A brief from THE PEW CHARITABLE TRUSTS | Feb 2016

Distributed Generation: Cleaner, Cheaper, Stronger
Energy Storage for the Evolving Power System

Overview

Distributed energy resources allow electricity to be generated closer to where it is used, protecting businesses and institutions from unexpected outages caused by natural disasters and other disruptions. The U.S. national laboratories as well as public-private partnerships provide financial resources and access to research facilities to foster innovations to modernize the power sector from a 100-year-old centralized system to one that incorporates disparate clean technologies such as microgrids, batteries, and energy smart tools. These investments and the resulting new products and capabilities decrease costs, improve grid reliability, reduce emissions, and offer consumers more options.

Energy storage technologies encourage adoption of renewable energy by addressing generation variation resulting from weather conditions. They also aid local utilities by providing an array of grid-balancing services, such as peak shifting—shifting grid usage by consumers from periods of high demand to less intensive times—and backup power supplies. These characteristics support a cleaner and more reliable electric system and present an important market opportunity for the clean energy economy.

Energy storage makes the system more efficient

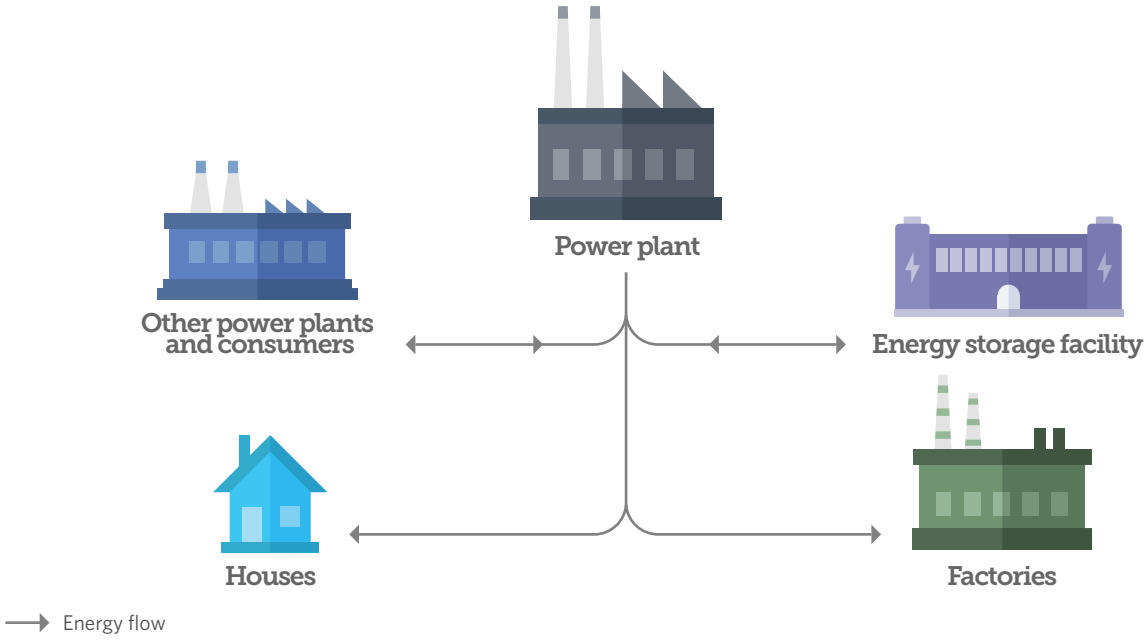
Although demand for electricity often varies by the minute, changing the nation's generating capacity is a slow process. Energy storage technologies enable utilities to better match fixed capacity with variable demand and offer more reliable, secure, and affordable service.

Batteries are an emerging storage option that can improve the central grid's reliability and increase the use of clean and efficient power sources. For example, when the wind is blowing but demand is low, batteries capture energy from spinning wind turbines and save it for later use. Energy storage can similarly enhance the usability of solar and other intermittent renewable resources. Batteries also offer environmental benefits because they have no emissions.[1] Further, energy storage supports local utilities by enabling peak shifting, providing backup power and ancillary grid services,[2] and potentially reducing the need for additional fossil-fueled generation sources.

Figure 1

Energy Storage Strengthens Distributed Grid Components

Sample system design and interconnection



Energy Storage Technologies

A variety of innovative technologies are capable of capturing energy as it is produced and storing it until it is needed. Among the leading approaches are:

- Batteries. These devices convert stored chemical energy into electrical energy. A variety of types are available, including lithium-ion, sodium sulfur, and lead acid, and more chemical alternatives are being developed.*
- Flywheels. This mechanical device converts electricity into kinetic energy by constantly spinning a small rotor. When needed, energy is released back to the grid through a turbinelike device.†
- Electrochemical capacitors. These systems store electrical charge in solid materials rather than converting charges to another form through chemical or phase changes, as occurs in batteries.‡
- Superconducting magnetic energy storage. These units employ superconducting coils, power conditioning systems, and cooling mechanisms to inductively store energy.§

Continued on next page

* Massachusetts Institute of Technology School of Engineering, "How Does a Battery Work?" http://engineering.mit.edu/ask/how-does-battery-work; U.S. Department of Energy, "Grid Energy Storage," December 2013, http://energy.gov/sites/prod/files/2014/09/f18/Grid%20Energy%20Storage%20December%202013.pdf.

† U.S. Department of Energy, "Grid Energy Storage"; Energy Storage Association, "Flywheels," http://energystorage.org/energy-storage/storage-technology-comparisons/thermal.

‡ U.S. Department of Energy, "Grid Energy Storage"; Cantec Systems, "What Is an Electrochemical Capacitor? How Does It Work? How Does It Differ in Operation and Performance From Today's Standard SLI Battery?" http://www.cantecsystems.com/oldsite/ccrdocs/how-electrochemical-capacitors-work.pdf.

§ U.S. Department of Energy, "Grid Energy Storage."

Federal support promotes technology development

Despite its ability to strengthen the power system, the storage industry continues to face barriers to widespread deployment, including high costs, limited benefit valuation—that is, quantifying and realizing the monetary worth of contributions to the system, such as improved resiliency and backup power—constrained grid access, and restrictive integration protocols.[3] The U.S. Department of Energy has sought to overcome these and other challenges through initiatives such as research, workshops, funding opportunities, small business innovation grants, collaboration between the agency and the national laboratories, and pilot projects.[4] The department's Office of Electricity Delivery & Energy Reliability supports these efforts through its Energy Storage Program, which works closely with industry partners to research and develop batteries, flywheels, electrochemical capacitors, superconducting magnetic energy storage, power electronics, control systems, and other technologies.[5]

The DOE Office of Science's Basic Energy Sciences Program oversees research on and development of novel materials to better understand the physical and chemical characteristics of advanced energy storage technologies. The office manages these efforts through the Joint Center for Energy Storage Research, a collaboration of four national laboratories, five universities, and four private firms headquartered at Argonne National Laboratory near Chicago. The cooperative center is one of four DOE facilities established in 2010 to address technological barriers in the energy sector through a combination of basic and applied science and engineering expertise.[6]

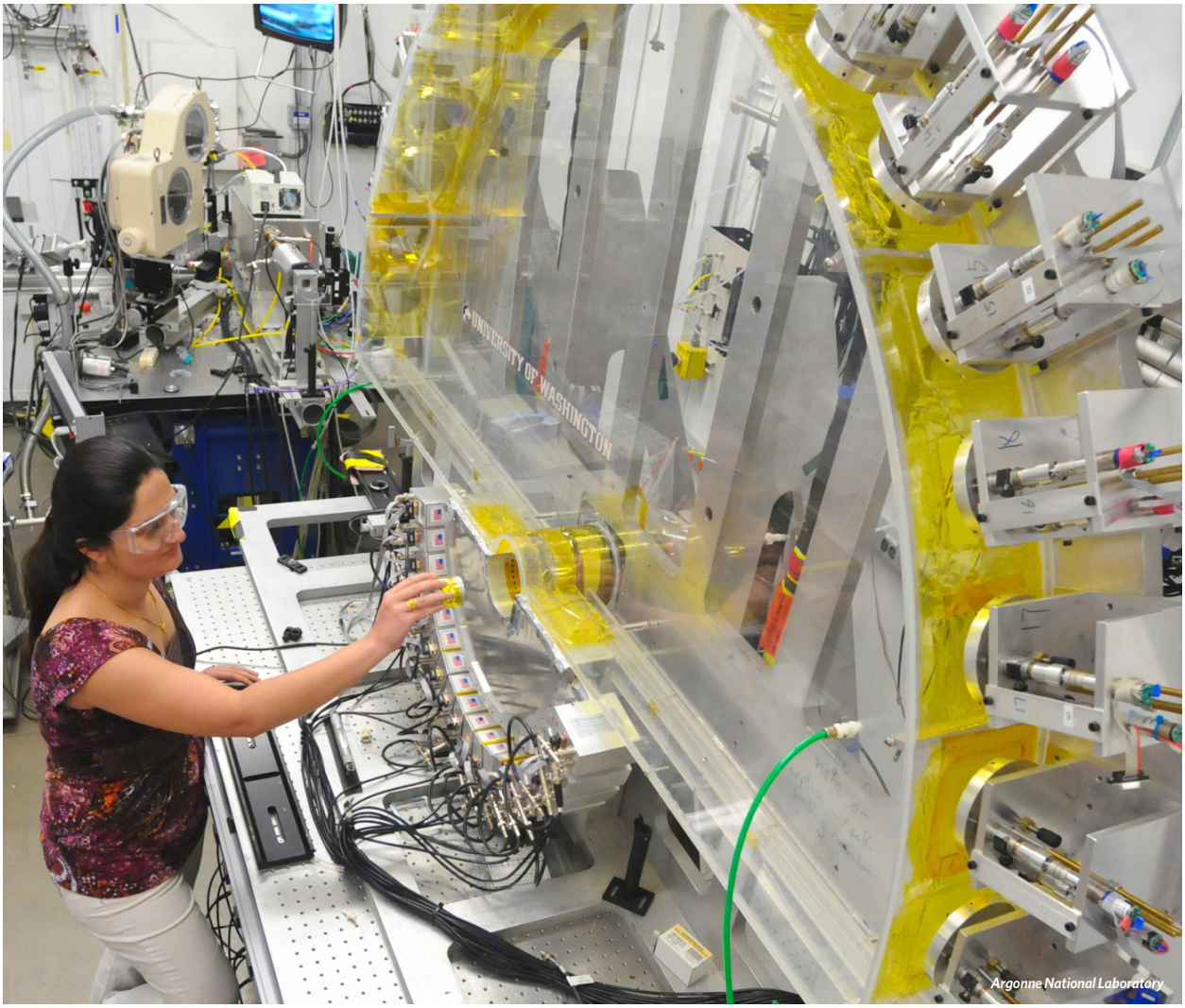
The Advanced Research Projects Agency-Energy (ARPA-E) helps commercialize cutting-edge energy technologies. The agency has several programs focused on research and development to prove and create prototypes of high-risk but promising new energy storage technologies, including transformational electrical energy storage systems.[7] Overall, the agency has provided $75.7 million in funding to 32 completed projects as of December 2015 and is supporting 36 ongoing ventures with over $108 million in grants.[8]

ARPA-E has three energy storage programs. The Advanced Management and Protection of Energy Storage Devices program is working to advance battery performance, safety, and longevity through innovations that reduce technology costs and battery sizes across the energy system.[9] The Cycling Hardware to Analyze and Ready Grid-Scale Electricity Storage program is testing battery technologies to accelerate commercialization under current and projected operating conditions. Finally, the Grid-Scale Rampable Intermittent Dispatchable

Storage program is creating low-cost technologies that can store renewable energy for use at any location on the grid at a cost of less than $100 per kilowatt-hour, compared with market costs for other storage products of $130 to $1,500 per kwh.[10] In November 2015, the agency selected four projects—housed at Oak Ridge National Laboratory, Iowa State University, and two private companies—to receive more than $10 million to develop advanced storage technologies and promote grid integration.[11]

At Sandia National Laboratories, the Energy Storage Systems program is collaborating with industry, academia, and government institutions to increase reliability and performance and market competitiveness of grid storage.[12] The lab also hosts DOE's Global Energy Storage Database, which provides information on grid-connected storage projects and relevant state and federal policies.[13]

In addition to the DOE's efforts, the Department of Defense's Installation Energy Test Bed, established in 2009 to demonstrate new technologies in real-world situations, includes incorporation of commercial-scale energy storage in microgrid systems as one of its five focus areas.[14]



Swati V. Pol, an assistant materials scientist at Argonne National Laboratory, loads an in situ lithium-ion battery into the low-energy resolution inelastic X-ray system at the Advanced Photon Source. This multielement X-ray scattering instrument is helping Argonne researchers understand the fundamental mechanisms that limit the performance of batteries.

Public-Private Partnership Tackles Energy Storage

The federal government is partnering with private industry and academic institutions to conduct large-scale, complex investigations into emerging technologies. Although battery efficiency and life span have improved over the past decade, further innovation is needed to provide sufficient capacity for use in grid and vehicle sectors. A team at the Joint Center for Energy Storage Research, led by experts from the Argonne National Laboratory, is working to create a next-generation battery that would perform five times faster, at a fifth of the cost of current technologies, to help electric cars drive farther and provide renewable energy storage to improve the electrical grid.*

* U.S. Department of Energy Office of Science, "Research: DOE Energy Innovation Hubs," http://science.energy.gov/bes/research/doe-energy-innovation-hubs; Joint Center for Energy Storage Research, "The National Mission," http://www.jcesr.org/research/the-national-need/.

Policies to advance energy storage

As of October 2015, 244 energy storage projects were operating or under construction in the U.S., representing 381 megawatts of capacity.[15] Researchers estimate that by 2019, the nation will have energy storage capacity of 861 MW, worth $1.5 billion annually, and by 2022 that capacity could increase more than 10,000 percent from 2014 levels.[16] The rapidly growing market for energy storage presents an important opportunity for investors, businesses, and the overall economy.[17] However, in order for these benefits to be realized, policy changes that address specific components of energy storage systems are needed.

10,000% Estimated growth of energy storage market, 2014-22

Benefit monetization and grid integration

Continued growth of the storage sector will require improved federal policies. Because the traditional utility business model does not monetize the benefits of storage and because regulations are often not designed to cover these resources, the industry faces barriers that inhibit market adoption.[18] Regulatory guidance and best practices are needed to set standards for energy storage performance, safety, packaging, cycle life, operational control, and integration with the grid. For example, the Heat Efficiency through Applied Technology (HEAT) Act introduced in 2015 helps to reduce uncertainty about where and how projects can connect and interact with the grid, improving the environment for development.[19] Valuing the economic, environmental, and security benefits and services of all distributed technologies in the electric system will further clarify the role of these technologies.[20]

One effort that is underway to address these barriers is the work of industry stakeholders and the Federal Energy Regulatory Commission to include storage under the commission's Order 755, which regulates compensation for ancillary grid services, and Order 784, which requires public utilities to take into account the speed and accuracy of regulation resources. These policies help to ensure that storage technologies have a role in nationwide energy markets.[21]

Investment tax credit

Government grants and tax credits also spur development by helping to reduce the time that investors must wait to see a return on their investments.[22] A few states have adopted storage incentives, but the federal investment tax credit does not recognize most storage technologies. Despite proposals introduced in Congress to expand the ITC, only energy storage projects paired with solar installations are currently eligible for the credit.[23] The ITC is scheduled to expire at the end of 2016, but the clean energy industry is pushing for an extension.

The Internal Revenue Service and U.S. Department of Treasury are also examining possible revisions to the credit. In response to questions from the business community, the agencies issued a notice in the fall of 2015 seeking comment on what types of storage technologies should be considered for ITC eligibility.[24] Businesses and investors need stable, predictable federal tax policy in order to create jobs, invest capital, and deploy pollution-reducing technologies. Allowing tax incentives to lapse jeopardizes long-term investments that have already been made and dampens future growth of clean energy industries.

Master limited partnerships

A bicameral, bipartisan group in Congress has proposed the Master Limited Partnerships Parity Act (S. 1656 and H.R. 2883), which would allow renewable generation and transmission projects, including electricity storage, to be part of master limited partnerships.[25] Established nearly 30 years ago, these business structures are levied as partnerships whose ownership interests are traded on a market like corporate stock, offering significant tax benefits to investors. They have been effective in attracting private investment in the conventional fuel sector, but clean energy technologies have been barred from accessing this structure to date.

Financial and planning incentives

A number of other opportunities exist for federal policy to support greater adoption of energy storage technologies:

- Funding mechanisms, such as the Energy Department's loan program, encourage communities to adopt storage technologies by helping to address upfront capital costs that can hinder project development.
- The Department of Defense aims to deploy three gigawatts of renewable energy on Army, Navy, and Air Force installations by 2025 as part of a larger goal to produce or procure at least 25 percent of total facility energy needs from renewable sources.[26]
- Including battery technologies as eligible components of federal government renewable or alternative energy portfolios or energy plans can help drive development.[27]
- Resource planning programs that require evaluation of the potential for these projects when anticipating future capacity ensure that opportunities are not overlooked.[28]

- At the state level, most public utility commissions use the Institute of Electrical and Electronics Engineers' 2003 voluntary standard for interconnection protocols and procedures.[29] This standard is being revised to account for continued sector innovation, including development of energy storage technologies. Updated procedures that are appropriate for emerging technologies will further promote market growth and community adoption by reducing and streamlining interconnection challenges.

The federal government continues to emphasize the important role of storage in the evolving grid through ongoing research and recommendations for future investigation. In April 2015, the Department of Energy released the Quadrennial Energy Review, which examines modernization of the nation's energy infrastructure to promote economic competitiveness, energy security, and environmental responsibility with a focus on energy transmission, storage, and distribution.[30] The QER discusses the importance of industry standards for connection of customer-owned generation to the local distributed system, not only for improving grid safety but also for encouraging overall reliability and promoting incorporation of distributed resources, including storage.[31] The department will use these findings to inform and guide future energy policy development.

Conclusion

The energy storage market is rapidly evolving in response to advancements that are making these technologies more attractive to consumers and more affordable for investors. In turn, storage systems help to modernize the grid by enhancing power reliability and integrating renewable resources. Federal support in all aspects of the market, from research to deployment, is helping to create new opportunities for the domestic energy industry and resulting in a cleaner, cheaper, and stronger grid. By extending and improving policies such as the investment tax credit and allowing clean and efficient energy properties access to master limited partnerships, federal policymakers can help these technologies advance and expand even more quickly. Congress and the administration should work together to support ongoing initiatives and new proposals to support U.S. leadership in energy storage.

Endnotes

1 Energy Storage Association, "Applications of Energy Storage Technology," http://energystorage.org/energy-storage/applications-energy-storage-technology.

2 Rocky Mountain Institute, "The Distributed Energy Storage Industry in One Chart," Feb. 4, 2015, http://blog.rmi.org/blog_2015_02_04_the_distributed_energy_storage_industry_in_one_chart.

3 Ibid.

4 U.S. Department of Energy, "Grid Energy Storage," December 2013, http://energy.gov/sites/prod/files/2014/09/f18/Grid%20Energy%20Storage%20December%202013.pdf.

5 U.S. Department of Energy, "Energy Storage," http://energy.gov/oe/services/technology-development/energy-storage.

6 U.S. Department of Energy, "Grid Energy Storage"; U.S. Department of Energy Office of Science, "Research: DOE Energy Innovation Hubs," http://science.energy.gov/bes/research/doe-energy-innovation-hubs/.

7 U.S. Department of Energy, "Grid Energy Storage."

8 Advanced Research Projects Agency-Energy, "Search Projects," http://arpa-e.energy.gov/?q=projects/search-projects.

9 Advanced Research Projects Agency-Energy, "View Programs," http://arpa-e.energy.gov/?q=arpa-e-site-page/view-programs.

10 Ibid; International Energy Agency, "Technology Roadmap: Energy Storage," 2014, https://www.iea.org/publications/freepublications/publication/TechnologyRoadmapEnergystorage.pdf.

11 Advanced Research Projects Agency-Energy, "ARPA-E Open 2015 Project Selections," Nov. 23, 2015, http://arpa-e.energy.gov/sites/default/files/documents/files/OPEN_2015_Project_Descriptions.pdf.

12 U.S. Department of Energy, "Energy Storage Systems Program," http://www.sandia.gov/ess.

13 U.S. Department of Energy Office of Electricity Delivery & Energy Reliability, "DOE Global Energy Storage Database," http://www.energystorageexchange.org.

14 Strategic Environmental Research and Development Program and Environmental Security Technology Certification Program, "Installation Energy Test Bed," https://www.serdp-estcp.org/Featured-Initiatives/Installation-Energy.

15 U.S. Department of Energy, "DOE Global Energy Storage Database."

16 Greentech Media, "U.S. Energy Storage Market to Grow 250% in 2015," March 5, 2015, http://www.greentechmedia.com/articles/read/us-energy-storage-market-grew-400-in-2014; Sam Wilkinson, "The Grid-Connected Energy Storage Market Is Set to Explode, Reaching a Total of Over 40 GW of Installations by 2022," IHS Technology, https://technology.ihs.com/483008/the-grid-connected-energy-storage-market-is-set-to-explode-reaching-a-total-of-over-40-gw-of-installations-by-2022.

17 Energy Storage Association, "Facts & Figures," http://energystorage.org/energy-storage/facts-figures.

18 Robert P. Thornton, "Microgrids: Moving Into the Mainstream," International District Energy Association (June 25, 2014), http://www.districtenergy.org/assets/pdfs/News_items/Thornton-AZ-Corp-Comm-IDEA-Microgrids-Mainstream-June-25-6.22-RPT.pdf.

19 U.S. Department of Energy, "Grid Energy Storage"; U.S. Senate Committee on Energy and Natural Resources, "S. 1202—HEAT Act," May 8, 2015, http://www.energy.senate.gov/public/index.cfm/legislation?ID=85564296-e682-4243-9662-482308e1041e.

20 Thomas Bourgeois et al., "Community Microgrids: Smarter, Cleaner, Greener," Pace Energy and Climate Center, Pace Law School (2013), http://energy.pace.edu/sites/default/files/publications/Community%20Microgrids%20Report%20(2).pdf.

21 Energy Storage Association, "Federal Regulatory Policy Action," http://energystorage.org/policy/regulatory-policy; Preti Flaherty, "FERC Order 784 Boosts Energy Storage," July 24, 2013, http://energypolicyupdate.blogspot.com/2013/07/ferc-order-no-784-boosts-energy-storage.html; Preti Flaherty, "FERC Order 755 Promotes Energy Storage," Dec. 21, 2011, http://energypolicyupdate.blogspot.com/2011/12/ferc-order-755-promotes-energy-storage.html.

22 Thomas Bourgeois et al., "Community Microgrids: Smarter, Cleaner, Greener."

23 Dave Yankee, "Financing Energy Storage With Tax Credits," Deloitte, Sept. 28, 2015, https://www2.deloitte.com/content/dam/Deloitte/us/Documents/energy-resources/us-er-financing-energy-storage-with-tax-credits.pdf; David Meyers and Randy Palombi, "Solar and Storage: Better Together?" Greentech Media, Aug. 17, 2015, http://www.greentechmedia.com/articles/read/Solar-and-Storage-Better-Together.

24 Energy Storage Association, "Legislative Policy Priorities," http://energystorage.org/policy/legislative-policy.

25 U.S. Senator Christopher Coons, "The Master Limited Partnerships Parity Act," http://www.coons.senate.gov/issues/master-limited-partnerships-parity-act; Energy Storage Association, "Legislative Policy Priorities."

26 The White House, "Fact Sheet: Obama Administration Announces Additional Steps to Increase Energy Security," April 11, 2012, https://www.whitehouse.gov/the-press-office/2012/04/11/fact-sheet-obama-administration-announces-additional-steps-increase-ener; Jeff St. John, "The Military Microgrid as Smart Grid Asset," Greentech Media, May 17, 2013, http://www.greentechmedia.com/articles/read/the-military-microgrid-as-smart-grid-asset.

27 KEMA, "Microgrids: Benefits, Models, Barriers and Suggested Policy Initiatives for the Commonwealth of Massachusetts," Feb. 3, 2014, http://nyssmartgrid.com/wp-content/uploads/Microgrids-Benefits-Models-Barriers-and-Suggested-Policy-Initiatives-for-the-Commonwealth-of-Massachusetts.pdf.

28 Thomas Bourgeois et al., "Community Microgrids: Smarter, Cleaner, Greener."

29 Ibid.

30 U.S. Department of Energy, "Quadrennial Energy Review: Energy Transmission, Storage, and Distribution Infrastructure," April 2015, http://energy.gov/sites/prod/files/2015/07/f24/QER%20Full%20Report_TS%26D%20April%202015_0.pdf.

31 Ibid.

For further information, please visit:

pewtrusts.org/cleanenergy

Contact: Kerry Schlichting, senior associate
Email: kschlichting@pewtrusts.org
Project website: pewtrusts.org/cleanenergy