2.2 Business

American businesses can drive significant improvements to U.S. energy productivity, and they stand to benefit significantly from increasing energy productivity within their own operations. Although the importance of energy use may vary by type of business, improving energy productivity can be a universal source of enhancing competitiveness by increasing the amount of goods and services produced for a given amount of energy used. Strategies in this section were developed using feedback from the regional dialogues, the roundtable discussions, and goal endorsers. Notable contributions were provided by Raleigh regional dialogue participants for energy productivity in buildings and by St. Paul regional dialogue participants for advanced and smart manufacturing.

Lack of funding is a common barrier to reducing energy costs in businesses; the most significant financial barriers are insufficient internal capital budgets and competition with other capital investments.[90] To more clearly target recommended strategies, the *Roadmap* separates businesses into commercial (i.e., businesses that provide services and have lower energy intensities) and industrial groups (i.e., businesses that produce physical goods and have higher energy intensities). Both groups have the opportunity to encourage gains in energy productivity for their customers while offering them innovative products and services. Actions by businesses contribute to all six energy productivity wedges.

Smart Energy Systems
Technologies for Buildings Energy Productivity
Financing for Buildings Energy Productivity
Water Infrastructure
Smart Manufacturing
Transportation

2.2.1 COMMERCIAL BUSINESSES

2.2.1.1 New Financing Models

The investments needed across all sectors of the economy to increase energy productivity will require both existing and new innovations in financing mechanisms. Financing of investments is a barrier to increasing energy productivity for households, industrial businesses, and commercial businesses.[91] Together with strategies implemented by government

90 Johnson Controls, *Energy Efficiency Indicator: 2013 U.S. Results*, accessed July 2015, http://www.institutebe.com/InstituteBE/media/Library/Resources/Energy%20Efficiency%20Indicator/061213-IBE-Global-Forum-Booklet_I-FINAL.pdf.

91 Johnson Controls, *Energy Efficiency Indicator*: 2013 U.S. Results.

on the federal, state, and local levels, improved financing can facilitate the adoption of existing energy productivity technology and pave the way for new markets for yet-to-be commercialized technologies.

Small commercial buildings are an untapped source of energy productivity improvements, as is apparent in the potential investment value and energy savings for them; the investment value of the market for small building energy retrofits is estimated at $36.5 billion, with associated potential energy and utility bill savings of 420 trillion Btu and $138 billion, respectively.[92] The approaches required for tapping this potential differ from large enterprises and large commercial buildings, but public-private partnerships such as PACE financing and on-bill financing are examples of strategies to overcome the barriers for this market segment. As of January 2014, on-bill financing programs were operating or preparing to launch at least 25 U.S. states as well as in Canada and the United Kingdom. In aggregate, the 30 programs reviewed for a study done through SEE Action have delivered over $1.8 billion of financing to consumers for energy improvements.[93] Specific improvements for financing of small building energy efficiency projects include developing turnkey solutions, expanding contractor-led programs, and improving underwriting and program execution.[94]

2.2.1.2 Workforce Training

Increasing the energy efficiency of buildings is essential to meeting the energy productivity goal, yet building and construction contractors, and building trades professionals often lack awareness of the potential growth of the energy efficiency services sector, and more workers with energy efficiency qualifications are needed.[95] An instrumental strategy for overcoming this barrier is to incorporate energy efficiency into existing union and trade organization training programs, especially in ways that teach whole-building approaches to efficiency.[96] These organizations can also team with community and technical colleges, universities, and public utility commissions to effectively address the efficiency workforce education and training needs. For example, Pulaski Technical College in Arkansas offers energy efficiency courses for continuing education credits to professionals in the building trades.[97]

92 National Institute of Building Sciences Council on Finance, Insurance and Real Estate, *Financing Small Commercial Building Energy Performance Upgrades: Challenges and Opportunities* (Washington, D.C.: National Institute of Building Sciences, 2015), accessed July 2015, http://c.ymcdn.com/sites/www.nibs.org/resource/resmgr/CC/CFIRE_CommBldgFinance-Final.pdf.

93 State and Local Energy Efficiency Action Network, *Financing Energy Improvements on Utility Bills: Market Updates and Key Program Design Considerations for Policymakers and Administrators* (Washington, D.C.: U.S. Department of Energy Office of Energy Efficiency and Renewable Energy, 2014), accessed July 2015, https://www4.eere.energy.gov/seeaction/system/files/documents/publications/executive/onbill_financing_es.pdf.

94 National Institute of Building Sciences, *Financing Small Commercial Building Energy Performance Upgrades: Challenges and Opportunities* (Washington, D.C.: National Institute of Building Sciences, 2014), accessed July 2015, http://c.ymcdn.com/sites/www.nibs.org/resource/resmgr/CC/CFIRE_CommBldgFinance-Final.pdf.

95 Charles A. Goldman, Jane S. Peters, Nathaniel Albers, Elizabeth Stuart, and Merrian C. Fuller, *Energy Efficiency Services Sector: Workforce Education and Training Needs*, LBNL-3163E (Berkeley, CA: Lawrence Berkeley National Laboratory, 2010), accessed July 2015, http://emp.lbl.gov/publications/energy-efficiency-services-sector-workforce-education-and-training-needs.

96 Goldman et al. (2010).

97 "Continuing Education Credit Offerings," Pulaski Technical College, accessed July 2015, http://www.pulaskitech.edu/center_for_applied_building_sciences/continuing_education_credit_offerings.asp.

BUSINESS SUCCESS STORY

Lime Energy Tackles Barriers to Energy Efficiency in the Small and Mid-Sized Business (SMB) Segment

Lime Energy (Lime) is an energy services provider. One of its core strategies is to partner with utilities providing energy efficiency programs to small and mid-sized businesses (SMBs), a segment that represents the majority of commercial buildings in the United State. Since launching their innovative efficiency programs in 2011, Lime has delivered more than one billion kilowatt-hours of savings to over 100,000 SMBs, resulting in over $720 million of avoided energy costs while also adding 5,500 jobs to the U.S. economy. Lime Energy works directly for 12 of the top 25 utilities in the nation, having effectively brought energy savings performance contracting to their 1.4 million SMB customers.

Incentive programs targeting energy efficiency in commercial buildings have been implemented by utilities and program administrators for years, but they have struggled to gain participation from the SMB segment. These customers use nearly 50 percent of the energy consumed in the entire commercial building sector. Traditional barriers have included small business owners' lack of resources, their difficulty navigating technical energy efficiency concepts, and the high cost of acquiring these resources in the diverse SMB building sector. Lime Energy has spent the last four years attacking these problems head on. Below are examples of overcoming these barriers.

EXAMPLE: OVERCOMING THE SMB RESOURCE AVAILABILITY BARRIER

A south New York utility had run a commercial energy efficiency program for three years with little participation from customers with buildings under 10,000 square feet. The utility determined the low participation was because the program was too time-consuming and confusing for customers. Working with the utility, Lime Energy proposed an integrated program offering simplified customer participation. Lime installed a technology-driven delivery platform that enabled energy services representatives to take no more than 15 minutes to market the program, conduct an analysis, present financing options, and close the project. Given a small business owner's lack of availability, Lime's integrated approach and technology proved valuable to the utility, as it standardized and drastically shortened the time and customer involvement needed to initialize and implement the energy efficiency program.

EXAMPLE: OVERCOMING THE COST CONSTRAINT FOR SMBs

Utilities are often not adequately incentivized through state regulation to offer cost-effective energy efficiency programs to SMBs. One utility recognized the value of customer satisfaction and public goodwill that energy efficiency could bring to small businesses, but it needed help navigating tight budgetary constraints and a challenging policy landscape. Lime worked with the utility's program managers and with state policy advocates to design a program to fit this need. The program design was aimed at reducing energy efficiency program costs through technology and software innovation, increased staff effectiveness, marketing efficiency (through deep market segmentation and data analytics), and lowered project costs for consumers (through bulk procurement of efficiency measures with leading national distributors). Innovatively, Lime delivered these features to the utility in a guaranteed performance contract vehicle—similar to a power purchase agreement—easing concerns voiced by state regulators regarding runaway incentive budgets. This example shows how the "utility of the future" will deliver cost-effective, clean energy for their customers.

Through these tailored approaches, Lime Energy has directly financed over $9.2 million in efficiency projects, enabling 1,332 SMBs to participate in energy efficiency programs, and saving a collective 100,000 kWh in annual consumption in hard-to-reach markets such as restaurants, service stations, laundromats, and small retailers. Lime has influenced real customer behavior change, helping 1,747 small businesses make long-term investments of over $8.5 million in less than three years. Additionally, Lime's services increased customer satisfaction with utility energy efficiency programs to 96 percent, and overall satisfaction with the providing utility to 98 percent. Lime is helping utility clients move into the future, aligning their business goals with customer satisfaction while simultaneously reducing the emissions from the electricity they deliver. As regulations require increased delivery of energy efficiency resources, utilities have great potential in the SMB segment, for which Lime Energy's program delivery breakthroughs can be key. Lime's methods have made SMB energy efficiency delivery so cost effective that several utility clients are implementing these programs despite not having a regulatory requirement to do so.

For more information on Lime Energy's programs, their performance model, or the platform that powers it, see www.lime-energy.com.

Reference to a non-federal entity does not constitute an endorsement on the part of DOE or the U.S. government.

2.2.2 INDUSTRIAL BUSINESSES

Industrial businesses are critical participants in helping the United States meet the energy productivity goal because of their importance as energy users and engines of economic growth. These businesses also have the opportunity to provide new products and services that enable other businesses and sectors of the economy to improve their energy productivity. As a result, the industrial sector is well positioned to increase U.S. energy productivity through high-impact product innovation and the use of highly efficient manufacturing processes to streamline operations, improve productivity, and advance U.S. economic competitiveness.

In addition to increasing output using the same or less energy, energy productivity for industrial businesses can lead to substantial non-energy benefits or "co-benefits"[98] including reduced operations and maintenance costs, increased product quality, and improved worker health and safety. However, these co-benefits are often missing from the business case for projects that may increase a company's energy productivity. Getting funding for these projects may involve strategies such as having a separate capital account for proposed energy efficiency and energy productivity projects, or incorporating estimates of the value of energy productivity co-benefits.

The DOE's Better Plants Program (Better Plants) calls on its participants to demonstrate their commitment to increasing energy efficiency by voluntarily reducing their energy intensity by 25 percent over ten years. As of fall 2014, the 143 participants, representing nearly 11 percent of the total U.S. manufacturing footprint, reported cumulative savings of 320 trillion Btu and $1.7 billion in energy costs; this is enough energy to power the entire state of Vermont for over two years.[99] Building on the success of its participants, Better Plants started a pilot program to improve coordination of energy management practices between companies and their supply chains. For some manufacturers, much of the energy footprints of their products can be traced back to the materials and processes of their suppliers. Better Plants offers participating suppliers technical assistance, energy management training, and priority access to no-cost energy audits through DOE's IACs.[100] Johnson Controls, a Better Plants participant, achieved an annual energy intensity improvement of 8 percent,[101] and it is expanding its own supplier efficiency program by 60 suppliers by 2018. The company's program uses its own energy experts to train suppliers on identifying and implementing cost-effective energy efficiency investments. These efforts have helped suppliers achieve energy savings of 5-10 percent on investments with less than a two-year payback.[102]

98 International Energy Agency, *Capturing the Multiple Benefits of Energy Efficiency* (Paris: International Energy Agency, 2014).

99 U.S. Department of Energy Better Plants, "Progress Update: Fall 2014" DOE/EE-1140 (Washington, D.C.: U.S. Department of Energy, 2014), accessed July 2015, http://energy.gov/sites/prod/files/2014/09/f18/Better%20Plants%20Progress%20Update%202014.pdf.

100 U.S. Department of Energy Better Plants, "Overview: Supply Chain Pilot" (Washington, D.C.: U.S. Department of Energy, 2014), accessed July 2015, http://energy.gov/sites/prod/files/2014/07/f17/better_plants_supply_chain_pilot.pdf.

101 "Johnson Controls, Inc.," U.S. Department of Energy Better Buildings, accessed July 2015, http://betterbuildingssolutioncenter.energy.gov/energy-data/Johnson%20Controls,%20Inc.

102 Johnson Controls, Inc., "Johnson Controls teams up to scale energy efficiency in corporate supply chains," news release, June 11, 2015, http://www.prnewswire.com/news-releases/johnson-controls-teams-up-to-scale-energy-efficiency-in-corporate-supply-chains-300097486.html.

Small and medium enterprises that lack internal expertise in evaluating projects to increase energy productivity may find it beneficial to hire external assistance. Energy service companies can be a valuable partner in realizing reductions in energy use. They provide customers with guaranteed energy savings in return for payment from a portion of the achieved savings. Customers of energy service companies saved an estimated 33.7 terawatt-hours of electricity in 2012, equivalent to 2.5 percent of U.S. commercial electricity retail sales.[103]

2.2.2.1 Public-Private Partnerships

Partnerships between private business, government and universities for clean energy technologies are important enablers for meeting the energy productivity goal. Public-private partnerships can help increase access to capital, facilitate use of shared infrastructure, and lower technical risks. One notable example is the National Network of Manufacturing Innovation (NNMI), which focuses on R&D of foundational technologies that have potentially transformational technical and productivity impacts for the U.S. industrial sector. NNMI has established five institutes each of which focuses on a promising manufacturing approach or technology. For example, the institute Lightweight Innovations for Tomorrow (LIFT), which focuses on lightweight technology, has a project to reduce the wall thickness of ductile iron cast parts by 50 percent which could result in weight savings of 30–50 percent and associated energy efficiency benefits.[104] These institutes begin with federal support, but they are expected to operate with private-sector funding and without further federal funding after five years.

High-performance computing is another example where industry and public sector resources can join to increase energy productivity. Public-private partnerships in this space could further empower small and large businesses to harness the power of, as well as the modeling and simulation capabilities from, the national laboratory system—to improve R&D, reduce the time required to bring a product to market, and optimize production and supply processes.[105]

The Oak Ridge National Laboratory Manufacturing Demonstration Facility offers shared RD&D infrastructure for additive manufacturing and low-cost carbon fiber, which could be significant enablers of energy productivity, particularly in transportation applications and other technology areas.[106] The facility provides industries with the types of technical expertise and state-of-the-art technology that reduce risk and accelerate the commercialization of innovative new processes and products.

103 Juan Pablo Carvallo, Peter H. Larsen, and Charles A. Goldman, *Estimating customer electricity savings from projects installed by the U.S. ESCO industry*, LBNL-6877E (Berkeley, CA: Lawrence Berkeley National Laboratory, 2014), accessed July 2015, http://emp.lbl.gov/sites/all/files/lbnl-6877e.pdf.

104 Lightweight Innovations for Tomorrow, "LIFT Announces First Technology Project will Focus on Iron Alloys in Thin-Wall Castings," news release, July 16, 2015, http://lift.technology/lift-announces-first-technology-project-will-focus-on-iron-alloys-in-thin-wall-castings/.

105 Council on Competitiveness, *Strengthen: Dialogue 5* (Washington, D.C.: Council on Competitiveness, 2015), accessed July 2015, http://www.compete.org/storage/documents/CoC_AEMC_D5_Strengthen_FINALv2.pdf.

106 Oak Ridge National Laboratory, *Manufacturing Demonstration Facility*, ORNL 2013-G00529/aas (Oak Ridge, TN: Oak Ridge National Laboratory, 2013), accessed July 2015, http://web.ornl.gov/sci/manufacturing/docs/MDF-factSheet.pdf.

SMALL BUSINESS SUCCESS STORIES

Eck Industries, South Shore Millwork, and Mid-South Metallurgical

Eck Industries of Manitowoc, Wisconsin, is a small four-generation, family-owned aluminum foundry. Eck Industries took advantage of the resources made available through Wisconsin's Focus on Energy program, an initiative that provides technical and financial resources for energy efficiency projects. Eck Industries worked with the state program to implement a lighting retrofit project that would better illuminate its production facilities. The lighting efficiency improvements proved successful—the new energy-efficient bulbs reduced the energy intensity of the facility's lighting by 46 percent, the project paid for itself in approximately eight months, and the company realized annual operating savings of more than $55,500.[1]

South Shore Millwork is a small business providing fine architectural woodwork in Norton, Massachusetts. In an effort to improve the efficiency of their millwork shop, the company reached out to Mass Save, an energy efficiency initiative sponsored by Massachusetts utility and efficiency companies. Through the program, South Shore Millwork installed high-efficiency lighting systems and controls, occupancy sensors, and variable speed drives at a total project cost of $218,000. The project saved $30,500 annually (a payback period of 4.5 years), and it reduced carbon emissions reduction by more than two tons annually.[2]

Mid-South Metallurgical is a niche commercial heat-treating company in Murfreesboro, Tennessee. The Mid-South Metallurgical facility operates 24 hours a day and it must accommodate furnace temperatures ranging from 120°F to 2375°F. To address efficiency challenges, the Industrial Assessment Center sponsored by the DOE at the University of Tennessee conducted an evaluation in which they discovered several areas where the company could save energy, including through better furnace insulation. Also found were opportunities to lower peak energy demand through an electrical demand system,

1 http://www.energy.gov/sites/prod/files/2014/05/f16/eck_industries_case_study.pdf

2 http://www.masssave.com/~/media/Files/Business/Case-Study/EE5200_MassSave_SouthShore.pdf

energy-efficient furnace burner tubes, and improvements in the lighting system. By adopting these recommendations, Mid-South Metallurgical lowered its energy use by 22 percent and decreased its energy costs by 18 percent, helping the company remain competitive through the recession and earning DOE's Energy Champion Award.[3]

Reference to a non-federal entity does not constitute an endorsement on the part of DOE or the U.S. government.

3 http://www.energy.gov/sites/prod/files/2014/05/f16/midsouth_metallurgical_casestudy.pdf

2.2.2.2 Energy Management System Certification

Establishing and certifying an energy management system that systematically tracks, measures, and continually improves energy performance can serve as the foundation for increasing the energy productivity of industrial businesses. For example, manufacturers may focus on the energy used in their processes, as 18 percent of the manufacturing sector's total electricity use is due to direct non-process uses such as facility lighting and space conditioning.[107] Participation in DOE's Superior Energy Performance program, which includes achieving certification under the International Organization for Standardization (ISO) 50001 standard and the American National Standards Institute (ANSI)/MS Standard 50021, yielded average energy savings of $500,000 per year, which is equivalent to a two-year payback period.[108] Additionally, program participants have noted that certification provided more awareness of and confidence in energy performance improvements, unlocking additional resources to fund further improvements.

2.2.2.3 Advanced Manufacturing

Advanced manufacturing is composed of "efficient, productive, highly integrated, tightly controlled processes across a spectrum of globally competitive U.S. manufacturers and suppliers."[109] Reinvigorating the U.S. industrial sector by fostering the growth of advanced manufacturing capabilities will also provide high-quality jobs, which can further improve the U.S. economy. However, in order to bring about the changes necessary for advanced manufacturing, private investment needs to be complemented by public investment.[110]

Information and communications technology (ICT), including sensors and controls that enable optimized energy consumption in plants and other buildings, can be important for enabling energy productivity gains for companies. These ICT-rich systems are also integral to improving product quality and communication technology that is now being deployed in the electric power sector, where it is often called the smart grid, where it is enabling better use of labor, materials, and capital inputs more efficiently, productively and cleanly, thus supporting economic efficiency and some forms of energy productivity improvements. Estimates of the market size for these technologies range from $43 billion in potential sales

107 "2010 MECS Survey Data," U.S. Energy Information Administration, accessed July 2015, http://www.eia.gov/consumption/manufacturing/data/2010/.

108 Peter Therkelsen, Ridah Sabouni, Aimee McKane, and Paul Scheihing, "Assessing the Costs and Benefits of the Superior Energy Performance Program" (paper presented at the ACEEE Summer Study on Energy Efficiency in Industry, Niagara Falls, NY, 2013), accessed July 2015, http://energy.gov/sites/prod/files/2014/07/f17/sep_costbenefits_paper13.pdf.

109 "Made in America: The Next-Generation of Innovation," National Institute of Standards and Technology Advanced Manufacturing National Program Office, accessed July 2015, http://www.manufacturing.gov/advanced_manufacturing.html.

110 President's Council of Advisors on Science and Technology, Report to the President on Ensuring American Leadership in Advanced Manufacturing (Washington, D.C.: The White House, 2011), accessed July 2015, https://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-advanced-manufacturing-june2011.pdf.

for building automation technologies by 2018[111] to over $120 billion for manufacturing automation sales by 2020.[112] While acknowledging cyber security concerns, attendees at the *Roadmap* regional dialogues noted the value of a standard protocol for new ICT products to allow interoperability between new entrants in this market. This QER also identified this.[113] The next section discusses strategies to develop new business models around enabling customers' energy productivity.

2.2.2.4 Innovative Products to Enable Energy Savings

The most significant opportunity for industry to help the U.S. meet its energy productivity goal is to develop, manufacture, and sell products and services that enable energy productivity improvements for their customers. Developing new business models around enabling energy productivity improvements for customers requires a better understanding of where energy is used along a product's value chain or life cycle. Tools like life-cycle assessment allow companies to uncover and target which portion of their products' life-cycles use the most energy, as well as other resources like water. Depending on the product, the energy required by industry to produce a product may only be a small fraction of its total life-cycle energy.

Providing products (e.g., lighter weight materials) that reduce this energy use not only provide value to the customer, but also reduce overall energy use and potentially create new markets. Continued advances in solid state lighting technology (SSL), such as fully controllable color tuning, have resulted in new and growing applications for highly efficient lighting that are geared specifically for productivity improvements. A sampling of these applications include spectrally controlled lighting to make people more alert or to facilitate sleep; spectrally optimized lighting for crop growth and livestock rearing; and spectrally tuned lighting for visual inspection processes or other enhanced visibility functions.[114]

111 ABI, "Commercial Building Automation Market to Top $43 billion by 2018, Says ABI Research." Press Release, April 30, 2013. http://www.reuters.com/article/2013/04/30/ny-abi-research-idUSnBw306552a+100+BSW20130430. As cited in Rogers et al. Intelligent Efficiency: Opportunities, Barriers, and Solutions, Report number E13J (Washington, D.C.: American Council for an Energy-Efficient Economy, 2013), accessed July 2015, http://aceee.org/sites/default/files/publications/researchreports/e13j.pdf.

112 Cullien, Matt, Machine to Machine Technologies: Unlocking the Potential of a $1 Trillion Industry. The Carbon War Room (2013). As cited in Rogers et al. Intelligent Efficiency: Opportunities, Barriers, and Solutions, Report number E13J (Washington, D.C.: American Council for an Energy-Efficient Economy, 2013), accessed July 2015, http://aceee.org/sites/default/files/publications/researchreports/e13j.pdf.

113 U.S. Department of Energy, Quadrennial Energy Review: Energy Transmission, Storage, and Distribution Infrastructure.

114 Norman Bardsley, Stephen Bland, Lisa Pattison, Morgan Pattison, Kelsey Stober, Fred Walsh, and Mary Yamada, *Solid-State Lighting Research and Development Multi-Year Program Plan* (Washington, D.C.: U.S. Department of Energy Office of Energy Efficiency and Renewable Energy, 2014), accessed July 2015, http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_mypp2014_web.pdf.

MANUFACTURING SUCCESS STORY

Legrand Employees Achieve 15.4 Percent Reduction over 26.2-Day "Energy Marathon"

Legrand is a manufacturing, global specialist in electrical and digital building infrastructures that effectively saved 588,540 kWh of electricity, enough energy to drive an electric car to the moon and back 3.3 times, in just 26.2 days during its "2014 Energy Marathon." These savings did not occur by chance, but rather through effectively leveraging previous efforts. First, Legrand became a Partner to the U.S. Department of Energy (DOE)'s Better Buildings, Better Plants Challenge, and committed to reducing its energy intensity by 20 percent from 2012 - 2022, on top of the 27 percent reduction the company achieved from 2009-2012. To tackle this new goal, Legrand conducted energy audits at manufacturing, warehouse, and office facilities, where the company identified energy efficiency opportunities with payback periods spanning immediate results to four years. Based on these audits, Legrand completed numerous technology upgrades and process changes across its facilities, and brainstormed new, innovative ways to engage its people.

In addition to DOE's resources, Legrand leveraged its own initiative, building on its "Power Down Day," a successful one-day energy efficiency event conducted in 2012, to create a 26.2-Day Energy Marathon. The Energy Marathon targeted longer-term energy behavior change, based on the idea that 'it takes 20 days to build a habit." Through the Energy Marathon individual sites established baseline electricity usage, and the site with the greatest percentage energy consumption reduction, compared to its baseline, was crowned the winner. A diverse steering committee and site leaders at each of the 18 participating locations drove energy savings at the facility level. For 26.2 days, site leaders read the facility's utility electric meter and reported the readings to a central event coordinator. Employees received daily tips for saving energy and event "standings" via emails, posters, and TV monitor displays – effectively driving competition through awareness and engagement.

As a result of employees' deliberate efforts to reduce energy consumption and some ready-to-implement technology changes at the facility level, the Energy Marathon reduced Legrand's electricity usage by

15.4 percent across the participating sites. In total, the company saved 588,540 kWh of electricity, preventing approximately 406 metric tons of CO_2 from entering the atmosphere. This amounted to a cost savings of $46,732 over the course of the 26.2-days. The winning facility achieved a 63.1 percent reduction vs. the baseline, while half of the participating sites exceeded a 20 percent reduction. Based on tracking data gathered since 2014, all sites are on goal to continuously reduce consumption based on Legrand's internal commitment and our Better Buildings, Better Plants Challenge pledge. Legrand has observed behavioral changes with more meetings and offices relying on natural light rather than overhead lighting. Part of the lasting impact is the awareness more of our employees have of our commitment to reduce our energy consumption. Since the majority of energy savings could be attributed to behavioral change and education, savings are expected to continue into the future in concurrence with repeating the competition and continuing energy education.

Looking beyond the event's tangible energy and cost savings, Legrand was able to bolster the visibility of its overall sustainability initiatives and highlight the importance of energy efficiency – both in terms of competiveness as a company and to the environment. The competition made saving energy fun and engaging for employees – something that will leave a lasting imprint on future sustainability events and campaigns. Legrand shares its experience in tools available for free download on its sustainability webpage.

A step-by-step guide to conducting your own Energy Marathon as well as other tools to help others save energy can be found at: http://www.legrand.us/aboutus/sustainability/high-performance-buildings/tools-and-downloads.

Reference to a non-federal entity does not constitute an endorsement on the part of DOE or the U.S. government.

2.3 Electric Utilities

Utilities—including investor-owned utilities, municipalities, and cooperatives—have significant potential to impact energy productivity through increased investments and reduced Btu consumption. In 2013, ratepayer-funded energy efficiency programs saved an estimated 23.16 billion kWh of electricity or 0.6 percent of U.S. retail electricity sales in 2013.[115] Such programs show the potential to increase energy productivity through reducing energy consumption. Although these energy efficiency impacts are important for increasing energy productivity, potentially even larger impacts could result from cost-effective investments. Investing in upgraded infrastructure and technologies, along with potential revenue increases from new product and services would induce economic growth. Through market transformation programs and other innovations, the electricity sector serves as a leader and test bed for enabling new technologies with products, services, and markets that contribute to energy productivity improvements. This section of the *Roadmap* takes a holistic look at the energy system and focuses on enhancing U.S. energy productivity through accelerated efforts to implement a smarter, modernized electric energy system.

Together with utilities, public utility commissions and public service commissions[116] can be drivers of electricity rate designs, distributed generation deployment, energy efficiency programs, and other strategies that increase energy productivity. For example, moving from traditional block electricity pricing to time-variant rates can be critical for the functioning of a smarter grid, integration of distributed energy resources (DER) like wind and solar, and adjusting to slower growth in electricity use. Actions by electric utilities contribute to all six energy productivity wedges:

Smart Energy Systems
Technologies for Buildings Energy Productivity
Financing for Buildings Energy Productivity
Water Infrastructure
Smart Manufacturing
Transportation

2.3.1 GRID INFRASTRUCTURE ENERGY PRODUCTIVITY

The term "smart grid" refers to modernization of the electricity delivery system through the deployment of information and communication technologies that can enable greater consumer interaction and choice, as well as monitor, protect,

115 Consortium for Energy Efficiency, *2014 State of the Efficiency Program Industry: Budgets, Expenditures, and Impacts* (Boston: Consortium for Energy Efficiency, 2015), accessed July 2015, http://library.cee1.org/sites/default/files/library/12193/CEE_2014_Annual_Industry_Report.pdf.

116 The name utility regulatory entities vary by state. The most common names are "public utility commission" and "public service commission."

and automatically optimize the operation of its interconnected elements. Smart grid applications offer great potential to increase the economic efficiency, and at times the energy efficiency, of U.S. power generation, transmission, and distribution while creating a more versatile, resilient, and reliable electric power grid.

Elements of the smart grid can allow for energy productivity benefits by enabling more energy efficiency in a number of areas, such as either at the end use or in the transmission and distribution of energy; reduced energy losses in the transmission and distribution system; and the ability to enable end-users more choice in their electricity consumption-resulting in reduced electricity use instead of new generation. For example, use of smart meters allows for the elimination of transportation energy used for manual meter reading as well as less transportation energy used for utility repair crews due to more precise detection and understanding of local electricity outage.

The smart grid enables more rapid adoption of distributed power generation and storage as well as the increased use of electric vehicles to become available to consumers more readily and easily available to consumers, without barriers or restrictions. Smart grid technologies also permit utilities to more actively manage voltage levels along their distribution circuits; when voltage levels can be optimized and reduced through conservation voltage practices, a considerable amount of energy savings can be realized without compromising reliability. Without the development of the smart grid, the full value of many individual technologies like electric vehicles, automated household devices, demand response, distributed resources such as residential solar, and larger-industrial distributed generation might not be fully realized.

Multiple regional dialogue participants at Accelerate Energy Productivity 2030 dialogues emphasized the transformative potential of a standard protocol for data to be communicated between smart grid devices. In the QER, the Administration recommended that DOE work with industry, the Institute of Electrical and Electronics Engineers, state officials, and other interested parties to identify additional efforts the Federal Government can take to better promote open standards that enhance connectivity and interoperability on the electric grid.[117] DOE efforts to support the development of voluntary standards in a number of areas continue.[118] These standards will allow devices created and operated by different companies to communicate, contributing to interoperability between grid technologies and increasing the value of smart grid technologies for all consumers. Standards are also important for the adoption of smart manufacturing, as described previously in the section on advanced manufacturing.

2.3.1.1 Reducing Economic Losses from Power Outages

Studies conducted by the Electric Power Research Institute (EPRI) show the annual cost of power disturbances to the

117 U.S. Department of Energy, *Quadrennial Energy Review: Energy Transmission, Storage, and Distribution Infrastructure.*

118 "Smart Buildings Equipment Initiative," U.S. Department of Energy Office of Energy Efficiency and Renewable Energy, accessed July 2015, http://energy.gov/eere/buildings/downloads/smart-buildings-equipment-initiative.

U.S. economy ranges between $119 and $188 billion per year.[119] The societal cost of a massive blackout is estimated to be in the order of approximately $10 billion per event.[120]

Smart grid technologies and infrastructure, such as automated feeder switches and smart meters, offer utilities the potential to provide more reliable energy, particularly during challenging emergency conditions, while managing their costs more effectively through real-time metrics with the smart grid. These benefits that reduce costs for utilities create spillover benefits of lower electricity prices, or of no price increases, to customers. Lower costs and decreased infrastructure requirements in turn enhance energy productivity, and reduced costs increase economic activity, which benefits society.

2.3.1.2 Effects of a Flexible Smart Grid on Energy Productivity

Transitioning the country's electric energy system to a smarter, modern system could result in direct energy productivity benefits through enhanced infrastructure investments, and more significantly, indirect benefits through enabling two-way flow of electricity and information. Managing the flow of information and electricity in two directions (traditionally electricity flows in one direction from large power generation stations through transmission and distribution grids to consumers) will enable the effective integration of electric vehicles, smart buildings and houses, distributed generation systems (such as rooftop solar systems), and energy storage devices with the electric grid and open opportunities for new markets where participants are rewarded for providing enhancements in efficiency and resiliency. The total economic value generated from a fully deployed smart grid is estimated as high as $130 billion annually.[121]

2.3.1.3 Improving Electric Generating Unit Heat Rates to Gain Energy Productivity

Results of a recent analysis indicate that approximately 4.6 percent of electricity is consumed in the production of electricity itself, making the electric sector the second largest electricity consuming industry in the United States.[122] The performance of a thermoelectric power plant can be measured by its heat rate—the efficiency of conversion from fuel energy input to electrical energy output. A generating unit with a lower heat rate can generate the same quantity of electricity than a unit with a higher heat rate while consuming less fuel to generate electricity. Lower fuel use per unit of electricity generated also reduces the corresponding emissions of pollutants.

119 David Lineweber and Shawn McNulty, *The Cost of Power Disturbances to Industrial & Digital Economy Companies* (Palo Alto, CA: Electric Power Research Institute, 2001), accessed July 2015, http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000003002000476.

120 119 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* (Washington, D.C.: U.S. Department of Energy, 2004), accessed July 2015, http://energy.gov/oe/downloads/blackout-2003-blackout-final-implementation-report.

121 Booth, Adrian, Mike Green, Humayun Tai, *U.S. Smart Grid Value at Stake: The $130 Billion Question* (McKinsey, 2010), accessed July 2015, http://www.mckinsey.com/~/media/McKinsey/dotcom/client_service/EPNG/PDFs/McK%20on%20smart%20grids/MoSG_130billionQuestion_VF.ashx.

122 C. Gellings, *Program on Technology Innovation: Electricity Use in the Electric Sector* (Palo Alto, CA: Electric Power Research Institute, 2001), accessed July 2015, http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001024651.

Modern coal-fueled power plants now achieve net conversion efficiencies of over 39 percent.[123] A variety of technologies show potential to increase efficiency of power plants. Examples include: the incorporation of adjustable-speed-drive mechanisms for plant motors; turbine upgrades for higher temperatures and pressures; advanced materials for expanded operational temperature ranges; condenser upgrades; replacement seals and firing system upgrades and diagnostics; and sensors and controls for optimizing performance.[124]

Over 80 percent of the U.S. electric power generation capacity comes from thermal turbines.[125] Consequently, improving heat rates at existing generators can lower fuel costs and help achieve compliance with environmental regulations. A heat rate improvement of 1 percent on a single 500-megawatt (MW) base-loaded coal-fired unit can save $700,000 per year in fuel costs alone, and it can reduce carbon dioxide (CO2) emissions by approximately 40,000 tons per year.[126]

2.3.1.4 Using Utilities to Improve Energy Productivity by Delivering End-Use Energy Efficiency

Utilities started delivering energy efficiency services in the 1980s, many of which are now standard, with regulators adopting policies to encourage and mandate them. Demand side energy efficiency driven by the 2015 Clean Power Plan is expected result in a 7 percent reduction in electricity demand by 2030.[127] A utility faces the following financial concerns adopting an energy efficiency program:

- Failure to recover program costs in a timely way has a direct impact on utility earnings.
- Reductions in sales due to energy efficiency can reduce utility financial margins.
- As a substitute for new supply-side resources, energy efficiency reduces the earnings that a utility would otherwise earn on the supply resource.[128]

123 The Coal Utilization Research Council and the Electric Power Research Institute, *The CURC-EPRI, Advanced Coal Technology Roadmap* (Washington, D.C.: Coal Utilization Research Council, 2015), accessed July 2015, http://www.coal.org/#!curc-epri-roadmap/c1r5g.

124 "Sources of Greenhouse Gas Emissions: Electricity Sector Emissions," U.S. Environmental Protection Agency, last modified May 7, 2015, http://www.epa.gov/climatechange/ghgemissions/sources/electricity.html; U.S. Environmental Protection Agency Sector Policies and Programs Division, *Available and Emerging Technologies for Reducing Greenhouse Gas Emissions from Coal-Fired Electric Generating Units* (Research Triangle Park, NC: U.S. Environmental Protection Agency, 2010), accessed July 2015, http://www.epa.gov/nsr/ghgdocs/electricgeneration.pdf; Eric Grol, Thomas J. Tarka, Steve Herron, Paul Myles, and Joseph Saracen, *Options for Improving the Efficiency of Existing Coal-Fired Power Plants*, NETL-2013/1611 (Pittsburgh: National Energy Technology Laboratory, 2014), accessed July 2015, http://www.netl.doe.gov/File%20Library/Research/Energy%20Analysis/Publications/Efficiency-Upgrade-Final-Report.pdf.

125 U.S. Energy Information Administration, *Electric Power Annual 2007*, EIA-0348(2007) (Washington, D.C.: U.S. Department of Energy, 2009), accessed July 2015, http://www.eia.gov/electricity/annual/archive/03482007.pdf.

126 S. Korellis, Range and Applicability of Heat Rate Improvements (Palo Alto, CA: Electric Power Research Institute, 2014), accessed July 2015, http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000003002003457&Mode=download.

127 "Fact Sheet: Energy Efficiency in the Clean Power Plan", United States Environmental Protection Agency, last updated August 20, 2015, http://www2.epa.gov/cleanpowerplan/fact-sheet-energy-efficiency-clean-power-plan.

128 National Action Plan for Energy Efficiency, *Aligning Utility Incentives with Investment in Energy Efficiency* (Washington, D.C.: U.S. Environmental Protection Agency, 2007), 2-1, accessed July 2015, http://www.epa.gov/cleanenergy/documents/suca/incentives.pdf.

These financial concerns can be effectively addressed through mechanisms such as decoupling and lost revenue adjustment mechanisms. These concerns are part of the broader discussion of evolving utility business models. The QER noted the impact and implications of new technologies, including those that facilitate increased energy productivity, including end-use efficiency on particularly the distribution part of utilities: "At high penetrations, many of these new technologies could challenge current distribution systems and the functional integrity of the current electricity system. New investments and changes to existing regulatory, policy, financial, and business structures may be necessary to fully realize the benefits of these technologies. Regulators and policymakers will need to address the operational issues associated with new technologies, as well as longer-term concerns, such as how the loss of revenue (and a utility's ability to cover fixed costs) and load resulting from increasing numbers of installations could challenge utilities' financial health under current business models."[129]

2.3.2 PROMOTING ENERGY PRODUCTIVITY IN RATE DESIGN

Since the year 2000, as noted in the QER, "many states have adopted policies to support utility investments in energy efficiency."[130] There are at least three different regulatory approaches being used: decoupling, lost revenue adjustment mechanism, and a broad set of methods to allow performance incentives. These efforts create a regulatory model that rewards utility shareholders for effective energy efficiency efforts that lower ratepayer bills in the long term. These three general categories of regulatory policy and rate-setting changes serve to address negative financial effects on utilities. Thus, they do modify the distribution utility's business model by making it at least neutral and in some cases, providing a financial return, for delivering energy efficiency to their customers, which represents a prime method of improving energy productivity.

The last decade and a half shows substantial growth in utility-delivered energy efficiency, whether through state's adopting mandates known as energy efficiency portfolio standards or allowing changes to distribution utility business models through the three regulatory policy and rate-setting categories noted earlier. Utility-delivered energy efficiency is projected to grow aggressively over the next decade through a combination of all these measures. The QER found that, "Appropriate valuation of new services and technologies and energy efficiency can provide options for the utility business model," but that "Different business models and utility structures rule out 'one-size-fits-all' solutions to challenges."[131]

While no single approach will be effective in meeting the needs of electricity customers in every part of the United States, information about the economic value of new grid services can provide clear signals to the range of entities that

129 U.S. Department of Energy, *Quadrennial Energy Review: Energy Transmission, Storage*, and Distribution Infrastructure, 3-17.

130 U.S. Department of Energy, *Quadrennial Energy Review: Energy Transmission, Storage, and Distribution Infrastructure*, 3-20.

131 U.S. Department of Energy, *Transforming U.S. Energy Infrastructures in a Time of Rapid Change: The First Installment of the Quadrennial Energy Review, Summary for Policymakers* (Washington, D.C.: U.S. Department of Energy, 2015), S-15, accessed July 2015, http://energy.gov/epsa/downloads/quadrennial-energy-review-full-report.

finance, plan, and operate the grid. Policies to provide consumers with affordable and reliable electricity must take into account the variety of business models for investing, owning, and operating electric grid infrastructure. Doing so could allow actors to make investments that deliver electric services at lowest cost. As new technologies develop, electric markets regulated by a patchwork of state and local jurisdictions may be hard-pressed to perform timely cost-benefit analysis to determine the value of new offerings to their ratepayers.

The federal government can use its convening power to gather information from a broad range of stakeholders, and it can provide tools and resources for understanding the value of services provided by new and innovative technologies. Such resources would allow policymakers to make informed decisions about how best to leverage new technologies in their communities to support growing energy productivity.[132] For example, Michigan passed the Clean, Renewable, and Efficient Energy Act in 2008. This act allowed certain utilities to decouple their rates thus making the utilities financially neutral to negative financials resulting from increased ratepayer energy efficiency; the act also required electric and natural gas utilities to help consumers increase the energy efficiency of their homes and businesses. These programs are expected to result in over $700 million in value to customers, and in 2011, the program achieved enough savings to power 1.5 million homes and heat 40,000 homes for a year.[133]

More sophisticated rate structures have the potential to (1) unleash additional new investments and innovations in distributed energy resources and (2) direct the deployment of these resources in a manner that maximizes the benefits to the system as a whole. With advanced rate structures, utility earnings could depend more on creating value for customers and achieving policy objectives. Freed from the business model that made new infrastructure a precondition for new profits, utilities could find earning opportunities in enhanced performance and in transactional revenues. With utilities focused on delivering value to customers, and not just on energy, productivity could be increased even while ratepayers consume less energy.

132 U.S. Department of Energy, *Transforming U.S. Energy Infrastructures in a Time of Rapid Change: The First Installment of the Quadrennial Energy Review, Summary for Policymakers.*

133 John D. Quackenbush, Greg R. White, and Sally A. Talberg, Report on the *Implementation of P.A. 295 Utility Energy Optimization Programs* (Lansing: Michigan Public Service Commission, 2015), accessed July 2015, http://www.michigan.gov/documents/mpsc/PA_295_Renewable_Energy_481423_7.pdf. Sept. 2013.

UTILITY SUCCESS STORY

Gulf Power's "Energy Select" Program Places Energy Efficiency in Consumers' Hands

Gulf Power, a subsidiary of Southern Company, is an investor-owned electric utility that serves more than 435,000 residential customers in northwest Florida. As are many investor-owned utilities, electric utilities are often mandated by local, state, and federal regulators to increase efficiency and sustainability measures while continuing to meet ever-increasing demand for power. Demand-side management programs, in the form of a reliably controlled demand reduction during critical-peak periods, have become a popular tool to meet these demands. However, the challenge for utilities with this type of demand-side management program is to obtain the amount of load control and verification they require while sufficiently incentivizing customers to participate.

As early as 1989, Gulf Power began to develop this solution to meet this challenge with the help of the Florida Public Service Commission. After years of development, Gulf Power officially launched Energy Select in 2000 as part of its broader EarthCents program and quickly gained attention as the first utility to provide a fully automated critical peak pricing program in the United States.

Energy Select is a demand-side management program that employs price-responsive programmable thermostats and timers for water heater and pool pumps. And, it uses a "residential service variable pricing" rate that features four different prices based on the time of day, the day of week, and the season that reflect the actual cost of producing electricity during those periods. With this program, Gulf Power found a way to combine dynamic pricing with a consumer-controlled management system to incentivize behavioral change in customers that avoids using excess electricity based on daily schedules, comfort levels, or market patterns—effectively reducing peak load levels and enabling reliable electric service.

On average, the program helps over 15,000 customers save up to 15 percent annually on electricity purchases. The benefits of Energy Select have also translated to a boost in overall customer satisfaction with the electric utility service itself, resulting in customer satisfaction rates as high as 95 percent and allowing program participants to take advantage of lower electricity prices 87 percent of the time.

Reference to a non-federal entity does not constitute an endorsement on the part of DOE or the U.S. government.

For more information, see www.gulfpower.com/residential/earthcents/energy-select/.

2.4 Water Utilities

In a 2002 report, EPRI estimated that 4 percent of the nation's electricity use goes towards moving and treating water and wastewater.[134] Providing the same water services while consuming significantly less energy offers a significant contribution to meeting the productivity goal. Actions taken by public and private water utilities contribute to two energy productivity wedges:

Smart Energy Systems
Water Infrastructure

Energy consumption by public drinking water and wastewater utilities represents a substantial cost for both public and private water systems. The cost of energy for municipal water systems can be extraordinarily burdensome for localities, accounting for as much as 25-40 percent of their energy bills.[135] Local governments can reduce energy use at water and wastewater facilities through energy efficiency programs, waste to energy technologies, measures that promote water conservation, investments that prevent water loss and reduce storm water.[136] For example, the Missouri Water Utilities Partnership, a public-private partnership, identified and implemented strategies projected to reduce water-related electricity use by more than 8 million kWh per year, which is enough energy to power over 730 homes for a year.[137]

Infrastructure is also pivotal to ensuring water and energy savings. Nationwide, aging, leaking infrastructure results in significant energy waste, with national estimates of leaks and other losses as high as 20-25 percent.[138] This indirectly translates to energy waste from additional required treatment and pumping. The situation can be addressed through advanced leak monitoring, advanced pressure management, and accelerated replacement of buried infrastructure.

134 R. Goldstein and W. Smith, *Water & Sustainability (Volume 4): U.S. Electricity Consumption for Water Supply & Treatment—The Next Half Century* (Palo Alto, CA: Electric Power Research Institute, 2002), accessed July 2015, http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001006787.

135 Malcolm Pirne, *Statewide Assessment of Energy Use by the Municipal Water and Wastewater Sector* (Albany: New York State Energy Research and Development Authority, 2008).

136 Design features that reduce stormwater include permeable pavements, green roofs, and rain gardens. See "Stormwater Management Best Practices," U.S. Environmental Protection Agency, last modified November 5, 2012, http://www.epa.gov/oaintrnt/stormwater/best_practices.htm.

137 U.S. Environmental Protection Agency, *Energy Efficiency in Water and Wastewater Facilities: A Guide to Developing and Implementing Greenhouse Gas Reduction Programs* (Washington, D.C.: U.S. Environmental Protection Agency, 2013), accessed July 2015, http://www.epa.gov/statelocalclimate/documents/pdf/wastewater-guide.pdf.

138 Black & Veatch, "Buried Infrastructure", accessed July 2015, http://bv.com/reports/2013/2013-water-utility-report/buried-infrastructure; Ashley Halsey III, "Billions needed to upgrade America's leaky water infrastructure," Washington Post, January 2, 2012, http://www.washingtonpost.com/local/billions-needed-to-upgrade-americas-leaky-water-infrastructure/2011/12/22/gIQAdsE0WP_story.html.

At drinking water plants, the largest energy use (about 80 percent) is to operate motors for pumping.[139] There is a recognized potential to improve the efficiency of water utility pumping processes by as much as 30 percent.[140] Water utilities like American Water are implementing pump efficiency programs. Improving the efficiency of motors used in water pumps from the current average of 55 percent to 80 percent would save 10 million MWh per year, the equivalent of lighting a city the size of Chicago for over two years.[141]

There is also significant opportunity for improving the wastewater aeration process, which consumes 30-50 percent of all energy in wastewater treatment plants. This can be accomplished through the use of more efficient aeration or the use of anaerobic processes that do not require aeration. Nutrient removal is also energy-intensive. Thus, more efficient microbial processes to remove nitrogen and phosphorus from wastewater, can also significantly reduce energy consumption.[142]

Waste streams from wastewater treatment plants provide a valuable energy source that can displace primary energy consumption. There is enough embedded energy in the waste streams of many wastewater treatment plants to achieve net zero or even net positive energy consumption. For example, many plants are currently using methane digesters with CHP to produce biogas and/or electricity from their waste streams and reduce the amount of electricity they draw from the grid.

Beyond improving the efficiency with which utilities move and treat water, energy savings can be realized by more efficient end-use of water. Indeed, "water-related energy consumption was 12.6 percent of national primary energy consumption in 2010."[143] Reducing this end user water consumption can thus have an indirect and significant impact on energy consumption. Outdoor watering practices can also indirectly waste energy. Technologies such as drip irrigation and low-flow plumbing fixtures can improve water use efficiency, which indirectly translates into energy savings.

2.4.1 RATE REFORM

Water utilities have the same financial conundrum as energy utilities do when it comes to incenting water and energy efficiency. Concerns over cost recovery and losses of sales limit the financial viability of energy and water efficiency programs. Under most rate structures, there are no water efficiency incentives, as recovery of fixed costs is dependent

139 Claudia Copeland, Energy-Water Nexus: The Water Sector's Energy Use (Washington, D.C.: U.S. Congressional Research Service, 2014), accessed August 2015, http://fas.org/sgp/crs/misc/R43200.pdf.

140 EPRI and WRF, Electricity Use and Management in the Municipal Water Supply and Wastewater Industries, 2013.

141 American Water, *The Water-Energy Nexus: EPA's Clean Power Plan* (Voorhees, NJ: American Water, 2014), accessed July 2015, http://www.amwater.com/files/WaterEnergy%20EPA%20Clean%20Power%20Plan%20v2.pdf.

142 U.S. Department of Energy, The Water-Energy Nexus: Challenges and Opportunities (Washington, D.C.: U.S. Department of Energy, 2015), accessed August 2015, http://www.energy.gov/sites/prod/files/2014/07/f17/Water%20Energy%20Nexus%20Full%20Report%20July%202014.pdf.

143 Claudia Copeland, Energy-Water Nexus: The Water Sector's Energy Use (Washington, D.C.: U.S. Congressional Research Service, 2014), accessed August 2015, http://fas.org/sgp/crs/misc/R43200.pdf.

on volume of water sold. This clashes with an ever-increasing need to be more resource efficient given the realities of water scarcity, stressed water systems and droughts, as well as rising energy costs.

Decoupling, and other investment recovery reforms, is vital to ensuring that water and wastewater utilities have the incentives and the tools to reduce water and energy consumption. By separating volumes of water sold, from rates charged, decoupling enables water companies to help customers use less water and therefore save more energy. Likewise, investment recovery reform can help accelerate the replacement of aging leaking water mains, thus reducing energy waste. These regulatory reforms will ultimately minimize energy costs and reduce carbon emissions related to water and wastewater services.

WATER UTILITY PUMP EFFICIENCY ENERGY SAVINGS SUCCESS STORY

American Water

Much of American Water's energy efficiency work concentrates on improving pump efficiencies through refurbishment and/or replacement. A total of 52 pump refurbishments/replacements were completed from 2011-2013, at a cost of approximately $6 million, and provided an estimated energy reduction of 8 million kWh/year.

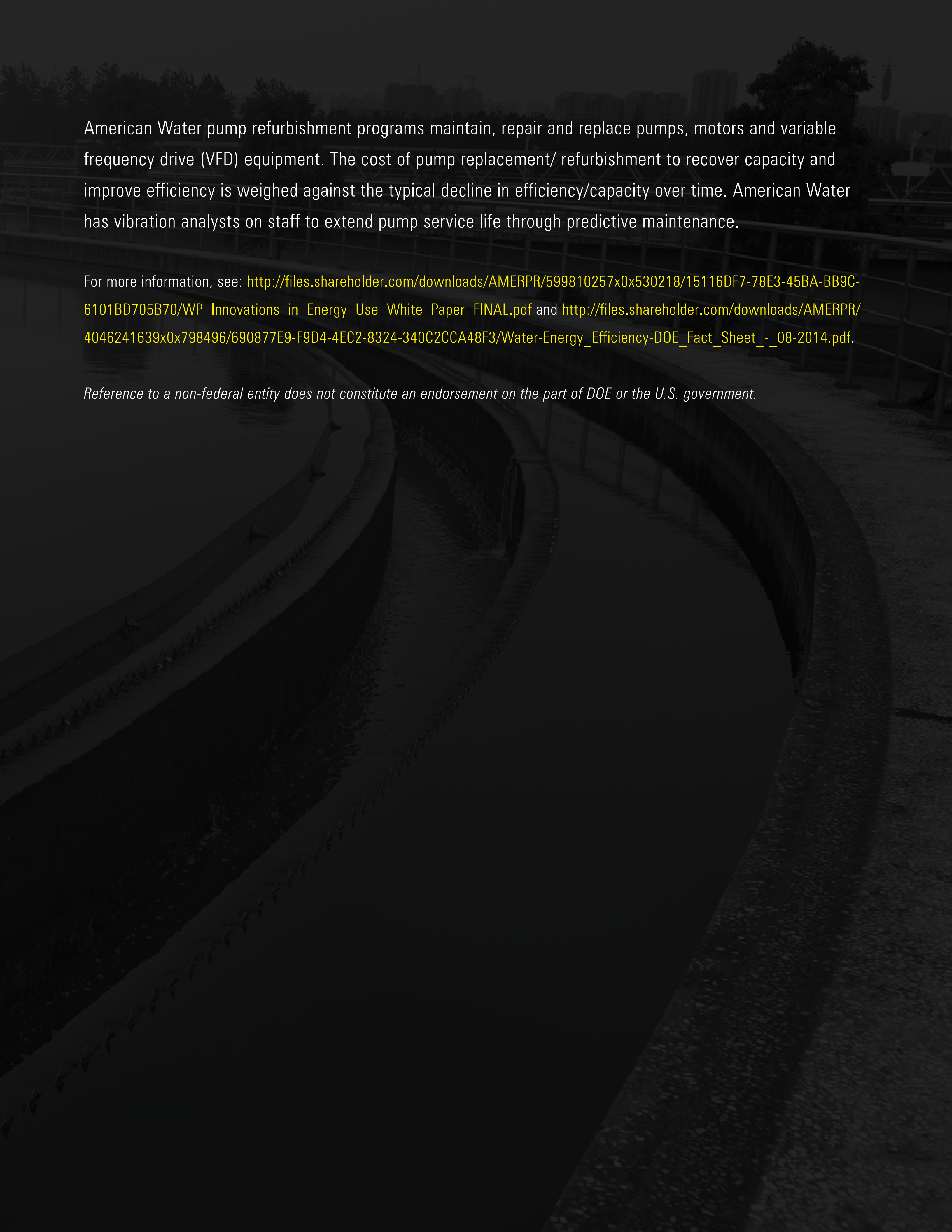
American Water manages its energy program using an Energy Usage Index (EUI) metric derived by dividing total power usage in megawatt-hours (MWh) by the volume of water sold in million gallons (MG) during a discrete period of time. The current baseline for this metric is 2.89 based on 2011-2013 operating data. The EUI data is collected and monitored to serve as a barometer for the condition of the pump fleet. Specifically, as pumps age, they wear and become less hydraulically efficient, which translates to more power required to deliver the same volume of water. American Water's pumping inventory is comprised of about 7,500 centrifugal pumping units. Of this, it is estimated that about 20 percent of the largest pumps consume 80 percent of American Water's total power usage.

American Water also conducts wire-to-water efficiency testing to monitor the efficiency of pumps and motors. We deliver over a billion gallons of water each day, so even a small increase in efficiency can yield energy savings. Research has shown that the average "wire-to-water" efficiency of existing "in-field" water utility pumps is about 60 percent. New installations are designed to achieve efficiencies of between 76 percent and 82 percent. American Water sees this as a major opportunity to decrease its carbon footprint. By replacing or refurbishing older pumps, studies have shown that pump efficiencies can be restored to their original efficiencies of 76-82 percent. This efficiency gain may yield energy savings of 10-20 percent at facilities that have completed pump improvements.

American Water pump refurbishment programs maintain, repair and replace pumps, motors and variable frequency drive (VFD) equipment. The cost of pump replacement/ refurbishment to recover capacity and improve efficiency is weighed against the typical decline in efficiency/capacity over time. American Water has vibration analysts on staff to extend pump service life through predictive maintenance.

For more information, see: http://files.shareholder.com/downloads/AMERPR/599810257x0x530218/15116DF7-78E3-45BA-BB9C-6101BD705B70/WP_Innovations_in_Energy_Use_White_Paper_FINAL.pdf and http://files.shareholder.com/downloads/AMERPR/4046241639x0x798496/690877E9-F9D4-4EC2-8324-340C2CCA48F3/Water-Energy_Efficiency-DOE_Fact_Sheet_-_08-2014.pdf.

Reference to a non-federal entity does not constitute an endorsement on the part of DOE or the U.S. government.



2.5 Higher Education Institutions

Increasing energy productivity across all sectors requires a suitably prepared workforce. And, cross-disciplinary coursework is needed to support the needs of emerging areas of energy productivity, such as the Smart Grid, advanced manufacturing, and building energy systems. Strategies in this section were developed using feedback from the regional dialogues, the roundtable discussions, and goal endorsers.Actions taken by higher education institutions contribute to four energy productivity wedges:

Smart Energy Systems
Technologies for Buildings Energy Productivity
Smart Manufacturing
Transportation

2.5.1 WORKFORCE TRAINING

Additional energy productivity gains can come from efficiently operating and maintaining buildings. Building operators can realize annual energy bill savings of 5-20 percent by implementing operations and maintenance (O&M) best practices, including operating equipment only when needed, performing preventative O&M, and tracking performance.[144]

The Building Operator Certification (BOC®) is a training and certification program that provides building operators with the skills and knowledge to implement the types of O&M best practices that can help maximize the efficiency of existing and future buildings. BOC certification is offered by several Regional Energy Efficiency Organizations as well as community and technical colleges in the Northeast, Mid-Atlantic, Southeast, and the West.[145] Annual energy and utility bill savings specific to companies with BOC-certified operators are estimated to be 170,000 kWh per year and $12,000 per year, respectively, which is enough electricity to power nearly 100 refrigerators for a year.[146]

While higher education can lead to certain careers that will help accelerate energy productivity, many job opportunities exist in the energy and advanced manufacturing fields that do not require four-year degrees. Technical and community

144 "Operations and maintenance reports," Energy Star, accessed July 2015, https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/save-energy/comprehensive-approach/operations-and; Portland Energy Conservation, Inc., *Fifteen O&M Best Practices for Energy Efficient Buildings* (Washington, D.C.: U.S. Department of Energy and U.S. Environmental Protection Agency, 1999), accessed July 2015, https://www.energystar.gov/sites/default/files/buildings/tools/Fifteen%20O%26M%20Best%20Practices.pdf.

145 "Training Locations & Schedules," Building Operator Certification, last updated August 11, 2015, http://www.theboc.info/h-training-locations.html.

146 "Value & Benefits of BOC," Building Operator Certification, last updated August 24, 2010, http://www.theboc.info/w-value-benefits.html.

colleges can provide the skills and knowledge for the next generation of energy and manufacturing industry employees. Mississippi's Get on the Grid[147] and Ohio's Advanced Manufacturing Industry Partnership[148] are examples of the types of workforce training programs that can be leveraged to increase energy productivity.

The workforce of an advanced energy economy needs to not only have the skills to operate today's technologies but needs to have the skills and support to make further innovations. Partnerships with industry and businesses, such as the DOE's Building University Innovators and Leadership Development (BUILD) program, can further help support educating and training future innovators in energy productivity.

2.5.2 ACCELERATING ENERGY PRODUCTIVITY FROM THE LAB TO THE REAL WORLD

Colleges and universities are instrumental partners for carrying out federally funded R&D. While the growth of federal R&D funding has largely stagnated since 2004, universities are contributing a larger share of funding and they were responsible for over $12 billion (FY 2014 dollars) of the $64 billion (FY 2014 dollars) total university science and engineering R&D funding in 2012.[149]

Universities can play an important role in transferring innovative technologies to businesses. Universities offer unique opportunities to act as real world testbeds for technologies and practices that increase energy productivity. For instance, the Future Renewable Electric Energy Delivery and Management (FREEDM) System Center, directed by North Carolina State University, supports fundamental research for breakthrough energy storage and power semiconductor technologies as well as partnerships with businesses to facilitate the transition of research into commercially viable products.[150] Several technologies developed by FREEDM have received commercial licenses.[151]

147 "Get on the Grid," Mississippi Energy Institute, accessed July 2015, http://www.getonthegridms.com/.

148 "Advanced Manufacturing Industry Partnership," Partners for a Competitive Workforce, accessed July 2015, http://www.competitiveworkforce.com/Advanced-Manufacturing.html.

149 "R&D at Colleges and Universities,"American Association for the Advancement of Science, last updated August 14, 2015, http://www.aaas.org/page/rd-colleges-and-universities.

150 "About: Center Goals," NSF FREEDM Systems Center, North Carolina State University, accessed July 2015, http://www.freedm.ncsu.edu/index.php?s=1&p=7.

151 NSF FREEDM Systems Center, "FREEDM Marks Progress in Innovation, Economic Impact," news release, undated, http://www.freedm.ncsu.edu/index.php?s=2&t=news&p=184.

HIGHER EDUCATION INSTITUTIONS SUCCESS STORY

North Carolina State University Creates Electricity at Renovated Utility Plant

When North Carolina State University (NC State) faced the challenge of deferred maintenance on equipment in its central utility plants with no available capital funding, university leadership used a $61 million energy performance contract to finance the addition of modern CHP technology. The new CHP facility enables NC State to generate some of its own electricity, and the money the university saves in avoided utility-provided energy costs pays back the loan that financed the CHP technology and boiler replacements.

Founded in 1887, NC State University has a campus community of more than 40,000 students, faculty, and staff in Raleigh. With an annual utility budget of approximately $32 million, the university provides electricity, steam, chilled water, and domestic water to more than 15 million square feet of campus building space.

As do many higher education institutions, NC State faces the challenge of funding vital maintenance on aging buildings and infrastructure, such as utility systems. As several crucial campus boilers exceeded the end of useful life, the university had no capital funding available for the replacement of this equipment. The university also faced challenges related to air quality compliance, as the old boilers relied on #6 fuel oil. NC State needed funding for new, cleaner-burning natural gas boilers and related equipment.

The university turned to an energy performance contract-funding model to finance replacement of critical boilers. A performance contract allows an owner to pay for a renovation through the energy savings generated by efficiency improvements. Using a performance contract, NC State was able to incorporate CHP technology on campus. The $61 million performance contract, financed over 17 years, also allowed the addition of two natural gas fired 5.5-MW combustion gas turbine generators and two 50,000-pound-per-hour heat recovery steam generators to the existing Cates Utility Plant in 2012. The contract also financed replacement of aging boilers, utility interconnects, and auxiliary equipment at the nearby Yarbrough Steam Plant. CHP allows NC State to create its own electricity and converts “waste heat,” which would be unused in traditional power plants, into energy. By using this campus-generated energy, NC State buys less energy from local utility companies.

In addition to more reliable steam production and better air quality compliance, the CHP facility reduced energy use and carbon emissions while expanding the university's resiliency and capacity for future growth. In the CHP plant's first two years, more than $10 million of energy costs were avoided and emissions associated with utility production on the university's central and north campuses dropped 24 percent. Educational benefits also resulted. Many NC State engineering students tour the facility to see CHP technology in action. The savings associated with the project have prompted the university to consider adding more CHP capacity at its nearby Centennial Campus utility plant.

An animation of CHP technology on campus is available at sustainability.ncsu.edu/chp/NCSU Case Study.

Reference to a non-federal entity does not constitute an endorsement on the part of DOE or the U.S. government.

2.6 Households

Households account for a large portion of U.S. energy use, and household purchases of goods and services drive much of the U.S. economy. Residential buildings and personal transportation together represented roughly 40 percent of primary energy use in 2014.[152] Household energy use is even more significant when the energy required to produce consumer goods and services, so called "embodied energy," is considered. Also, household expenditures constitute a large portion of overall economic activity.

The concept of household energy productivity may not be as intuitive as it is for a business, but the fundamental aspects are the same. Households can choose to purchase goods and services that allow more productive use of energy in providing services such as transportation, indoor comfort and illumination, and entertainment. However, these purchasing decisions can be clouded by market failures such as incomplete information and split incentives whose remedies may require government policies. Strategies in this section were developed using feedback from the regional dialogues, the roundtable discussions, and goal endorsers. Actions taken by households contribute to two energy productivity wedges:

Technologies for Buildings Energy Productivity
Transportation

2.6.1 ENERGY PRODUCTIVITY AT HOME

Households can reap energy productivity benefits by participating in the *Roadmap* strategies identified for government and businesses. The goal of many of these strategies is to enable households to choose the most energy-efficient products, which translates into savings on energy bills. Purchasing more energy-efficient appliances, in addition to taking other energy efficiency measures such as installing insulation, could reduce household electricity and natural gas use by 34 percent and 35 percent respectively and could result in utility bill savings of $83 billion (in 2007 dollars) by 2030.[153]

152 The sum of residential buildings, light-duty vehicles, bus transportation, passenger rail, and air primary energy use is from U.S. Energy Information Administration, *Annual Energy Outlook 2015 with Projections to 2040* (Washington, D.C.: U.S. Energy Information Administration, 2015), accessed July 2015, http://www.eia.gov/forecasts/aeo/.

153 America's Energy Future Energy Efficiency Technologies Subcommittee, National Academy of Sciences, National Academy of Engineering, and National Research Council, *Real Prospects for Energy Efficiency in the United States* (Washington, D.C.: National Academies Press, 2010).

Many strategies aim to improve the amount and quality of energy information available to households in order to allow consumers to make better-informed decisions on the use of energy in their home and to encourage early adoption of more energy-efficient products. Information-based strategies have been found to reduce electricity use by 7 percent.[154] The federal government provides a suite of websites that address the many facets of household energy efficiency, including homes (http://www.energysaver/.gov) and transportation (www.fueleconomy.gov). Utilities and companies are offering households greater visibility into home energy use. For example, they are providing homeowners and others the option to compare energy use with that of that their neighbors and similar houses.[155] A collaboration of the University of Florida and the International Carbon Bank and Exchange took energy data visibility a step further and created an online platform where anyone can view electricity use and building characteristics of homes in Gainesville, Florida.[156] Initiatives like DOE's Green Button initiative allow households to access their electricity meter data in a standardized format.[157] Green Button also allows users to automatically connect their data to services that will evaluate opportunities to reduce their electric bills.

As many as 37 states and the District of Columbia incentivize the use of EVs.[158] The Federal government and certain states, including California, Colorado, Connecticut, Louisiana, and Maryland, offer rebates or tax credits for purchases of EVs.

154 Magali A. Delmas, Miriam Fischlein, and Omar I. Asensio, "Information strategies and energy conservation behavior: A meta-analysis of experimental studies from 1975 to 2012," *Energy Policy* 61 (2013): 729–739, accessed July 2015, http://dx.doi.org/10.1016/j.enpol.2013.05.109.

155 Research points to the need at some minimal frequency to provide households with reports on their energy use in order for energy savings to persist. See Hunt Allcott and Todd Rogers, "The Short-Run and Long-Run Effects of Behavioral Interventions: Experimental Evidence from Energy Conservation," *American Economic Review* 104:10 (2014): 3003–3037, accessed July 2015, http://dx.doi.org/10.1257/aer.104.10.3003.

156 "Gainesville Green: Your Home Energy Tracking System," Gainesville Green, accessed July 2015, http://www.gainesville-green.com.

157 "Helping You Find and Use Your Energy Data," Green Button Data, accessed July 2015, http://www.greenbuttondata.org/.

158 Kristy Hartman, "State Efforts Promote Hybrid and Electric Vehicles," National Conference of State Legislators, June 29, 2015, http://www.ncsl.org/research/energy/state-electric-vehicle-incentives-state-chart.aspx.

HOUSEHOLDS SUCCESS STORY

Opower Partners with the Nation's Utilities to Drive Energy Savings through Customer Engagement and Applied Behavioral Science

For utilities around the world, keeping the lights on is no longer enough. The utility industry is now in a time of significant change, and utilities are placing technology at the center of their strategies to navigate the path to a successful future. Today's utility customer only spends about 9 minutes thinking about their energy consumption each year, so utilities are challenged to make every moment of customer contact matter.

By combining data management, analytics, and behavioral science, Opower's customer engagement platform positions utilities as energy advisors to the customers they serve. Opower's technology platform analyzes more than 300 billion meter reads to deliver its services, and created enough energy savings to power all the homes in a city of 1 million people for a year. Opower has facilitated savings over 8 terawatt-hours of electricity to date, which equates to over $1 billion saved by customers on their monthly energy bills, affecting more than 50 million households today.

EXAMPLE: OPOWER'S CUSTOMER ENGAGEMENT PLATFORM

The utility National Grid Massachusetts (National Grid MA) needed to meet a strict state energy efficiency mandate, and traditional solutions like retrofitting and appliance rebates incurred high costs with limited return on investment. Furthermore, National Grid MA wanted to elevate its levels of customer engagement and satisfaction.

Opower's software gave National Grid MA the applications it needed to transform their customer experience. Built specifically for the energy industry, Opower's customer engagement platform met National Grid MA's need by combining the efficiency of the cloud with insightful analytics, applied behavioral science, and great design.

EXAMPLE: OPOWER'S HOME ENERGY REPORT

National Grid MA deployed Opower's Home Energy Report (HER) program, a tailored energy usage evaluation that offers personalized energy-saving tips, anonymously compares customers' energy usage with that of neighbors with similar home size and demographics, and suggests lifestyle changes to reduce their energy consumption. HERs are proven to reduce residential consumption by 1.5-3 percent across a utility's territory, and furthermore have shown to increase positive customer sentiment towards utilities.

Several years after deploying Opower's energy efficiency program in Massachusetts, National Grid MA announced that customers saved over $70 million on their energy bills. Working with Opower, National Grid MA helped customers reduce their electricity usage by 300 million kilowatt hours (kWh) and gas usage by 18 million therms – the equivalent of eliminating more than 300,000 metric tons of carbon dioxide from the environment.

Reference to a non-federal entity does not constitute an endorsement on the part of DOE or the U.S. government.