards within one year.[43] The FERC was then directed to conduct rulemaking proceedings as appropriate to adopt such standards necessary to ensure Smart Grid functionality and interoperability in interstate transmission of power and in regional power markets.[44]

The Act also included provisions guiding state consideration of Smart Grid investments through amendments to the 1978 Public Utilities Regulatory Policies Act, which sought consideration of Smart Grid investments by utilities as well as consideration of means for rate recovery by the state.[45] The DOE was directed to report on the security attributes of Smart Grid systems.[46] Finally, various Smart Grid demonstration programs were authorized as well as federal matching funds for Smart Grid investments.

B. FERC Smart Grid Policy Statement

The FERC's jurisdiction over the transmission system is largely derived from the Federal Power Act in regard to both transmission of electric energy in interstate commerce and the reliable operation of the Bulk Electric System. The EISA added additional provisions regarding the process for adopting standards and protocols for the Smart Grid.[47] As a result of these additional provisions from the EISA, the FERC issued its final Smart Grid Policy Statement on July 16, 2009.[48]

As previously discussed, the EISA directs the NIST to coordinate the development of a Smart Grid interoperability framework[49] and directs the FERC, through a rulemaking proceeding, to adopt such standards and protocols as necessary.[50] In order to prioritize the development of key interoperability standards in its final Policy Statement, the FERC reaffirmed the key priorities it identified as necessary to address important challenges

43. *Id*. § 1305(c), 42 U.S.C. § 17385(c).
44. *Id*. § 1305(d), 42 U.S.C. § 17385(d).
45. *Id*. § 1307(a), 42 U.S.C. § 17386(c)(3).
46. *Id*. § 1309(a).
47. EISA, *supra* note 44.
48. *See* Smart Grid Policy, 128 FERC § 61.060 (2009), http://www.ferc.gov/whats-new/comm-meet/2009/071609/E-3.pdf.
49. EISA, *supra* note 42.
50. *See* EISA, *supra* note 35, at 1787.

to the operation of the bulk power system. According to the Commission, those challenges are:

- Existing cybersecurity issues;
- Large-scale changes in generation mix and capabilities, and
- Large potential new load from electric vehicles.[51]

The key priorities the FERC identified as necessary to address these existing and emerging challenges include the two cross-cutting issues of system security and inter-system communications. The four key grid functionalities are:

1. Wide-area Situational Awareness;
2. Demand Response (DR);
3. Electric Storage; and
4. Electric Transportation.[52]

C. American Recovery and Reinvestment Act

When the President announced The American Recovery and Reinvestment Act (ARRA) in October 2009, he said it was designed to be a federal stimulus program that "will make our grid more secure and more reliable, saving us some of the $150 billion we lose each year during power outages . . . [and facilitate] the creation of a clean energy economy [which] . . . will help us lay a foundation for lasting growth and prosperity."[53] The ARRA provided funding for the Smart Grid Investment Grant Program (SGIG) through amending the EISA.[54] The ARRA distributed a total of 4.5 billion dollars to the SGIG, the Smart Grid Demonstration Program, Renewable and Distributed Systems Integration Programs, Smart Grid Workforce Training and Development, Consumer Behavior Studies and Standards, Interoperability, and Cybersecurity.[55]

A total of 3.4 billion dollars went to Smart Grid Investment Grants, which were matched by private funding for a total public-private investment worth over eight billion dollars. The Smart Grid Investments Grant funded

51. *See* FERC, *supra* note 48, at 4.
52. *Id.* at 5.
53. Barack Obama, Remarks by the President on Recovery Act Funding for Smart Grid Technology (Oct. 27, 2009), http://www.whitehouse.gov/the-press-office/remarks-president-recovery-act-funding-smart-grid-technology.
54. *Smart Grid Investment Grant Program*, SMARTGRID.GOV, https://www.smartgrid.gov/recovery_act/overview/smart_grid_investment_grant_program ("The Smart Grid Investment Grant (SGIG) program is authorized by the Energy Independence and Security Act of 2007, Section 1306, as amended by the Recovery Act.").
55. *Recovery Act Smart Grid Programs: Overview of the Programs*, SMARTGRID.GOV, https://www.smartgrid.gov/recovery_act/overview.

projects such as: Cross Cutting Programs, AMI, Electric Distribution, Electric Transmission, Customer Systems, and Equipment Manufacturing.[56] The Investments have resulted in significant positive impacts in just a few years. As of July 2014, grant recipients had installed over sixteen million smart meters.[57] By September 2014, hundreds of "customer devices" were deployed to help conduct behavioral studies to learn how to best engage customers regarding their energy consumption. Those customer devices include: in-home displays, energy management, direct load control devices, programmable controllable thermostats and smart appliances.[58] Almost half a million customers are enrolled in some kind of dynamic pricing program that incentivizes off-peak energy consumption.[59] Additionally, the experiences of the SGIG recipients resulted in a number of case studies and analytical tools meant to help others make informed Smart Grid project investments.[60]

III. SMART DISTRIBUTED TECHNOLOGIES

A. Deploying the Smart Grid

The reality is that no one knows exactly what the Smart Grid will ultimately look like in each region of the U.S. There are, of course, plenty of educated guesses. The Smart Grid represents a major shift in the electrical energy infrastructure, which will likely take billions of dollars in new investment and multiple years, if not decades, to implement. Modernizing the grid is a capital-intensive undertaking. The Electric Power Research Institute (EPRI) estimates that it will cost $338 to $476

56. *Smart Grid Investment Grant Program*, SMARTGRID.GOV, https://www.smartgrid.gov/recovery_act/overview/smart_grid_investment_grant_program.

57. *Advanced Metering Infrastructure and Customer Systems*, SMARTGRID.GOV, https://www.smartgrid.gov/recovery_act/deployment_status/ami_and_customer_systems##SmartMetersDeployed (last updated Jan. 29, 2015) ("As of November 30, 2014, the number reported in SIPRIS is 16,870,279. This count may be greater than the number reported in this chart because the numbers reported to SIPRIS may include meters that have been installed, but are not yet operational or able to transmit the information that they are collecting to the utility (i.e., able to perform their primary function).").

58. *Id.*

59. *Id.*

60. Featured Case Studies, SMARTGRID.GOV, https://www.smartgrid.gov/recovery_act/publications.

billion (or $17 to $24 billion per year over the next 20 years) to fully deploy Smart Grid technologies across the country.[61]

1. Automated Meter Infrastructure

The first step that many utilities are undertaking is the installation of smart meters and associated Automated Meter Infrastructure (AMI). A significant part of AMI is adding two-way communication technology to the electric distribution system so that the smart meters installed at individual homes and businesses can both receive and send data on electricity consumption, the status of the grid and other relevant information. While we have made some progress in this area to date, "we need to acknowledge that full-blown grid modernization is nascent at this state, with end-of-line sensors (smart meters), being installed and distribution automation getting underway. There's much work ahead to derive full value."[62] By July 2014, almost half of American electric customers had a networked, two-way communicating smart meter.[63]

As a result of the challenges facing the traditional grid, distributed generation has gained increasing public policy support, given the opportunities for it to benefit both the reliability of the grid, as well as reduce its environmental footprint. The American Council for an Energy-Efficient Economy (ACEEE) defines "distributed generation" as "the generation of electricity from sources that are near the point of consumption, as opposed to centralized generation sources such as large utility-owned power plants."[64] Renewable distributed generation like solar, energy storage systems, geothermal, and wind is an attractive energy resource option that, in addition to providing energy to meet demand, can also reduce electric load, regulate voltage on the distribution system, and eliminate the need for or defer distribution system upgrades.[65]

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61. 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 1–4 (2011), *available at* http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001022519&Mode=download.

62. John D. McDonald, *Sandy and the Smart Grid*, PUB. UTIL. FORTNIGHTLY, Apr. 2013, at 48.

63. Jeff St. John, *50 Million US Smart Meters and Counting*, GREENTECH MEDIA, (Sept. 16, 2014), http://www.greentechmedia.com/articles/read/50-million-u.s.-smart-meters-and-counting.

64. *Distributed Generation*, AMERICAN COUNCIL FOR AN ENERGY-EFFICIENT ECONOMY, http://aceee.org/topics/distributed-generation (last visited Apr. 14, 2015).

65. KEVIN B. JONES & DAVID ZOPPO, A SMARTER GREENER GRID: FORGING ENVIRONMENTAL PROGRESS THROUGH SMART ENERGY POLICIES AND TECHNOLOGIES 7 (2014) (citing Electric Power Research Institute, *The Green Grid: Energy Savings and Carbon Emissions Reductions Enabled by a Smart Grid* at 122–23 (2008)).

2. Microgrids

The Smart Grid will help facilitate new coordination among clean distributed technologies and also help create microgrids. Microgrids are "small-scale electricity systems for one or more large users, which combine efficient generation of power and its carefully monitored use, with demand response (DR) and energy efficient technologies, in a single geographic location."[66] There are a number of reasons that customers would want to deploy a microgrid, including "improving the resilience and reliability, to improving the cost or environmental characteristics of their energy supply."[67] Microgrids can operate independently from the larger system because they are composed of an energy supply source and electric infrastructure to distribute energy from its generation resources. This independent generation and distribution system is a *power island*, or "an energized section of circuits separate from the larger system."[68] When the area disconnects from the centralized gird, the islanded area transitions from redundant infrastructure to the primary power source for all consumers connected to the islanded area.[69]

3. Distributed Photovoltaic Solar Generation

The fastest growing distributed generation recently has been solar photovoltaic (PV) generation. Solar PV is on the rise and if the installed costs continue to decline it could become a disruptive technology in the future. Former FERC Chairman, Jon Wellinghoff, remarked, "solar is growing so fast it is going to overtake everything."[70] Cumulatively installed solar PV will surpass 10 GW in 2013 with 4.4 GW of PV installed in 2013, up 30% from the previous year, with residential PV system prices falling to \$4.81/W and \$2.10/W for utility scale installations.[71] According to the U.S. DOE, once solar installation costs reach \$1.0/W installed they will

66. Edward N. Krapels and Clarke Bruno, *Smaller, Cheaper, and More Resilient: The Rationale for Microgrids*, PUB. UTIL. FORTNIGHTLY, Apr. 2013, at 12.
67. *Id*. at 13.
68. ALEXANDRA VON MEIER, ELECTRIC POWER SYSTEMS: A CONCEPTUAL INTRODUCTION 152 (Emmanuel Desurvire ed., 2006).
69. *Id.* at 153.
70. Mark Hertsgaard, *Will Solar Save the Planet?*, THE NATION, Oct. 21, 2013, *available at* http://www.thenation.com/article/176475/will-solar-save-planet.
71. Solar Energy Indus. Ass'n, *U.S. Solar Market Insight Report Q2* (2013), *available at* http://www.seia.org/reserch-resources/solar-market-insight-report-2013-q2.

be competitive with the wholesale rate for electricity without further subsidy.[72] In the next 2.5 years the U.S. will double its entire cumulative capacity of distributed solar—repeating in the span of a few short years what it originally took four decades to deploy.[73] According to the Edison Electric Institute, the trade association for the nations investor-owned electric utilities, "a variety of technologies are emerging that may compete with the utility provided services" including solar PV and battery storage. As the cost curve for these technologies improves, they could directly threaten the centralized utility model."[74]

4. Energy Storage

Energy storage comes in many shapes and sizes. Lithium-ion Batteries are common, but energy can also be stored with flywheels, compressed air, and pumped hydro projects.[75] Energy storage provides benefits in avoided costs and in grid support services.[76] Energy storage can be used to firm steady and intermittent sources of power from voltage disruptions (drops and surges) in the distribution grid. Grid services created by storage could include voltage regulation, which is especially necessary to balance increased renewable energy. Avoided costs are created when storage is used as opposed to building new generation facilities for the same load demand. Storage can also supply capacity and ancillary services.

In 2013, California recognized these benefits and passed a game-changing mandate to require the state's three investor-owned utilities to install 1,325 MW in energy storage projects by 2020.[77] The first required installment in 2014 adds up to200 MW.[78] By mid-2014, more than 2,000

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72. Benjamin Kroposki, Robert Margolis & Kevin Lynn, *Power to the People*, 9 IEE POWER & ENERGY MAG., May/June 2011, at 18.

73. Herman K. Trabish, Wellinghoff, *Solar is Going to Overtake Everything*, GREENTECH MEDIA (Aug. 21, 2013), http://www.greentechmedia.com/articles/read/ferc-chair-wellinghoff-sees-a-solar-future-and-a-utility-of-the-future.

74. Peter Kind, *Disruptive Challenges: Financial Implications and Strategic Responses to a Changing Retail Electric Business*, EDISON ELECTRIC INSTITUTE (Jan. 2013), at 3, http://www.eei.org/ourissues/finance/Documents/disruptivechallenges.pdf.

75. *Energy Storage Technologies*, ENERGY STORAGE ASSOCIATION, http://energystorage.org/energy-storage/energy-storage-technologies (last visited Apr. 14, 2015).

76. *Energy Storage Benefits*, ENERGY STORAGE ASSOCIATION, http://energystorage.org/energy-storage/energy-storage-benefits (last visited Apr. 14, 2015).

77. Cal. P.U.C., *Decision Adopting Energy Storage Procurement Framework and Design Program*, Agenda no. 12370, at 2 (2010), http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M078/K929/78929853.pdf.

78. John S. Scott, *The Coming Storage Boom: Project Proposals Nearly Double California's Storage Target*, GREENTECHGRID: (July 18, 2014), http://www.greentechmedia.com/articles/read/californias-massive-on-paper-grid-energy-storagemarket?utm_source=Daily&utm_medium=Headline&utm_campaign=GTMDailyhttp://www.greentechmedia.com/

MW of energy storage project applications were submitted to the state's grid operator.[79]

B. The Advantages of the Smart Grid

While there are innumerable direct and indirect benefits stemming from Smart Grid deployment, this paper's focus is primarily on reliability, resiliency, and environmental benefits. Reliability and resiliency are distinct benefits. Reliability means the provision of electricity that is "dependable and steadfast, not prone to random breakdowns perhaps due to component failures."[80] Resiliency on the other hand, relates to an electric system's ability to, "bend under stress without breaking."[81] Smart Grid technologies, like automatic reclosers, phase measurement units, and Synchrophasors, provide reliability by regulating voltage and maintaining electric flow. Smart meters also create more resilience after an outage by creating more visibility to allow the operations team at each utility to verify and better manage connections.

Increased resiliency and reliability are essential for the U.S. Economy. As climate change increases the severity and frequency of weather-related disasters,[82] distribution utilities will face increased challenges to keep the

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articles/read/californias-massive-on-paper-grid-energy-storage-market?utm_source=Daily&utm_medium=Headline&utm_campaign=GTMDaily.

79. John S. Scott, *The Coming Storage Boom: Project Proposals Nearly Double California's Storage Target*, GREENTECHGRID: (July 18, 2014), http://www.greentechmedia.com/articles/read/californias-massive-on-paper-grid-energy-storage-market?utm_source=Daily&utm_medium=Headline&utm_campaign=GTMDailyhttp://www.greentechmedia.com/articles/read/californias-massive-on-paper-grid-energy-storage-market?utm_source=Daily&utm_medium=Headline&utm_campaign=GTMDaily ("In other words, project developers have received the market signal of a 1.3-gigawatt mandate and proposed enough storage to provide nearly double that amount over the coming years. The list includes 1,669 megawatts of standalone battery storage, 44 megawatts of other standalone storage, 255 megawatts of batteries combined with generation projects, and a 90-megawatt project combining solar and batteries.").

80. Richard Larson et al., *The 3 R's of Critical Energy Networks*, MIT ENERGY RESEARCH COUNCIL 1 (Oct. 30, 2005), http://cesf.mit.edu/papers/ThreeRs.pdf.

81. Richard Larson et al., *The 3 R's of Critical Energy Networks*, MIT ENERGY RESEARCH COUNCIL 1 (Oct. 30, 2005), http://cesf.mit.edu/papers/ThreeRs.pdf (An electrical distribution network that can shed loads gracefully on hot days, under contracts negotiated with large energy consumers, is resilient in the face of unusually large demands. The network is also resilient if it minimizes disruptions in service during unplanned equipment failures by reducing the risks of cascading failures characteristic of major blackouts.").

82. *Economic Benefits of Increasing Electric Grid Resilience to Weather Outages*, EXEC. OFFICE OF THE PRESIDENT 9 (Aug. 2013), http://energy.gov/sites/prod/files/2013/08/f2/Grid%20Resiliency%20Report_FINAL.pdf.

power connected. Single storm outages can have significant costs, which can be compounded by the indirect cost-related damage of the storm itself. In 2008, Hurricane Ike cost an estimated 24 and 45 billion dollars in outage-related costs.[83] Superstorm Sandy cost an estimated 14 and 26 billion dollars in outage-related costs alone in 2012.[84] Investments in Smart Grid technologies "improve the overall effectiveness of grid operations leading to greater efficiencies in energy use with accompanying reductions in carbon emissions, as well as providing greater assurance to businesses upon which our economy depends."[85]

Resilient Smart Grid investments also create enhanced situational awareness, which is the key to preventing indirect costs related to "expenditures by firms and individuals on back-up generators, second utility feeds, power conditioning equipment, and other items purchased to mitigate the effects of power outages."[86] The ripples of economic impacts of outages may run even broader than the immediate service territory. If a manufacturer's supply chain is disturbed by an outage, it may experience economic impacts even if it is very far away. The same may be true for "[o]nline businesses engaged in long-distance transactions," which "may also be negatively affected by reduced internet traffic."[87] Other indirect outage impacts stem from the lack of societal benefits normally created by the provision of electricity like "public safety since police, firefighters and emergency medical personnel struggle to provide assistance during outages."[88]

Smart Grid investments can help boost reliability and resilience by correcting many of the traditional grid's inefficiencies and, in so doing, mitigate some of the electric power sector's negative environmental externalities. A shift to the Smart Grid is needed to better integrate more distributed renewable resources. The grid was built for one-way power flows from the generating station to the load. With the advent of customer-side generation, new back-flow strains are being put on distribution circuits. Smart Grid technology is creating more energy consumption

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83. *Economic Benefits of Increasing Electric Grid Resilience to Weather Outages*, EXEC. OFFICE OF THE PRESIDENT 21 (Aug. 2013), http://energy.gov/sites/prod/files/2013/08/f2/Grid%20Resiliency%20Report_FINAL.pdf.
84. *See id.*
85. *Economic Benefits of Increasing Electric Grid Resilience to Weather Outages*, EXEC. OFFICE OF THE PRESIDENT 23 (Aug. 2013), http://energy.gov/sites/prod/files/2013/08/f2/Grid%20Resiliency%20Report_FINAL.pdf.
86. *See id.*
87. *Economic Benefits of Increasing Electric Grid Resilience to Weather Outages*, EXEC. OFFICE OF THE PRESIDENT 24 (Aug. 2013), http://energy.gov/sites/prod/files/2013/08/f2/Grid%20Resiliency%20Report_FINAL.pdf.
88. *See id.*

information than ever before, which "can be employed to tailor incentives for big blocks of customers"[89] and ensure that the generation and load continue to be perfectly matched as the U.S. shifts to a more renewable-centered generation portfolio.

The Smart Grid will make the existing electric power system both more reliable and also more efficient, such that generators will be able to burn fewer fossil fuels while still providing improved quality of service to customers. Of course, every unit of avoided fossil fuel combustion "carries an associated reduction in air emissions, including nitrogen oxides, sodium dioxide, volatile organic compounds, other criteria air pollutants, and most significantly, greenhouse gases."[90] The Smart Grid will also help integrate newly distributed and cleaner technologies into the American energy portfolio, which will displace fossil fuel combustion as a source of electricity.[91]

The Smart Grid is therefore critical, not only for updating the nation's aging electricity infrastructure, but also for reducing emissions of both CO_2 and other harmful pollutants. The Pacific Northwest National Laboratory (PNNL) estimates that, if Smart Grid technologies are fully deployed across the country in the next two decades, the electric power sector could reduce both energy use and carbon emissions by 12% of what they are projected to be in 2030.[92] If the indirect benefits from the PNNL study are taken into account, then expected energy usage and carbon emissions decrease by an additional 6% for a combined reduction of 18% in direct and indirect savings.[93]

IV. DISTRIBUTED ENERGY CASE STUDIES

Some of the most progressive utilities are already embracing the shift away from business as usual and experimenting with ways to promote distributed technologies to improve reliability and reduce their environmental footprint. This article highlights the experiences of one investor-owned utility, one municipally-owned utility, and one cooperatively-owned utility. They provide three examples of on-the-ground distributed generation: the

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89. *Smart grid needed to shift electrical system to alternative energy*, TECHNOLOGY (Jan. 28, 2015), http://www.domain-b.com/technology/20141113_smart_grid.html#sthash.pInVuSZf.dpuf.

90. JONES & ZOPPO, *supra* note 65, at 10–11.

91. *Id.* at 7.

92. R R.G. PRATT, P.J. BALDUCCI, C. GERKENSMEYER, AND S. KATIPAMULA, THE SMART GRID: AN ESTIMATION OF THE ENERGY AND CO_2 BENEFITS at 3.3 (2010).

93. *Id.* at 3.34.

San Diego Gas & Electric's (SDG&E) Borrego Springs Micro grid Demonstration Project; the Sacramento Municipal Utility District's (SMUD) PV & Smart Grid Pilot project in Anatolia, California; and the Hawaiian Kauai Island Utility Cooperative's (KIUC) energy storage initiatives.

A. San Diego Gas & Electric

San Diego Gas & Electric (SDG&E) is a regulated public utility that serves about 3.5 million customers. Its service area covers 4,100 square miles in San Diego and southern Orange counties throughout the state of California. It is a subsidiary of Sempra Energy—a San Diego based Fortune 500 Company.[94] SDG&E is located in one of the most renewable resource rich areas of the nation, Southern California, and has taken an active role in developing distributed generation through its utility business and by procuring renewable energy from other energy service companies. To promote the Smart Grid, SDG&E integrated distributed generation into its Smart Grid efforts. The California Public Utility Commission lists a series of goals that are to be achieved through Smart Grid rollout projects, such as enabling the support of distributed generation. Coupled with the state's strong renewable portfolio standard (RPS), SDG&E sees that now is the time to take advantage of the resource rich area and develop Smart Grid projects.

SDG&E estimates that Smart Grid deployment can lead to anywhere from $391 million to $1.324 billion in benefits from its ability to help integrate distributed generation, large scale centralized renewable energy generation, and plug-in electric vehicles (PEVs).[95] SDG&E has strong support from its customer base through the distribution of rooftop solar. In fact, SDG&E customers "have already installed more megawatts of rooftop solar in San Diego than utility customers in any other city in the United States.[96]

SDG&E has also said that the Smart Grid technology's ability to increase the automation of service and information flow will allow it to mitigate problems caused by the intermittency of distributed renewable resources like wind and solar.[97] To this end, SDG&E is building out a network designed to acquire information about electricity generation from distributed generators and other intermittent generators. SDG&E plans to

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94. *Company Facts*, SAN DIEGO GAS & ELECTRIC, http://www.sdge.com/aboutus (last visited Apr. 14, 2015).
95. San Diego Gas & Electric, Smart Grid Deployment Plan 2011-2020, 295 (2011).
96. Katie R. Thomas & Kevin B. Jones, *San Diego Gas & Electric, The Smart Grid's Leading Edge*, VT. L. SCH. INST. FOR ENERGY AND THE ENV'T 19 (2013), *available at* http://www-assets.vermontlaw.edu/Assets/iee/SDGandEFinal.pdf.
97. *Id.*

install enough smart transformers, inverters, and capacitors to control voltage fluctuations by 2020, to better integrate all the distributed resources on its system. SDG&E expects to install enough of this technology to ensure reliability in the Smart Grid by 2020.[98]

1. Borrego Springs Microgrid Demonstration Project

The San Diego County California community of Borrego Springs is home to an experimental microgrid funded in part by grants from U.S. DOE and the California Energy Commission, and a cost share with SDG&E. The goal is to showcase and test various aspects of microgrid technology, including smart meters and price driven load management, distributed renewable energy generation, advanced energy storage, and distribution automation technologies.[99] While not completely cut-off from the main grid, the Borrego Springs microgrid acts as a self-contained grid that can maintain power on its own, should the main grid experience a power shortage. To execute this project, SDG&E has developed specific project strategies to design and demonstrate a smart electrical grid that incorporates sophisticated sensors, communications, and controls. SDG&E is installing solar power generation on homes and businesses to integrate them into the electrical delivery system, enable coordinated DR programs, and integrate reliable electrical storage devices to operate the microgrid in a more cost effective manner.

Borrego Springs is a small community with residents who have avidly adopted rooftop solar, with 600 to 700 kilowatts (kW) of distributed generation that is already deployed. The community was chosen to participate to enhance overall reliability and capitalize on the opportunity to become more self-sufficient as a locality by balancing supply and demand. Aside from the installation of solar, energy storage is a key technology in the Borrego Spring demonstration project. SDG&E plans to install a 500 kW (instantaneous capacity) by 1.5 MWh (total energy production) battery at the substation, and three 25kW by 50 kWh batteries for community energy

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98. *Id.*
99. CA Energy Comm'n, CEC-500-2014-067, Borrego Springs Microgrid Demonstration Project 6 (2013).

storage.[100] Some residences will also receive utility-supplied batteries capable of delivering 4.5 kW by 12 kWh of electricity.[101]

There are two important microgrid applications for batteries that are being evaluated. They can be used for operating as an island delivering electricity when generation sources are offline. The storage system can also be used to smooth variability of intermittent sources of power so that drops and surges in voltage do not create problems on the distribution grid. The project's objective "is to conduct a pilot scale 'proof of concept' demonstration of how advanced information-based technologies and distributed energy resources may increase utilization and reliability of the grid."[102]

The project demonstrated various scenarios for operating a microgrid under real operating conditions. According to the final report, a highlight "of the project was the ability to effectively island the entire microgrid supporting more than 600 customers."[103] During the project SDG&E was able to "transition in and out of islanding mode without affecting the quality of customer service," and the microgrid was able to successfully meet its objective of reducing "peak load on the circuit by 15 percent or more."[104] The project also proved that energy storage could "firm the intermittency" of rooftop solar PV. However, the project conclusions exposed "that operating storage in parallel with the local distribution grid is much more difficult than storage vendors indicated," as it was a challenge "to resynchronize the energy storage after islanding."[105] "The project also successfully implemented a price-driven signal to Home Area Networks (HANs) and devices such as pool pumps, electric vehicles, and thermostats."[106] This allowed "SDG&E to demonstrate how residential customers will respond to price signals."[107]

In conclusion, SDG&E found that microgrids can "provide a locally controlled resource to address issues of new electric use and impacts on the grid, especially with more Photovoltaics, electric vehicles and energy storage systems," and that with proper design and standardization "a competitive market for supply and demand management can be developed where small and large customers may be market participants."[108] Microgrids

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100. *In Middle of Desert, SDG&E will Explore Solar Smoothing*, SMART GRID TODAY, July 2, 2012.
101. *Id*.
102. JONES & ZOPPO, *supra* note 90, at 136.
103. SAN DIEGO GAS & ELEC., *supra* note 99, at 3.
104. *Id.*
105. *Id.*
106. *Id.*
107. *Id.*
108. *Id.*

may also be paired with dynamic pricing to advance "the concept of market-based electric tariffs where customers are empowered to make informed decisions."[109]

B. Sacramento Municipal Utility District

SMUD is a municipally-owned, not-for-profit electric utility that has provided public power throughout Sacramento since 1946.[110] SMUD operates under an elected Board of Directors, which has exclusive legal authority to establish the rates and rules for electricity customers within its service territory.[111] It is the sixth largest community owned electric utility in the United States and the second largest in the state of California. SMUD currently serves 529,695 residential customers and 68,510 business customers in a service area with a total population of about 1.4 million. All of its customers are serviced within a 900-square mile territory, including Sacramento, Placer and Yolo Counties.[112]

SMUD has spearheaded programs to promote renewable energy and energy efficiency that are nationally recognized for their leadership and innovation. In 2008, SMUD adopted a goal to obtain 33% renewable power by 2020 before the state instituted the same goal for the states' three investor-owned utilities.[113] SMUD was also the only large utility that met the previous 20% renewable goal by 2010 using eligible resources under the current California Energy Commission Renewable Energy Portfolio Standards Eligibility Guidebook. It currently has 102 MW of wind-powered facilities and 35 MW of photovoltaic generating facilities. In

109. *Id.*

110. Sacramento County residents originally voted to establish SMUD in 1923 as a customer-owned utility, but due to legal controversy with Pacific Gas & Electric Company of San Francisco, it did not start providing power for two decades. Additionally, it needed to build an organization of engineers, electricians, managers and office workers to take over Sacramento's old electric system before supplying electricity to Sacramento customers. *History-1940s*, SACRAMENTO MUN. UTIL. DIST. (last visited Apr. 15, 2015), https://www.smud.org/en/about-smud/company-information/history/history-1940.htm.

111. CAL. PUB. UTIL. CODE § 11885 (West 2014).

112. *Company Profile*, SACRAMENTO MUN. UTIL. DIST. (last visited Feb. 27, 2015), https://www.smud.org/en/about-smud/company-information/company-profile.htm.

113. Preparation of the 2011 Integrated Energy Policy Report, Comments of the SMUD on "Renewable Power in California: Status and Issues," (Cal. Energy Comm'n Oct. 5, 2011), *available at* http://www.energy.ca.gov/2011_energypolicy/documents/2011-0914_workshop/comments/SMUD_Comments_on_Draft_Renewable_Power_in_California_TN-62550.pdf.

2010, these sources generated about 3% of SMUD's energy output with the remaining renewable energy supplied by Power Purchase Agreements. In 2010, SMUD's total energy from renewable sources was approximately 24%.[114]

As an organization, SMUD's overall policies focus on serving the community first. Its vision is to "empower its customers with solutions and options that increase energy efficiency, protect the environment, reduce global warming and lower the cost to serve its region."[115]

SMUD received a 127.5 million dollar "Smart Grid Investment Grant" from the DOE under the ARRA to implement a total of 308 million dollars' worth of projects. A portion of this budget allocates funds to residential information and control pilots, smart controls in multifamily projects, and a microgrid demonstration.[116] These demonstrations will test the surrounding variables and benefits of emerging technologies for the future of Smart Grid development. With the support of this funding, SMUD became a nationally recognized leader in Smart Grid deployment, due in part to its "Smart Grid Demonstrations—Storage for Grid Support" project.[117] This initiative awards a sub-grant to Premium Power for two battery systems to demonstrate the integration of PV and energy storage into Smart Grid applications.[118] SMUD also plans to develop infrastructure standards for plug-in electric vehicles (EVs) "smart charging," to allow the utility to ensure that the EVs charge off peak and feed electricity back to the grid during peak periods.[119]

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114. *Id.*

115. *Vision Statement*, SACRAMENTO MUN. UTIL. DIST. (last visited Apr. 15, 2015), https://www.smud.org/en/about-smud/company-information/board-of-directors/strategic-direction.htm.

116. A. Silverman and K. B. Jones, *SMUD's Smart Sacramento: A Clean Technology Pioneer 9*, VT. L.S., INST. FOR ENERGY & THE ENV'T (June 2012), *available at* http://www-assets.vermontlaw.edu/Assets/iee/SMUD-Report-Final-120618.pdf.

117. Jim Parks, *SMUD's Smart Grid Engagement Initiatives* (Nov. 15 2010), *available at* http://www.publicpower.org/files/PDFs/Parks.pdf.

118. Jim Parks, *Smart Grid Implementation at the SMUD*, Cal. Pub. Util. Comm'n, (Mar. 18, 2010), *available at* http://www.cpuc.ca.gov/NR/rdonlyres/D25C3103-D534-4F19-B267-823FD40C9C20/0/CPUCWorkshop31810SMUDParks2.pdf; *Grants*, SACRAMENTO MUN. UTIL. DIST. (last visited Apr. 15, 2015), https://www.smud.org/en/about-smud/company-information/grants.htm.

119. SILVERMAN & JONES, *supra* note 114, at 21–22.

1. PV & Smart Grid Pilot at Anatolia

While SMUD found that utility-scale energy storage is not yet economically viable,[120] it has been an early leader in enhancing grid operations through distributed solar and storage technology.[121] For example, it has a utility-scale energy storage system that provides support for a three MW PV solar plant. The storage system project is a partnership with Mitsubishi industries for a Lithium Ion 500kW power application that provides 125 kWh support to balance the PV system. The utility has found that the storage colocation is demonstrating the ability for storage to firm the intermittency of the PV plant.[122]

Another example of SMUD's leadership in energy storage is a recently completed pilot project called "The Anatolia Solar Smart Community." Anatolia is a planned 795 home neighborhood southeast of Sacramento, California in Ranchero Cordova. It is an area in which each house is built with highly energy efficient features and an average of 2.0 to 5.0 kW of PV on each home.[123] Of the 795 homes located in this community, 600 will be implemented under SMUD's SolarSmart project—eventually amounting to 1.2 MW of potential generation.[124] The Anatolia SolarSmart Homes typically include radiant barriers to reflect summer heat, high efficiency furnaces and HVAC systems, compact fluorescent lighting, ENERGY STAR qualified windows, and independent third-party verification to confirm all energy efficiency measures are installed and operating correctly.[125]

The Anatolia pilot project utilized a control group of twenty-five homes to install fifteen 10 kW residential energy storage (RES) systems with 5 kw by 8.8 kWh of battery storage. In addition, three 30 kW by 30 kWh of

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120. SACRAMENTO MUNI. UTIL. DIST., SMUD AB 2514 STORAGE PROCUREMENT REPORT 1 (2014).

121. Interview by Katie R. Thomas with David Brown, Principal Distribution System Engineer, Sacramento Muni. Util. Dist. (Nov. 21, 2014); SACRAMENTO MUNI. UTIL. DIST., SMARTSACRAMENTO® FACT SHEET 73–74 (Aug. 2013).

122. *Id.*

123. Press Release, Sacramento Mun. Util. Dist., SMUD, Partners Kick-off Energy Storage Project: Batteries to Help Power Homes in Sacramento (June 29, 2012) (on file with author).

124. Peter McNutt et al., *Impact of SolarSmart Subdivisions on SMUD's Distribution System*, NATIONAL RENEWABLE ENERGY LABORATORY 1 (July 2009), http://www.nrel.gov/docs/fy09osti/46093.pdf.

125. Mark Rawson, SMUD PV and Smart Grid Pilot at Anatolia (Mar. 2011), *available at* http://www1.eere.energy.gov/solar/pdfs/highpenforum1-14_rawson_smud.pdf.

community energy storage (CES) systems were installed, linking five to ten homes with battery storage capacity.[126] The residential energy storage units are essentially refrigerator-sized batteries that were located in the garage of each home.[127] The community energy storage systems were connected to pad mounted transformers on distribution feeders.[128] They were sized to work with the group of homes fed by each transformer.[129] SMUD used installed AMI technology to monitor and control energy storage resources and coordinate the system at a more granular level.[130]

The Anatolia pilot project addressed three key technical issues associated with deploying photovoltaics in high penetrations: the lack of utility based PV power control, the lack of PV power production data in high penetration scenarios, and the lack of data on storage technologies.[131] The project began as a joint effort between the National Renewable Energy Laboratory (NREL) and SMUD.[132] The objective of this project was to analyze distribution impacts of high penetration, grid-integrated PV-equipped SolarSmart homes.[133]

At the completion of the Anatolia Project, SMUD concluded, among other lessons learned, that co-locating distributed energy storage with the customer's PV generation may add value for SMUD and its customers,[134] may help mitigate power flow and voltage control issues,[135] and may reduce peak loads.[136] SMUD found that the peak load was shifted in a helpful way because the output of PV systems tends to drop off later in the day.[137] SMUD was also able to use the homes' smart meters to control

126. *Id.* at 9; *see, e.g.*, *DOE Global Energy Storage Database*, Dep't of Energy (June 30, 2014, 2:09 PM), http://www.energystorageexchange.org/projects/794.

127. Interview, *supra* note 121.

128. Mark Rawson, *supra* note 125, at 9.

129. *Id.* at 7.

130. *Id.* at 11.

131. *Sacramento Municipal Utility District: PV and Storage of Anatolia, California,* ENERGY.GOV, https://solarhighpen.energy.gov/project/sacramento-municipal-utility-district (last visited Apr. 15, 2015).

132. Mark Rawson, *supra* note 125, at 11.

133. *Sacramento Municipal*, *supra* note 131.

134. "We quantified benefits of $88/kW to $215/kW for customer-sited and $67/kW to $176/kW for transformer-sited distributed energy storage." Mark Rawson, *Sacramento Municipal Utility District PV and Smart Grid Pilot*, ENERGY.GOV (forthcoming) (final report at viii) (on file with authors).

135. *Id.* ("Energy storage can be used to manage high penetrations of PV and mitigate potential issues such as reverse power flow, voltage control violations, power quality issues, increased wear and tear on utility equipment, and system wide power supply issues.").

136. *Id.* at 18 ("SMUD proved many times that energy storage in both the RES and CES configuration can reduce peak loads. SMUD ran load shifting 2,847 times with for the RES units and 719 times for the CES units.").

137. JONES AND ZOPPO, *supra* note 65, at 137.

the PV,[138] but found that dedicated broadband would prevent the loss of communications visibility between the PV/storage units and the utility.[139]

The 2500 R Street project, a 34-home development project, complements the Anatolia by integrating PV, storage, energy efficiency, and communications solutions.[140] The residential energy storage systems are outside the home and connected to the electrical service panel.[141] SMUD can control the smart devices and appliances if needed to reduce load and can similarly control all the energy storage units individually, or as a fleet. SMUD implemented a telecommunication related lesson learned in this project by including broadband capabilities on each storage unit instead of depending on the home's broadband system.

Additionally, SMUD is working with eighteen local, regional, and national homebuilders to construct 1,041 homes that combine solar energy and advanced energy efficiency design. SMUD provides incentives to builders to buy down the cost of solar PV systems and provides rebates for energy efficiency upgrades. These rebates and incentives, along with attractive tax credits, make these homes an affordable option for more homebuyers. Residents save as much as 60% on energy bills.[142] SMUD provides customers with the opportunity to buy a SolarSmart Home or build a SolarSmart Home within additional SolarSmart Home communities. Today new homebuyers can choose from one of SMUD's fifteen SolarSmart Home communities. Incentives for purchasing one of these homes include:

- $1,250 for a baseline of 25 percent of household efficiencies,
- An additional $250 for 30%,
- An additional $250 for 35%,
- An additional $500 for 40%,
- And $0.65 provided for a solar electric installation.

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138. Mark Rawson, *supra* note 125, at 31–33; Interview by Katie R. Thomas with Mark Rawson, Energy Research Technology Officer, SACRAMENTO MUN. UTIL. DIST. (Dec. 8, 2014).

139. *Id.*

140. *Community Partners*, 2500RMIDTOWN.COM, http://www.2500rmidtown.com/community-partners/ (last visited Jan. 21, 2015).

141. Katie R. Thomas interview with Mark Rawson, Energy Research Technology Officer, SACRAMENTO MUN. UTIL. DIST. (Dec. 8, 2014).

142. *SolarSmart Homes: Buying a New Home*, SACRAMENTO MUN. UTIL. DIST. (last visited Feb. 27, 2015), https://www.smud.org/en/residential/environment/solarsmart-homes/buying.htm.

Furthermore, builders receive a Zero Peak Home incentive of $2,000 for each home built, to use no electricity during SMUD's peak period of 4 pm to 7 pm.[143]

C. Kauai Island Utility Cooperative

The Kauai Island Utility Cooperative (KIUC), a non-profit entity with cooperative by-laws,[144] serves the Hawaiian island of Kauai, with a total population of 65,000 people.[145] The total production capacity is approximately 125 MW.[146] KIUC operates two main power plants on Kauai—Port Allen and Kapaia Power Station (KPS). Port Allen has 12 generators with a 96.5 MW capacity. It also has a heat recovery steam generator. The generator uses the waste heat from two of the combustion turbines to produce steam for additional electrical generation. KPS has a 27.5 MW steam-injected gas turbine facility, which is KIUC's more efficient and cleaner burning power plant. KPS provides the majority of the power to the island. Currently, KIUC derives over 90 percent of its power from diesel and naphtha. KIUC also maintains the Waiahi hydro power plant, which has two hydroelectric generating units. The Waiahi hydro plant, along with several other existing hydro plants, provides approximately 7 percent of renewable energy annually.[147]

With Hawaii's heavy dependence on fossil fuels, KIUC has taken tremendous strides to move toward a more resilient and clean energy future. By utilizing its flexible, cooperative business model, KIUC sets ambitious goals for clean energy and Smart Grid deployment. Currently, the island has a target goal of using renewable energy to generate 50 percent of electricity by 2023.[148] Additionally, KIUC aims to decrease the average residential energy bill by 10%, become a leader in the deployment of energy storage technology, and reduce CO_2 levels to 1990 by 2023.[149] To meet the unique challenges of grid stability on an island, KIUC has taken several measures to ensure reliability throughout the island. In November 2009, the DOE awarded the National Rural Electric Cooperative Association's (NRECA) Cooperative Research Network with funding to

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143. *Id.*

144. *Homepage*, KAUA'I ISLAND UTILITY COOPERATIVE, http://website.kiuc.coop/ (last visited Apr. 15, 2015).

145. *Energy Information*, KAUA'I ISLAND UTILITY COOPERATIVE, http://website.kiuc.coop/ (last visited Apr. 15, 2015).

146. *Id.*

147. *Id.*

148. Interview by Samantha Ruiz with Michael Yamane, Chief of Operations, Kaua'i Island Utility Cooperative (Apr. 6, 2015).

149. KAUA'I ISLAND UTIL. COOP., 2013–2025 KIUC STRATEGIC ENERGY PLAN 4 (2013).

test and develop technologies that make the grid more effective and reliable.[150] Additionally, the DOE awarded KIUC $11 million to install 33,000 smart meters and a communications infrastructure that allows two-way communication between the meters and KIUC's Operations Center.[151] Its AMI allows for load control, DR options, and outage detection.[152]

1. KIUC's Battery Storage Initiative

At the core of KIUC's vision for increasing renewables throughout the island, there is a simple reality—ensuring adequate support for its high penetration of solar PV. KIUC continues to implement sufficient battery storage to ensure necessary reinforcement for its intermittent renewables. Kauai's strong leadership in solar PV integration has necessitated the support of battery storage throughout the island. In 2011, KIUC invested in a 1.5 MW utility scale battery storage system to help mitigate the effects of a 3 MW PV project[153] At the end of 2013, KIUC had 19 MW of solar, including 12 MW customer-sited and 9 MW utility scale.[154] The total battery storage throughout the island of Kauai is currently 4 ½ MW with an additional 6 MW planned to come online in the next year. The 6 MW will serve the recently approved 53-acre, 12 MW solar farm located in Anahola, Kauai.[155]

Within the electric cooperative community, KIUC is recognized as a distributed energy leader because it has over 20 MW of Solar PV combined with a rapidly growing storage resource, all for a system with a

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150. AMI Load Research—KIUC Demonstration: Confirming the Value of AMI, NRECA & CRN (2013), http://www.nreca.coop/wp-content/uploads/2014/01/NRECA_DOE_AMI_KIUC_b.pdf.

151. *Smart Meter FAQs*, KAUA'I ISLAND UTILITY COOPERATIVE, http://website.kiuc.coop/content/smart-meter-faqs (last visitd Apr. 15, 2015); *Kauai Island Utility Cooperative gets green light for smart meters*, INTELLIGENT UTILITY (Nov./Dec. 2011), *available at* http://www.intelligentutility.com/magazine/article/247175/puc-calls-project-transformative.

152. AMI Load Research, *supra* note 150; *see also* Duane Shimogawa, *KIUC to Use $11m to Add Smart Meters*, Pacific Business News, (Sept. 30, 2011, 2:12 PM), http://www.bizjournals.com/pacific/blog/2011/09/kiuc-to-use-11m-to-add-smart-meters.html.

153. Interview by Samantha Ruiz with Michael Yamane, Chief of Operations, Kaua'i Island Utility Cooperative (Nov. 28, 2014); Press Release, Kaua'i Island Util. Coop., Kauai Island Utility Cooperative Purchases Battery Energy Storage System (Jan. 10, 2011) (on file with author); KAUA'I ISLAND UTIL. COOP., 2013 ANNUAL REPORT 5 (2014).

154. *Id.*

155. *Id.*; *see also* Press Release, Kaua'i Island Util. Coop., Blessing, Groundbreaking Held for $54 Million Kaua'i Solar Project (Jun. 26, 2014).

peak demand of 78 MW. This represents one of the highest ratios of solar as a percentage of peak demand of any electric utility in the world.[156] In addition, the Hawaii Department of Land and Natural Resources (DLNR) approved right of entry to conduct soil testing and other studies to initiate a permit for construction of a pumped hydro storage system utilizing existing reservoirs on the island.[157] The storage system, capable of providing 20-25 MW, will provide Kauai with 13 percent of the island's energy needs and ensure grid stability, as well as a higher integration of PV Solar on the grid. By 2018, KIUC plans to have 80-95 percent[158] of its typical daytime demand supplied by renewables, primarily solar PV. Additionally, KIUC foresees achieving these targets to integrate more PV onto the grid, offset peak power, and allow for a transfer of over-generation of PV Solar. KIUC plans to increase its renewable portfolio in a variety of other ways as well, including alternative fuel sources and hydropower and biomass projects to meet its targeted goals. In 2011, KIUC signed a long term Power Purchase Agreement with Green Energy Team, LLC for a 7 MW biomass-to-energy project located near Koloa, Kauai.[159] This project will reduce Kauai's dependence on fossil fuels by 3.7 million gallons per year, and provide biomass-fired generation to serve the energy needs of more than 8,500 Kauai households.[160]

V. CONCLUSION

Technological change is taking place throughout the electric industry. Each of the projects aforementioned highlights many of the different advantages smart grid technologies provide to customers and utilities, while revealing some of the remaining challenges. Additionally, all three case studies provide a platform for other states seeking to implement distributed generation in similar ways. The SDG&E and SMUD projects take a customer-oriented approach in some aspects. SDG&E incorporated price driven load management and SMUD incorporated customer sited storage and dynamic pricing. Both the SMUD Anatolia project and the SDG&E Borrego Springs Microgrid initiatives aim to place the power of

156. Press Release, Collet & Associates, Collet & Associates Advises Electric Cooperatives on Portfolio of Renewable Projects (Aug. 29, 2011), http://www.colletassociates.com/wp-content/uploads/Collet_Advises_Coops_On_Renewables.pdf.

157. *Id.* Interview by Samantha Ruiz with Michael Yamane, Chief of Operations, Kaua'i Island Utility Cooperative (Apr. 6, 2015).

158. Interview by Samantha Ruiz with Michael Yamane, Chief of Operations, Kaua'i Island Utility Cooperative (Apr. 6, 2015).

159. *Id.*

160. Interview by Samantha Ruiz with Michael Yamane, Chief Operating Officer, Kaua'i Island Utility Cooperative (Nov. 28, 2014).

choice in the homeowner's hands. Further, both projects included dynamic pricing approaches to getting the customer involved.

The objectives behind the Borrego Springs Microgrid demonstration project and the KIUC battery storage initiative projects focus on the utilities' obligation to provide reliable electricity to the customers in their service territories. The elements incorporated throughout Borrego Springs follow the same trends as the other two projects, yet there is a heavier emphasis placed on the utility-side application. Although there is a customer-side component to this project, there is much more of an emphasis placed on reducing load on a constrained circuit. Because there is little resistance from their customers to adopt renewables, the focus behind all three projects is to integrate all elements to create a more robust, self-sustaining grid that will incorporate solar power, battery energy storage, automated switching, and active customer participation.

In observing these projects, federal and state public policy has clearly spurred investment and innovation. The current federal policy framework encourages investments in resiliency, reliability, and climate change mitigation. As these projects demonstrate, ARRA funding has been helpful in moving demonstration projects forward. Specifically looking at the Borrego Springs and Anatolia project in California, the driving force behind these demonstration projects have both been federal financial incentives, as well as leading state policy supporting smart, clean, and distributed energy. Similarly, KIUC investment in smart distributed technology can be linked to federal support for NRECA smart grid initiatives, progressive state policy, as well as the utility's need to respond to some of the highest electric rates in the country, which results from the geographic isolation of an island-based grid. Two important principles of smart grid policy development have been demonstrated here: (1) clear public policies will speed smart grid results and research, and (2) development and demonstration projects are essential to continued progress on grid modernization and climate change preparedness.[161]

California and other states that set clear policies are moving steadily toward their goals. California continues to lead in smart, clean, and distributed technologies. This is shown by its recent energy storage mandate and the early success of its utility that seeks to exceed early program goals

161. JONES & ZOPPO, *supra* note 65, at 152–54.

by a factor of five.[162] With the state and federal governments defining smart grid goals, leading utilities and their progressive regulators prove that they can move swiftly. Early leadership by SDG&E, SMUD and KIUC continues to highlight the value of cutting edge demonstration projects that deliver on the potential of the smart grid and ensure that the technology operates on an integrated basis, prior to rolling out to the broader market. Continued leadership and innovation in this area will ensure a transition from a "brittle" grid to one that is more resilient and climate friendly.

162. R. Walton, *SoCal Edison Signs Contracts for 250 MW of Storage*, UTILITY DIVE (Nov. 6, 2014), *available at* http://www.utilitydive.com/news/socal-edison-signs-contracts-for-250-mw-of-energy-storage/329870/.