U.S. DEPARTMENT OF ENERGY
ALLIANCE TO SAVE ENERGY
Compete. Council on Competitiveness

ACCELERATE ENERGY *Productivity* 2030

A Strategic Roadmap for American Energy Innovation, Economic Growth, and Competitiveness

Accelerate Energy Productivity 2030: A Strategic Roadmap for American Energy Innovation, Economic Growth, and Competitiveness was developed by the U.S. Department of Energy in partnership with the Council on Competitiveness and the Alliance to Save Energy.

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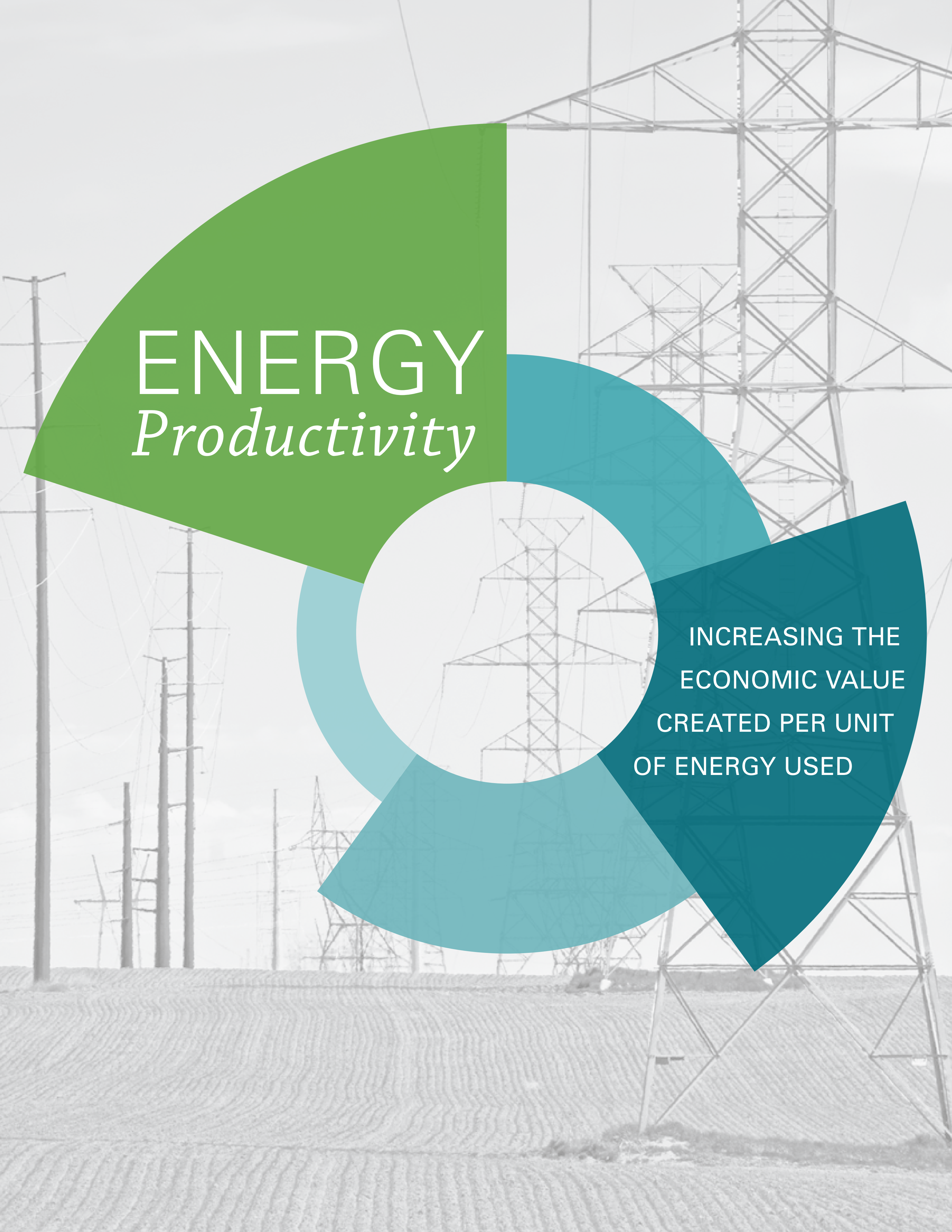
TABLE OF CONTENTS

SUCCESS STORIES

LIST OF FIGURES

LIST OF TABLES



ENERGY *Productivity*

INCREASING THE ECONOMIC VALUE CREATED PER UNIT OF ENERGY USED

EXECUTIVE SUMMARY

In September 2014, responding to the presidential call to action to double energy productivity by 2030, U.S. Secretary of Energy Dr. Ernest Moniz announced the Accelerate Energy Productivity 2030 initiative. The U.S. Department of Energy (DOE) partnered with the Council on Competitiveness and the Alliance to Save Energy (collectively, the Partners) in a series of public dialogues and executive roundtables to raise awareness, galvanize support and develop the strategies necessary to double the United States' energy productivity, defined as the ratio of economic output (gross domestic product (GDP)) to primary energy use.

This publication—*Accelerate Energy Productivity 2030: A Strategic Roadmap for American Energy Innovation, Economic Growth, and Competitiveness* (*Roadmap*)—outlines a set of pathways to achieve this goal, and makes clear the direct, tangible, and long-lasting benefits in doing so: lower energy bills; job creation; economic growth; a more globally-competitive manufacturing and industrial base; and greater prosperity for Americans in the decades to come. This *Roadmap* identifies actions a broad range of stakeholders—including businesses; federal, state, and local governments; universities and community colleges; and individual consumers—can take to achieve the national goal of doubling energy productivity by 2030.

The *Roadmap* is organized around two main findings informed by the work of the Partners over the last 12 months:

1. **There are demonstrated, proven opportunities in every part of our economy to improve energy productivity.** The federal government can support increasing energy productivity in many ways, but cannot achieve the goal on its own. To be successful and achieve this national goal, we need decision-makers across the country also to take action. Attendees of Accelerate Energy Productivity 2030 events discussed a wide range of opportunities for diverse stakeholders to improve their energy productivity and contribute to meeting the national goal. The *Roadmap* highlights these success stories along with other effective approaches to driving increased productivity over the next 15 years.
2. **New analysis shows how energy productivity can contribute to economic growth.** Drawing on discussions from the regional roundtables and dialogues as well as existing studies, DOE analyzed illustrative scenarios under which the United States can meet the president's goal by investing in energy productivity improvements.

Underpinning the *Roadmap* is a newly developed modeling framework that uses historical data to project how changes in investment, energy use, and personal expenditures impact economic activity nationwide. The framework also provides insight into the macroeconomic effects of energy productivity. The model is built on established metrics for the economic and energy outcomes of six significant policy and investment strategies, each of which is based on broad areas of opportunity that stakeholders identified. The model then dynamically analyzes how changes in energy use from these strategies would impact GDP.

SUMMARY: HIGHLIGHTS OF STAKEHOLDER STRATEGIES

The Partners launched a series of dialogues with business, academic, and laboratory leaders; state and local government officials; and researchers to identify the most promising pathways to meet the national goal of doubling energy productivity by 2030. These three regional dialogues and roundtable discussions have informed the sample strategies explored in the *Roadmap*. Example strategies described in the *Roadmap* are presented by entity: federal, state, and local governments; commercial and industrial businesses; electric, gas, and water utilities; higher education institutions; and households. The strategies presented here are not meant to be comprehensive. Rather, the *Roadmap* focuses on scalable actions that have the potential to reduce energy consumption and support economic growth. These energy productivity strategies often involve multiple economic sectors and levels of government. To present a cohesive analysis of the potential impacts of the strategies, this analysis developed six productivity "wedges" as representations of aggregated individual strategies. These wedges are summarized in Section 3.

Taken together, these strategies offer a feasible path to the doubling of national energy productivity by 2030. The strategies also indicate that participating entities—including both individuals and organizations—can enjoy a potential share of the benefits of achieving this goal.

Government

- *Federal Government:* Invest in long-term energy productivity through research, development, and demonstration in transportation, buildings, and manufacturing technologies; secure energy productivity through setting and updating vehicle and product codes and standards, and providing energy performance information to consumers; support policy action by state and local governments and the private sector through the provision of tools and other resources to reap the benefits of energy efficiency; set the financial foundation for energy productivity through tax policies; help train a workforce geared for energy productivity; and lead by example in adopting new technologies and strategies in its own operations.
- *State Government:* Pursue policies to encourage greater energy efficiency; promote new and innovative financing for investments that support energy productivity; support and incentivize increased deployment of combined heat and power

(CHP); implement smart regional transportation solutions; and adopt and enforce increasingly efficient building codes.

- *State Regulators:* Adopt rates and implement related policies affecting utility sector efficiency programs that more effectively align efficiency efforts with utility business models; and support energy productivity investments in buildings and infrastructure.
- *Local Government:* Facilitate distributed generation; establish best practices regarding building energy information; support the development of advanced manufacturing ecosystems; and reduce personal vehicle miles traveled[1] through the built environment-transportation nexus.
- *National Laboratories:* Serve as incubators for new energy productivity technologies—and where appropriate, enable new energy-efficient technologies to move rapidly from the lab to the marketplace.

Businesses

- *Commercial Businesses:* Reduce energy consumption in their own buildings and facilities through energy efficiency; reinvest the resulting avoided energy costs into growing their businesses; adopt new financing models that promote energy productivity investments; encourage their suppliers and vendors to take measures to improve energy productivity; and assist in training a workforce geared for energy productivity.
- *Industrial Businesses:* In addition to taking similar steps to those taken by commercial entities, leverage public-private partnerships; adopt energy management systems; transition to advanced manufacturing technologies; and explore new, innovative products that enable energy productivity for customers and suppliers.

Utilities

- *Electric Utilities:* Modernize the grid infrastructure through smart grid investments and improving the efficiency and interoperability of generation, transmission, storage, and distribution; adopt new utility business models to empower the improvement of energy productivity; design rates and support related policies for utility energy efficiency programs that more effectively align energy efficiency with utility business models; and support energy productivity investments in buildings.
- *Water Utilities:* Adopt more energy-efficient and energy-extracting technologies at water and wastewater treatment facilities and more water-efficient technologies in distribution and end use water systems (e.g., wastewater treatment plants can implement more efficient pumps and deploy onsite waste to energy conversion, such as digesters and combined heat and power; end use hot water conservation measures also have a direct impact on energy consumption).

Higher Education Institutions, and Individuals and Households

- *Higher Education Institutions:* Create new curricula and expand workforce training opportunities across multiple disciplines (e.g., building trades, engineering, governmental policy, economics, and law) for careers in the clean

1 Vehicle miles traveled is a measure of distance traveled by vehicles over a given period, typically one year.

energy, energy efficiency, and advanced manufacturing fields; and act as demonstration and commercialization "accelerators," enabling new energy-productive technologies to move rapidly from the lab to the marketplace. In addition, higher education institutions can invest in making their facilities and fleets more efficient.

- *Individuals and Households:* Support the markets associated with energy-efficient products in the home and for transportation and use available resources to make informed choices.

MODELING ENERGY PRODUCTIVITY IMPROVEMENTS

To model the effect of the aforementioned strategies for energy productivity on the U.S. economy, the *Roadmap* describes six illustrative productivity "wedges" that collectively represent the strategies. Underlying each wedge are assumptions based on existing published studies of the effect of productivity investments on energy use in a particular sector of the economy. As a result, the wedges are representative of the types of first order effects one could anticipate from the strategies and actions identified in the *Roadmap*.

Using the wedges as a model input, the *Roadmap* employed a vector error correction model (VECM) to estimate the effect of the wedges on U.S. GDP. Although there are many different types of econometric models, VECMs have two advantages. First, they robustly capture interactions and feedback between sectors of the economy using historical relationships. And second, they dynamically estimate future effects of changes to the economy using those historical relationships. In other words, VECMs do not assume GDP remains fixed like many static models but allow, for example, changes in energy efficiency investment to produce GDP feedback effects through changes in energy prices and the amount of energy consumed, among other factors.

After running the model, the *Roadmap* is able to rank the six wedges according to their net effect on GDP. The wedges analyzed are not the only six options available for improving energy productivity, but are intended to be illustrative of the types of energy and economic changes that are expected from following *Roadmap* strategies and actions. The six wedges are presented in descending order of their estimated impact to U.S. energy productivity[2]:

- *Transportation:* Increasing the energy productivity of moving goods and people relies on developing and deploying new technologies that increase vehicle efficiency, create more options for mass transit, and better integrate transportation needs with the built environment to reduce the demand for motorized transport.
- *Technologies for Buildings Energy Productivity:* Improving the energy productivity of buildings requires both the widespread use of currently available energy-efficient technologies and practices, and the development of next generation technologies.
- *Smart Energy Systems:* Energy systems, particularly electricity generation systems and the electricity grid, are sources

2 Economic and energy effects are not estimated for wedge sub-elements. As a result, it is not possible to determine the relative impacts to energy productivity of wedge sub-elements.

and enablers of improvements to U.S. energy productivity. Broad and deep transformations are required to enable transitions to distributed energy resources, real-time energy pricing, smart appliances, and increased energy efficiency.

- *Financing for Buildings Energy Productivity:* Significant changes to financing mechanisms and market recognition of the value of energy productivity are required to ensure energy productivity-enabling technology is used by businesses and households. This includes addressing real or perceived risk to the use and deployment of these technologies, which can immediately and adversely impact the cost of financing.
- *Smart Manufacturing:* Sensors and other information and communications technology (ICT) will allow industries better control over their processes and will improve the energy management of their buildings.
- *Water Infrastructure:* Reducing energy consumption at water and waste water treatment plants and in water conveyance and distribution systems involves three actions: improving energy efficiency and demand response, implementing emerging technologies and processes, and deploying energy recovery and generation technologies.[3]

DOUBLING ENERGY PRODUCTIVITY BY 2030 IS ACHIEVABLE

The analysis demonstrates that through immediate and sustained actions, doubling energy productivity by 2030 is possible. The model estimates the energy productivity wedges increase energy productivity in 2030 to $287/million British thermal units (Btu) (MMBtu)— more than double the 2010 baseline of $134/MMBtu. The change in energy productivity is the result of increasing GDP ($2005) to $22.5 trillion and reducing primary energy use to 78 quadrillion (quads) Btu by 2030. In comparison, model baseline estimates are $21.5 trillion ($2005) and 104 quads in 2030. Thus, in 2030, the Roadmap scenario achieves 4.3 percent higher GDP and 25 percent lower primary energy use compared to the baseline.[4] The model does account for energy used to produce the additional goods and services purchased by households. This results in aggregate energy savings values, including this additional energy from more goods and services, are approximately 14 percent smaller than the sum of each individual productivity wedge, as indicated by the dashed line in Figure 1.

3 Pabi, S., A. Amarnath, R. Goldstein, and L. Reekie, Electricity Use and Management in the Municipal Water Supply and Wastewater Utilities (Palo Alto, CA: Electric Power Research Institute, 2013), accessed July 2015, http://www.waterrf.org/PublicReportLibrary/4454.pdf.

4 This compares to the Energy Information Administration's Annual Energy Outlook 2015 Reference Case estimates of $22.0 trillion ($2005) and 103 quads in 2030.

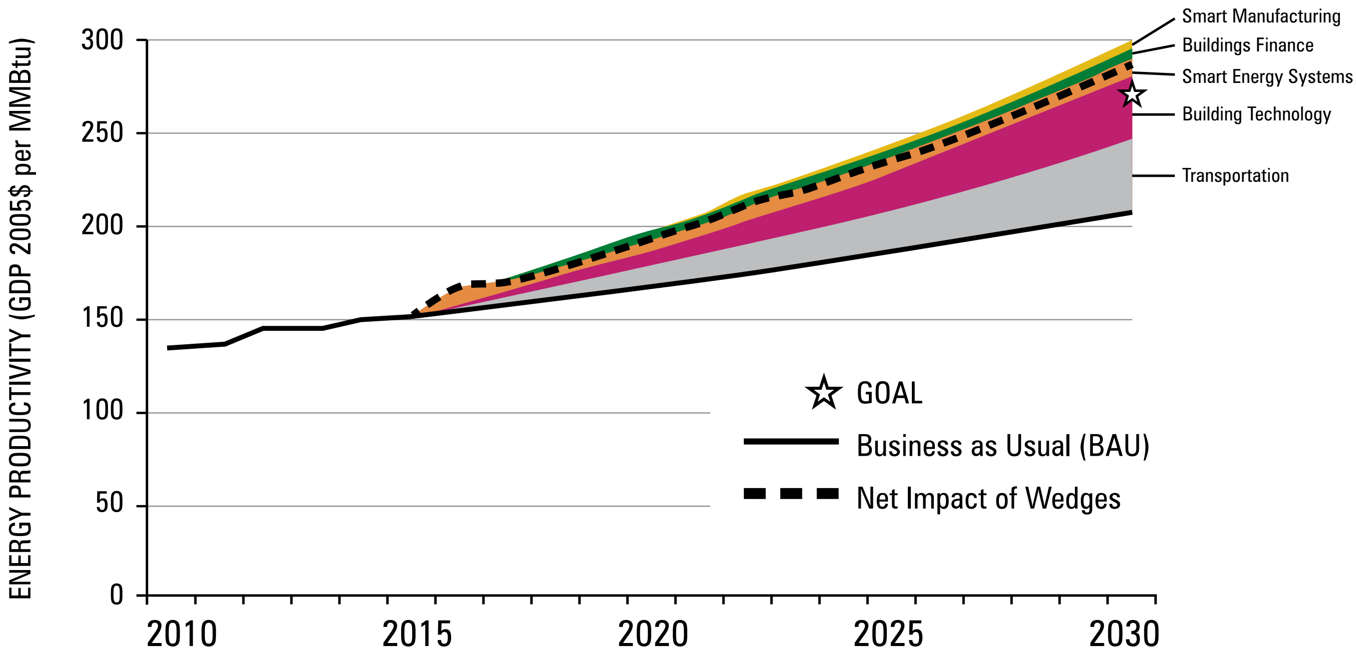


Figure 1. Estimated Energy Productivity Benefits to 2030

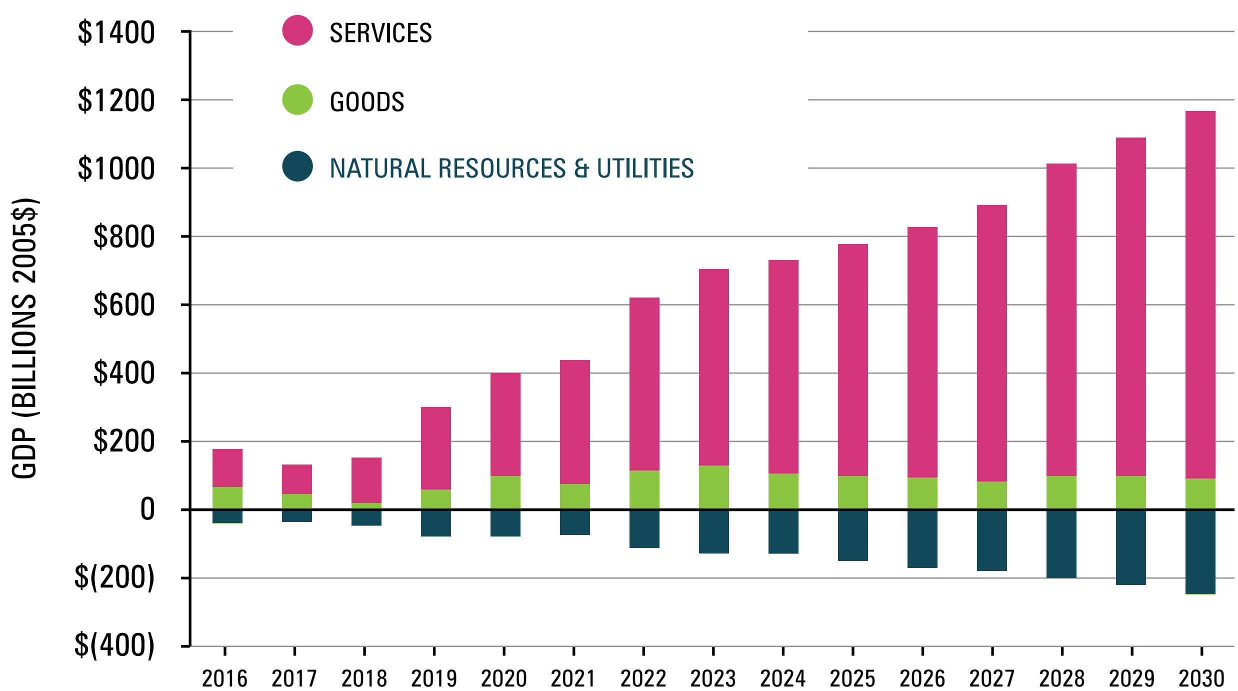


Figure 2. Estimated Changes to GDP by Sector

According to the model underpinning the *Roadmap*, the six energy productivity wedges will contribute in aggregate to a net increase of $922 billion in U.S. GDP by 2030. This is primarily supported by an increase of $753 billion in household expenditures and by a $169 billion increase in investment in products and services that increase energy efficiency. For households, there is a double benefit: they are able to increase their purchases of other goods and services in part by making energy efficiency investments that reduce their energy bills. Figure 2 shows the estimated changes to GDP by sector.

Producers of goods and services are also shown to benefit from increased economic activity spurred by energy productivity investments. The service industry shows the most significant growth, with a nearly $1.08 trillion increase over baseline economic activity by 2030. By 2030, goods-providing industries (e.g., manufacturing, agriculture, and construction) increase by approximately $91 billion over the model baseline. Declines in economic activity in the natural resources and utilities are due to decreases in energy expenditures and demand for production from utilities and their supply chain. No specific assumptions are made concerning export markets for natural resources.

CONCLUSION

As is clear from the Accelerate Energy Productivity 2030 regional roundtables and dialogues, as well as the modeling analyses, a wide range of available activities will yield significant productivity benefits. Implementing these activities will require changes in behavior, investment, and technology deployment in both the public and private sectors. Collectively, they can improve U.S. economic output, reduce U.S. energy consumption, and reduce the energy impact on the environment. Government and the private sector are already deploying many of these changes. While the task of doubling energy productivity is a significant challenge, the fact that many activities are already underway suggests that the nation can – and already is – beginning to meet this challenge. The *Roadmap* provides a foundation for scaling these efforts nationwide while allowing for flexible and tailored solutions.

Increasing energy productivity is doing more with less, generating greater economic well-being for the amount of energy used, and improving living standards and quality of life.

INTRODUCTION TO THE ROADMAP

In his 2013 State of the Union address, President Obama announced the bold goal of doubling energy productivity with the statement, "I'm also issuing a new goal for America: Let's cut in half the energy wasted by our homes and businesses over the next 20 years."[5] The goal of doubling energy productivity complements other administration goals, such as deploying 40 gigawatts (GW) of new combined heat and power (CHP) by 2020.[6]

Secretary Moniz echoed the president's remarks, stating, "Taking action today to increase our energy productivity, by boosting the competitiveness of American manufacturers and building clean energy technologies here in the U.S., will help grow our economy for generations to come."[7] In November 2014, Secretary Moniz on behalf of DOE, the Council on Competitiveness, and the Alliance to Save Energy (the Partners) created the Accelerate Energy Productivity 2030 initiative. And, the Partners jointly launched a series of three dialogues (Appendixes 3–5) with business, academic, and laboratory leaders; state and local government officials; and researchers to identify the most promising pathways to meet the national goal of doubling energy productivity by 2030. These regional dialogues—in Raleigh, Seattle, and St. Paul—and accompanying roundtable discussions informed the sample strategies explored in this document: *Accelerate Energy Productivity 2030: A Strategic Roadmap for American Energy Innovation, Economic Growth, and Competitiveness.*

The challenges facing the adoption of energy-efficient technologies and behavior are well-documented.[8] The recent

5 The White House Office of the Press Secretary, "Remarks by the President in the State of the Union Address," news release, February 12, 2013, https://www.whitehouse.gov/the-press-office/2013/02/12/remarks-president-state-union-address.

6 The White House Office of the Press Secretary, "Executive Order -- Accelerating Investment in Industrial Energy Efficiency", news release, August 30, 2012, https://www.whitehouse.gov/the-press-office/2012/08/30/executive-order-accelerating-investment-industrial-energy-efficiency.

7 U.S. DOE. 2015. Accelerate Energy Productivity 2030 Fact Sheet. http://energy.gov/epsa/downloads/accelerate-energy-productivity-2030-fact-sheet.

8 William H. Golove and Joseph H. Eto, Market Barriers to Energy Efficiency: A Critical Reappraisal of the Rationale for Public Policies to Promote Energy Efficiency, LBL-38059 (Berkeley, CA: Lawrence Berkeley National Laboratory, 1996), accessed July 2015, http://eetd.lbl.gov/sites/all/files/lbnl-38059.pdf; Steve Sorrell, Eoin O'Malley, Joachim Schleich, and Sue Scott, The Economics of Energy Efficiency: Barriers to Cost-Effective Investment (Cheltenham, UK: Edward Elgar Publishing, 2004); Richard B. Howarth and Bo Andersson, "Market Barriers to Energy Efficiency," Energy Economics 15:4 (1993): 262–272.

recession highlighted structural impediments to robust continual economic growth. The loss of economic potential[9] in 2015 due to effects of the recession is estimated to be between 5.3 percent and 7.7 percent.[10] With a focus on producing more economic output with less energy, the national goal to double energy productivity encompasses strategies focusing on reducing energy consumption as well as growing the economy.

Since 2014, the federal government has implemented several significant actions that will accelerate U.S. energy productivity:

- DOE adopted new appliance efficiency standards, in addition to those issued since 2008, that will help households save over $26 billion on their utility bills by 2030.[11]
- DOE and the U.S. Department of Housing and Urban Development launched an initiative to increase energy literacy to support science, technology, engineering, and mathematics (STEM) fields.
- The Green Preservation Plus loan program was expanded to improve further the efficient use of energy and water in multifamily properties.[12]
- As part of President Obama's Climate Action Plan, the federal government created three "Better Buildings Accelerators" (BBA) in 2013, bringing the total number of accelerators to seven.[13]
- Federal buildings were given an additional $2 billion goal for energy efficiency investments, which will create tens of thousands of new jobs at no net cost to taxpayers through reduced energy expenditures.

The strategies presented in this *Roadmap* build on these existing efforts and provide stakeholders with the information needed to undertake similar efforts themselves. The *Roadmap* does not provide an exhaustive list of strategies and actions that could double energy productivity. Rather, the strategies presented here represent a survey of known, demonstrated, and replicable options for the United States to reach the goal of doubling energy productivity.[14]

9 Economic potential refers to the normal level of GDP that could be expected for an economy given its available resources and technology. See Pierre-Olivier Beffy, Patrice Ollivaud, Pete Richardson, and Franck Sédillot, New OECD Methods for Supply-side and Medium-term Assessments: A Capital Services Approach (Paris: Organisation for Economic Co-operation and Development, 2006), accessed July 2015, http://dx.doi.org/10.1787/628752675863.

10 Lawrence M. Ball, Long-Term Damage from the Great Recession in OECD Countries, NBER Working Paper No. 20185 (Cambridge, MA: National Bureau of Economic Research, 2014), accessed July 2015, http://www.nber.org/papers/w20185.

11 The White House Office of the Press Secretary, "Fact Sheet: President Obama Announces Commitments and Executive Actions to Advance Solar Deployment and Energy Efficiency," news release, May 9, 2014, https://www.whitehouse.gov/the-press-office/2014/05/09/fact-sheet-president-obama-announces-commitments-and-executive-actions-a.

12 Fannie Mae, "HUD and Fannie Mae Announce Expansion of Green Preservation Plus," news release, May 8, 2014, http://fanniemae.com/portal/about-us/media/corporate-news/2014/6117.html.

13 "Accelerating Investment in Energy Efficiency," U.S. Department of Energy Better Buildings, accessed July 2015, http://www1.eere.energy.gov/buildings/betterbuildings/accelerators/.

14 Note that reference to any non-Federal entity in this document does not constitute an endorsement on the part of DOE or the U.S. government.

The Clean Power Plan and Energy Productivity

On August 3, 2015, President Obama and EPA Administrator Gina McCarthy announced the Clean Power Plan (CPP), new regulations that will reduce carbon emissions from new and existing power plants. States can draw on a wide range of options to meet the emissions standards outlined in the plan, designed to allow states to choose plans that work for their unique energy mix, resources and economy.

Because each of the Accelerate Energy Productivity 2030 regional dialogues occurred before the Clean Power Plan was finalized, discussions at these dialogues were not intended to address the CPP. However, many of the strategies in this Roadmap can increase energy productivity while also assisting with CPP compliance, including shifting to renewable electricity generation as well as efficiency improvements at power plants, transmission and distribution infrastructure, and ramping up demand-side energy efficiency.

For more information on the CPP, please visit http://www2.epa.gov/cleanpowerplan. For information on DOE resources that could be helpful for state plans, please visit www.doe.gov/ta.

1.1 Energy Productivity

ENERGY EFFICIENCY VS. ENERGY PRODUCTIVITY

ENERGY EFFICIENCY *provides the same level of goods and services using less energy.*

ENERGY PRODUCTIVITY *increases the economic value created per unit of energy used.*

Energy is a foundation for economic activity and a requisite for every product we buy and every service we use. Increasing energy productivity is doing more with less, generating greater economic well-being for the amount of energy used, and, critically, improving living standards and quality of life. National efforts to boost energy productivity date back at least 35 years. In 1981, the United States Congress Joint Economic Committee worked to develop a national energy productivity index,[15] and the concept gained momentum more recently through announcements like President Obama's goal of doubling energy productivity by 2030.

Energy productivity (the inverse of energy intensity) is defined in the *Roadmap* as the ratio of annual GDP to annual total primary energy use. The energy productivity of an economy, like its energy intensity, is a highly aggregated measure of energy use and economic output. As a result, the energy productivity metric reflects many underlying factors, including structural changes (i.e., changes to the relative contribution of different economic sectors) and changes in energy efficiency (i.e., changes to the amount of energy used to provide a good or service). Unlike analysis that aims to distinguish the impacts of energy efficiency to national energy use,[16] the energy productivity analysis completed here implicitly includes structural, efficiency-

15 A. Penze and D. Bakke, A National Index for Energy Productivity (Washington, D.C.: Joint Economic Committee (U.S. Congress), 1981), accessed July 2015, http://www.osti.gov/scitech/biblio/6531717.

16 Energy Intensity Indicators," U.S. Department of Energy Office of Energy Efficiency and Renewable Energy, last modified March 3, 2015, http://www1.eere.energy.gov/analysis/eii_index.html.

International Interest in Energy Productivity

The United States is not alone in its interest in increasing energy productivity. A number of governments and international actors are embracing this framework to set or support the achievement of national and regional goals. Additional information on international interest in energy productivity can be found in Appendix 1.

related, and activity-related factors, and it does not separately identify the GDP or energy effects of each factor.

Because energy productivity is defined as a ratio, increasing energy productivity can be achieved by either growing GDP at a faster rate than energy use or reducing the growth rate of energy use to a rate of growth less than GDP growth. However, energy use and GDP are linked and tend to move in the same direction (see Figure 3), raising concerns that any reduction in the rate of growth of energy use may contribute to lower GDP growth. Analysis conducted for the *Roadmap*, which is discussed in Section 3, examines the interaction between energy use and GDP and estimates the net impacts to GDP, energy use, and energy productivity.

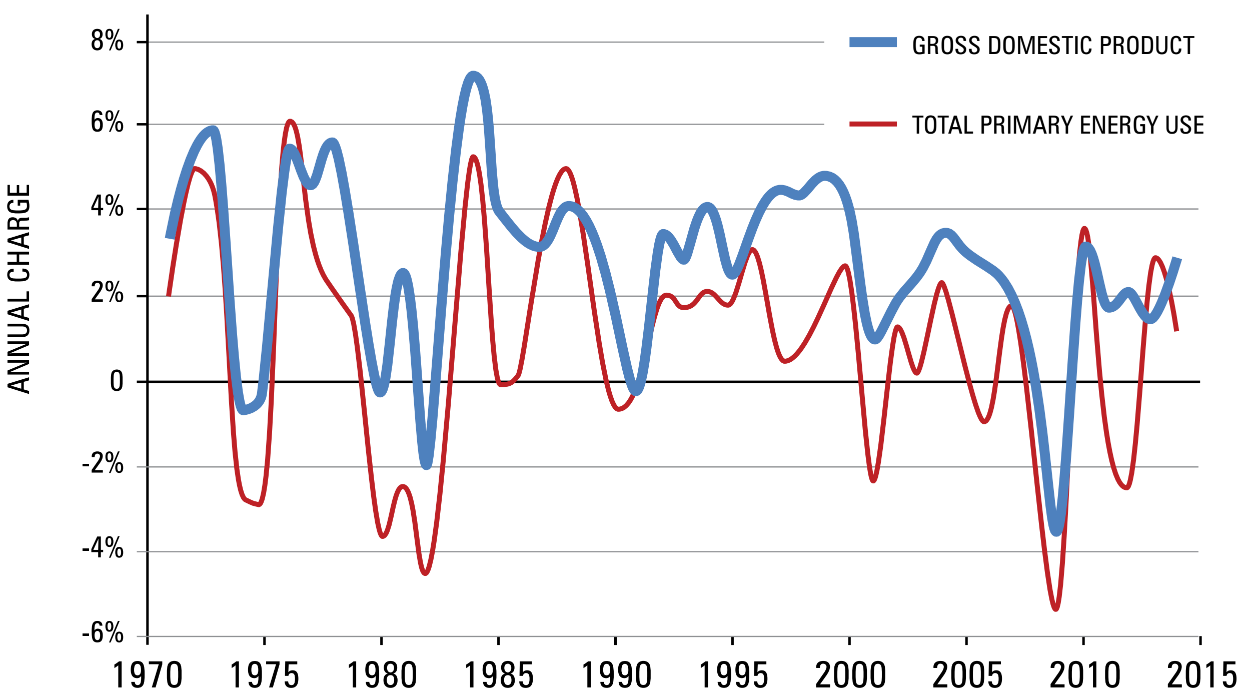


Figure 3. U.S. Total Primary Energy and Real GDP (1971–2014)[17]

17 GDP in chain-weighted 2005 dollars from the Bureau of Economic Analysis; total primary energy from the Energy Information Administration, adjusted for International Energy Agency accounting of renewable electricity.

1.2 Overview of the 2030 Productivity Goal

1.2.1 SYNOPSIS OF CURRENT ENERGY USE AND ECONOMIC ACTIVITY

Figure 4 summarizes the trends in U.S. GDP and primary energy use since 1970. As the figure depicts, primary energy use for the period peaked in 2007, and it remains largely flat since 2000. Conversely, GDP has grown for most of the period. In 2010, the U.S. economy produced approximately $136 (chained 2005 dollars[18]) in GDP for each MMBtu used.[19]

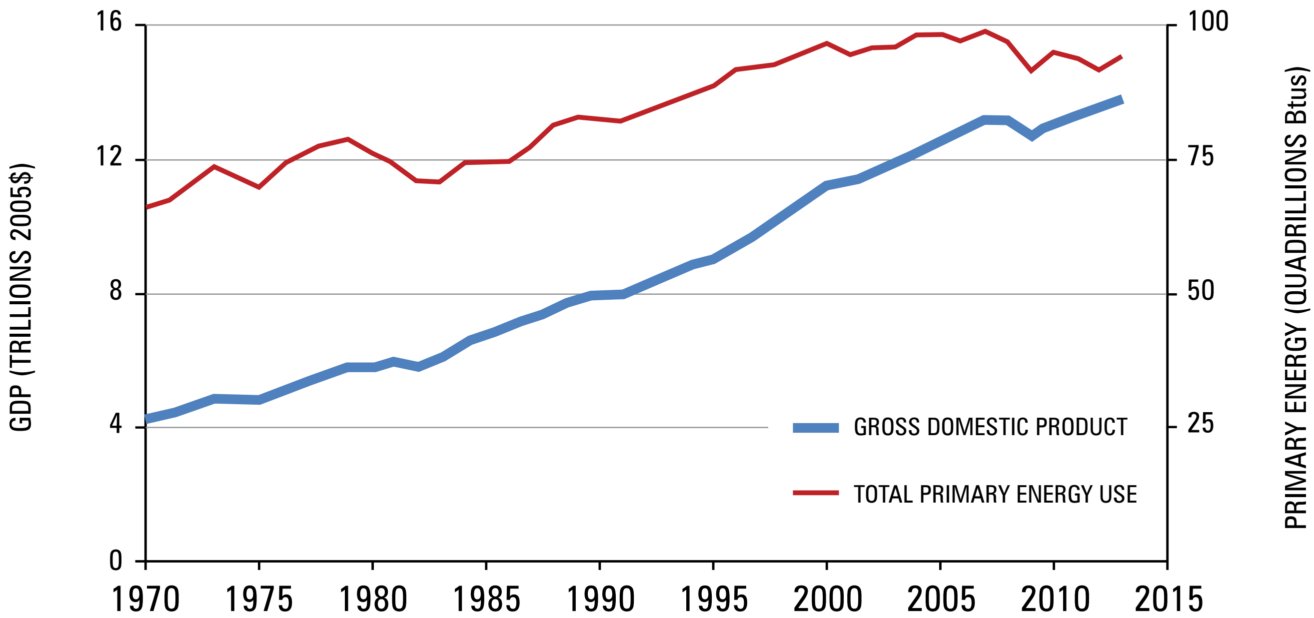


Figure 4. U.S. GDP and Total Primary Energy Use (1970–2014)

18 The U.S. Bureau of Economic Analysis uses chain-weighted indexes to adjust nominal estimates of GDP to account for inflation.

19 National primary energy accounting is performed on a "production" rather than a "consumption" basis. This means that national energy data does not include the energy used to create imported materials and products (i.e., "embodied" energy), and they do not subtract energy used to produce exported materials and products.

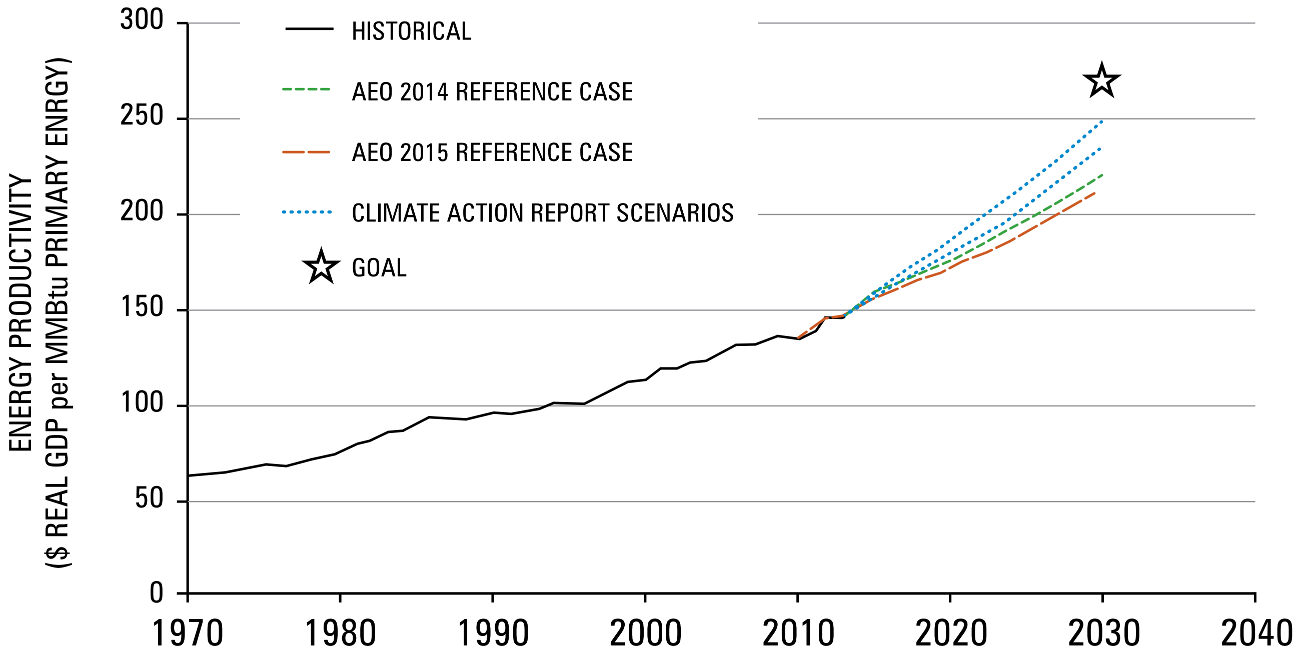


Figure 5. Historical and Projected Energy Productivity (1970–2030)

Figure 5 summarizes the historical performance and projected trends in U.S. energy productivity. Energy productivity has increased since 2010, reaching $149 per MMBtu in 2014. The business-as-usual (BAU) pathway is represented by the U.S. Energy Information Administration's (EIA's) Annual Energy Outlook (AEO) 2014 Reference Case, and it achieves 57 percent of the goal. A combination of nearly flat primary energy demand growth (0.24 percent average annual growth rate from 2010 to 2030) and moderate economic growth forecast (2.43 percent average annual growth rate from 2010 to 2030) drive BAU improvements.

The Side Cases of AEO 2014 offer scenarios for how policy and technology may affect the U.S. energy productivity trajectory. Yet, even the most aggressive energy efficiency Side Case in AEO 2014, Best Available Technology, represents only a 6 percent improvement in energy productivity by 2030 over the AEO 2014 Reference Case BAU, achieving 70 percent of the goal by 2030.[20]

20 The EIA did not conduct any energy efficiency Side Cases for the 2015 AEO.

Actions identified in the 2014 *Climate Action Report*[21] could lead to as much as a 62 percent increase in energy productivity over the AEO 2014 Reference Case BAU. However, achieving the remaining portion of the goal will require *significant* additional actions in transforming how the U.S. economy provides and uses energy. The most effective strategies for meeting the productivity goal will involve both reducing energy use and increasing economic growth; however, there is another significant opportunity to improve energy use intensity by modernizing the manufacturing sector to use innovative, effective, and more efficient manufacturing processes. Achieving the goal within the current national economic-energy structure will require significant action on the part of government, private businesses, and individual citizens.

1.2.2 IDENTIFIED ENERGY PRODUCTIVITY POTENTIAL

1.2.2.1 Synopsis of Existing Studies and Strategies

The *Roadmap* follows on a report[22] commissioned by the Alliance to Save Energy that identifies specific strategies for doubling U.S. energy productivity by 2030. The 2013 report's supporting analysis of the impacts of doubling energy productivity estimates that an additional $166 billion annual investment in energy efficiency in the buildings, industry, and transportation sectors could reduce energy use in 2030 by 18 percent relative to 2011 levels and save $343 billion in annual energy costs.[23] Together with savings of $151 billion from lower energy prices that could result from decreased demand, the annual savings by 2030 would equal approximately $327 billion, which is equivalent to 2 percent of nominal GDP in 2030. The analysis also highlighted associated benefits of increased net employment, reduced greenhouse gas emissions, and improved energy security. The net economic effects of these savings and investments (i.e., changes to GDP) were not estimated in the 2013 report.

In 2012 the Alliance to Save Energy's Commission on National Energy Efficiency Policy issued a set of 54 diverse policy recommendations in 2012 that, taken together with the elements of this *Roadmap*, could achieve the goal of doubling U.S. energy productivity. The report[24] highlights the roles of utilities, residential and commercial buildings, industries, and the transport sector in achieving cost-effective energy efficiency improvements. The report also provides recommendations for accelerating energy innovation through research, development, demonstration, and deployment.

21 The Climate Action Report identifies potential greenhouse gas emissions reduction scenarios from private sector uptake of federal government greenhouse gas emissions mitigation measures. See U.S. Department of State, United States Climate Action Report 2014 (Washington, D.C.: U.S. Department of State, 2014), accessed July 2015, http://www.state.gov/documents/organization/219038.pdf.

22 Rhodium Group, American Energy Productivity: The Economic, Environmental and Security Benefits of Unlocking Energy Efficiency (New York, 2013), accessed July 2015, http://www.ase.org/sites/ase.org/files/rhg_americanenergyproductivity_0.pdf.

23 Rhodium Group, American Energy Productivity: The Economic, Environmental and Security Benefits of Unlocking Energy Efficiency.

24 Alliance to Save Energy, Doubling U.S. Energy Productivity by 2030, accessed July 2015, http://www.ase.org/sites/ase.org/files/full_commission_report.pdf.

The Bipartisan Policy Center also has issued a report that includes recommendations for improving the nation's energy productivity.[25] In addition to proposing policies like those contained in the Alliance's report, the Bipartisan Policy Center also recommends expanding the portfolio of energy resources; and modifying the federal government's role in energy markets, both of which may support achieving the energy productivity goal.[26]

The Council on Competitiveness and DOE's Clean Energy Manufacturing Initiative also focuses the nation's most senior private and public sector leadership on opportunities around energy productivity. The American Energy and Manufacturing Competitiveness Partnership—launched in 2012 and encompassing a series of nine dialogues and three summits—catalyzed a movement and set of recommendations to drive energy productivity through new-to-the-world public-private partnerships.[27] The partnership has two clear goals: to increase U.S. competitiveness in the production of clean energy products and to increase U.S. manufacturing competitiveness across the board by increasing energy productivity.

1.3 A Sample of Existing Efforts within and across the Federal Government

1.3.1 RESEARCH AND DEVELOPMENT OF NEW TECHNOLOGIES FOR INCREASING ENERGY PRODUCTIVITY

The federal government maintains a long-standing commitment to performing research and development in energy technology areas where private investments may not yet be justified. Research and development (R&D) funded in these areas is taking place at DOE, DOE national laboratories, the National Science Foundation, and Department of Defense (DOD). Examples of DOE program successes are included throughout the section on strategies for accelerating energy productivity (Section 2).

25 Bipartisan Policy Center, America's Energy Resurgence: Sustaining Success, Confronting Challenges (Washington, D.C.: Bipartisan Policy Center, 2013), accessed July 2015, http://bipartisanpolicy.org/library/americas-energy-resurgence-sustaining-success-confronting-challenges/.

26 Bipartisan Policy Center, America's Energy Resurgence: Sustaining Success, Confronting Challenges.

27 "American Energy & Manufacturing Competitiveness (AEMC) Partnership," Council on Competitiveness, accessed July 2015, http://www.compete.org/initiatives/compete-energy-a-manufacturing/22-aemc.

1.3.2 PROGRAMS TO DEPLOY INNOVATIVE TECHNOLOGIES

Once a new technology or practice is successfully demonstrated, financial and informational barriers can slow adoption. The federal government and its partners continue to address these barriers by helping energy consumers across all economic sectors manage their energy use and costs based on accessing the information needed to take action. Examples include the DOE Federal Energy Management Program (FEMP)'s energy savings performance contracts (ESPCs), DOD test beds, the General Services Administration's Green Proving Ground program, DOE's Weatherization and Intergovernmental Programs Office, the DOE and Environmental Protection Agency (EPA)'s State and Local Energy Efficiency in Action Network (SEE Action), and the Better Buildings Challenge initiative.

1.3.3 SETTING THE BAR FOR ENERGY PERFORMANCE

Through both market-based voluntary programs and regulatory standards, the federal government identifies commercial products that can be manufactured to limit the amount of energy needed to operate them, providing significant cost savings to the end user as well as significant public benefits. Examples include appliance standards, the EPA-led ENERGY STAR®, and vehicle fuel economy standards. For instance, DOE developed energy conservation standards for appliances and equipment, which saved consumers $60 billion on their energy bills in 2014.[28] This reduction of absolute energy use contributes directly to increasing energy productivity.

28 U.S. Department of Energy Office of Energy Efficiency and Renewable Energy, Saving Energy and Money with Appliance and Equipment Standards in the United States, DOE/EE-1086 (Washington, D.C.: U.S. Department of Energy, 2015), accessed July 2015, http://energy.gov/sites/prod/files/2015/07/f24/Appliance%20and%20Equipment%20Standards%20Fact%20Sheet%207-21-15.pdf.

The ten energy efficiency standards DOE finalized in 2014 alone will save U.S. families and businesses an estimated $67 billion in electricity bills through 2030.

STRATEGIES AND ACTORS FOR ENERGY PRODUCTIVITY

Achieving the goal of doubling energy productivity by 2030 will require action across the economy, in both the private and public sectors. This section identifies strategies for achieving the goal within each major sector. These strategies were gathered from roundtable discussions, regional dialogues, and endorsers of the goal that include a wide array of energy efficiency, energy productivity, smart grid, clean energy, advanced manufacturing, clean transportation, and other organizations committed to promoting energy-efficient economic growth. While not an exhaustive list, strategies provided in the *Roadmap* form a foundation to accelerate U.S. energy productivity. They also illustrate the broad range of actions available to citizens and a wide range of stakeholder groups that can share the benefits of achieving the productivity goal.

The energy productivity strategies presented in the *Roadmap* often involve multiple economic sectors and levels of government. To present a cohesive analysis of the potential impacts of the strategies, six productivity “wedges” were developed as representations of aggregate individual strategies. Table 1 provides a brief description of each wedge; Section 3 provides details about how the wedges were used in the energy productivity analysis. The six energy productivity wedges are color-coded throughout the *Roadmap*. The beginning of each strategy section identifies the relevant energy productivity wedges to highlight the connections between the strategies and the energy productivity analysis.

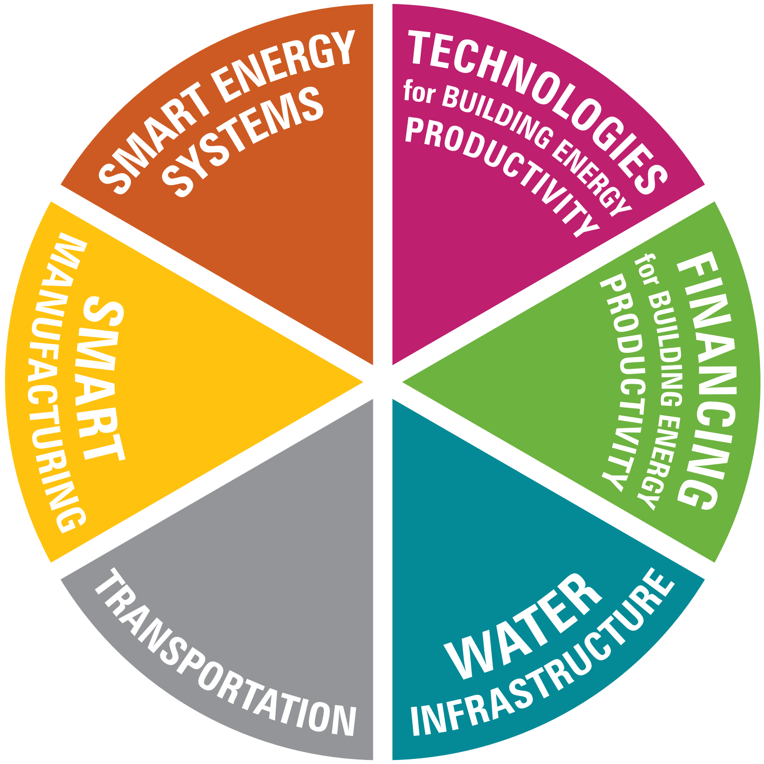


Table 1. Analysis Sources and Inputs: Summary Description of Energy Productivity Wedges

Energy Productivity Wedge	Description
Smart Energy Systems	Energy systems, particularly electricity generation systems and the electricity grid, are sources and enablers of improvements to U.S. energy productivity. Broad and deep transformations are required to enable transitions to distributed energy resources, real-time energy pricing, smart appliances, and increased energy efficiency.
Technologies for Buildings Energy Productivity	Improving the energy productivity of buildings requires both the widespread use of currently available energy-efficient technologies and practices, and the development of next generation technologies.
Buildings Energy Productivity Financing	Significant changes to financing mechanisms and market recognition of the value of energy productivity are required to ensure that energy productivity-enabling technology is used by businesses and households. This includes addressing real or perceived risk to the use and deployment of these technologies, which can immediately and adversely impact the cost of financing.
Smart Manufacturing	Sensors and other information and communications technology (ICT) will allow industries better control over their processes and improved energy management of their buildings.
Transportation	Increasing the energy productivity of moving goods and people relies on developing and deploying new technologies that increase vehicle efficiency, increasing options for mass transit, and better integrating transportation needs with the built environment to reduce the demand for motorized transport.
Water Infrastructure	Reducing energy consumption at water and waste water treatment plants and in water conveyance and distribution systems involves three actions: 1) improving energy efficiency and demand response; 2) implementing emerging technologies and processes; and 3) deploying energy recovery and generation technologies.

Renewable Energy's Role in Growing Energy Productivity

To calculate the primary energy of electricity generated from noncombustable renewable energy sources (i.e., hydroelectric, geothermal, solar, and wind), the EIA assumes a heat rate equal to the average heat rate of electricity generated from fossil fuels. The energy productivity analysis for the Roadmap instead uses the heat content of electricity, which is approximately one-third the value of the fossil fuel average heat rate, in its primary energy accounting. This approach is consistent with International Energy Agency accounting of primary energy production,[1] and it was chosen to avoid ascribing transformation losses where they do not exist in electricity production from solar, wind, and other noncombustable renewables. The effect is that replacing fossil generation with generation from noncombustable renewables can improve energy productivity, although this was not a focus of the analysis performed for this Roadmap.

1 OECD, IEA, and Eurostat, Energy Statistics Manual, (Paris: OECD, 2005), accessed July 2015, http://www.iea.org/publications/freepublications/publication/statistics_manual.pdf.

2.1 Government

Action from all levels of government is necessary to accelerate energy productivity. The identified strategies recognize government's own energy use, as well as interactions and responsibilities each level of government has with respect to businesses and private citizens.

2.1.1 FEDERAL GOVERNMENT

Throughout the Accelerate Energy Productivity 2030 meetings, stakeholders emphasized ways the federal government, through a range of policies and programs, can drive increases in U.S. energy productivity. While federal agencies are advancing energy productivity across different sectors of the U.S. economy through existing programs, policies, and proposals for innovative new strategies, they have the potential to do even more. For example, federal minimum efficiency standards for appliances and equipment cover the vast majority of energy use in buildings including 88 percent of all residential energy use, 77 percent of all commercial energy use, and 26 percent of industrial energy use. The standards promulgated by DOE since January 2009 will cumulatively save over 39 quadrillion Btu of energy by 2030. As an additional example, the 2015 Clean Power Plan is expected to drive energy efficiency across states, resulting in a 7 percent reduction in electricity demand by 2030.[29]

The federal government can play a role in promoting energy productivity strategies in five areas: (1) supporting the R&D of new technologies and strategies; (2) using regulatory programs to secure energy and cost savings; (3) setting

29 "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.

the financial foundation through revised tax policies; (4) identifying and reducing barriers to the adoption of innovative, proven strategies; and (5) leading by example in adopting and deploying new technologies and strategies in its own operations. Actions taken by the federal government 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

2.1.1.1 Investing in Long-Term Energy Productivity: Research and Development

The federal government has an established role in conducting and supporting long-term R&D—the fundamental seed of innovation. This is a vital role because, as the Congressional Budget Office states in its 2014 report, *Federal Policies and Innovation*[30], "Innovation is a central driver of economic growth in the U.S. Workers become more productive when they can make use of improved equipment and processes, and consumers benefit when new goods and services become available or when existing ones become better or cheaper—although the transition can be disruptive to established firms and workers as new products and processes supersede old ones. Innovation produces some benefits for society from which individual innovators are not able to profit, and, as a result, those innovators tend to underinvest in such activity. Policymakers endeavor to promote innovation to compensate for that underinvestment. The federal government influences innovation through two broad channels: spending and tax policies, and the legal and regulatory systems." The report adds, "Because the effects of innovation on the economy can be difficult to measure, economists typically use the growth in total factor productivity (TFP) as a proxy. Growth in TFP is defined as the growth of real output that is not explained by increases in the amount of labor and capital—typically physical structures and equipment used in production, along with intangible capital such as computer software and research and development (R&D)." The more efficient use of physical resources, such as energy, can also translate into gains in TFP. For example, in its *2014 Global R&D Funding Forecast*, Battelle projected a 1.2 percent decline in U.S. investment in aerospace, defense, and security R&D.[31] To ensure continued increases in U.S. energy productivity through 2030 and beyond, federal R&D will be essential to continuing to advance the technical potential and lowering the costs of productivity-enabling technologies. The following are a few key areas of technology R&D that will help achieve the goal.

30 United State Congressional Budget Office, Federal Policies and Innovation (Washington, D.C.: U.S. Congressional Budget Office, 2014), accessed July 2015, http://www.cbo.gov/publication/49487.

31 Martin Grueber and Tim Studt, 2014 Global R&D Funding Forecast (Columbus, OH: Battelle and R&D Magazine, 2013), accessed July 2015, http://www.battelle.org/docs/tpp/2014_global_rd_funding_forecast.pdf.

2.1.1.1.1 Transportation Technologies

The development and deployment of technologies that displace fossil-based transportation fuels or reduce fuel consumption are critical to doubling energy productivity. Federal efforts in vehicle technology R&D span eight agencies. Areas of work include light-weight materials; next-generation aircraft configurations; alternative fuels and lubricants; hybrid propulsion systems; batteries and energy storage; electrical power management between vehicles and the grid; afloat power systems; locomotive engine efficiency; exhaust emissions reduction; vehicle automation; and baseline safety performance of electric vehicles. The fiscal year (FY) 2016 budget requests $1.3 billion for vehicle technology R&D (e.g., automobiles, aircraft, and locomotives), 95 percent of which is divided across the agencies that have transportation programs, such as DOE, DOD, and the National Aeronautics and Space Administration (NASA).[32]

DOE's investments in hybrid and electric vehicle technologies have helped drivers save one billion gallons of gasoline between 1999 and 2012, and they are projected to save another billion gallons by 2022, in total saving consumers $7.3 billion from 1999 through 2022.[33]

Beyond electric and hybrid vehicles, DOE investment in advanced combustion engines has drastically improved the efficiency of cars on the road. A 2010 study estimates that between 1995 and 2007, DOE-supported R&D on advanced combustion engines saved 17.6 billion gallons of diesel fuel, which is equivalent to a 1 percent reduction in total crude oil imports to the United States over those twelve years.[34] The DOE's SuperTruck Initiative, which aims to increase tractor-trailer efficiency by 50 percent over baseline models by 2015, has demonstrated a vehicle that increases freight efficiency by 115 percent and saves $20,000 per year on fuel costs.[35] Federal policies incentivizing the conversion of all Class 8 vehicles[36] into "SuperTrucks" could save the United States $30 billion in annual fuel costs.[37]

32 Executive Office of the President Office of Management and Budget, Government-Wide Funding for Clean Energy Technology (Washington, D.C.: The White House, 2015), accessed July 2015, https://www.whitehouse.gov/sites/default/files/omb/budget/fy2016/assets/fact_sheets/government-wide-funding-for-clean-energy-technology.pdf.

33 Albert N. Link, Alan C. O'Connor, Troy J. Scott, Sara E. Casey, Ross J. Loomis, and J. Lynn Davis, Benefit-Cost Evaluation of U.S. DOE Investment in Energy Storage Technologies for Hybrid and Electric Cars and Trucks (Washington, D.C.: U.S. Department of Energy Office of Energy Efficiency and Renewable Energy, 2013), accessed July 2015, http://www1.eere.energy.gov/analysis/pdfs/2013_bca_vto_edvs.pdf.

34 Albert N. Link, Retrospective Benefit-Cost Evaluation of U.S. DOE Vehicle Combustion Engine R&D Investments: Impacts of a Cluster of Energy Technologies (Washington, D.C.: U.S. Department of Energy Office of Energy Efficiency and Renewable Energy, 2010), accessed July 2015, http://www1.eere.energy.gov/analysis/pdfs/advanced_combustion_report.pdf.

35 "SuperTruck Initiative Partner Improves Class 8 Truck Efficiency by 115%," U.S. Department of Energy, last modified June 23, 2015, http://energy.gov/eere/success-stories/articles/supertruck-initiative-partner-improves-class-8-truck-efficiency-115.

36 A Class 8 vehicle has a gross vehicle weight of more than 33,000 pounds. See "Vehicle Weight Classes & Categories," U.S. Department of Energy Alternative Fuels Data Center, accessed July 2015, http://www.afdc.energy.gov/data/10380.

37 The White House, Improving the Fuel Efficiency of American Trucks: Bolstering Energy Security, Cutting Carbon Pollution, Saving Money and Supporting Manufacturing Innovation (Washington, D.C.: The White House, 2014), accessed July 2015, https://www.whitehouse.gov/sites/default/files/docs/finaltrucksreport.pdf.

2.1.1.1.2 Building Technologies

R&D on next-generation building technologies will lead to advances in end uses representing the majority of building energy consumption, including efficient and cost-competitive lighting, heating and cooling technologies, and windows that decrease energy demand, reduce energy costs for consumers, and improve comfort. DOE also invests in whole-building R&D that demonstrates how new energy-efficient technologies can function together to create an efficient system and achieve greater overall energy bill savings for families and businesses. DOE is also performing applied research on methods to reduce U.S. building-related energy use in existing homes.

As part of the American Recovery and Reinvestment Act of 2009 (ARRA), DOE initiated the Better Buildings Neighborhood Program to both accelerate the adoption of energy-efficient technologies in buildings and generate employment and economic activity during the worst economic crisis in a generation. Between 2010 and 2012, the program created over 4,200 jobs, generated over $155 million in personal income, and saved nearly 1.4 trillion Btu of energy. The standards finalized since the inception of the program are estimated to save 127 quads of energy and offer consumers utility bill savings of $1.8 trillion by 2030.

2.1.1.1.3 Manufacturing Technologies

Development of advanced materials for solar energy conversion, refrigeration systems, and reduced vehicle component mass (i.e., “lightweighting”) carry significant potential for improving U.S. energy productivity, through both the use of the materials in U.S. products and the increased global competitiveness that would be realized by developing and manufacturing them in the United States. As an FY 2016 key focus area of DOE’s Clean Energy Manufacturing Initiative, DOE offices will collaborate in a crosscutting advanced materials development acceleration effort across the Department. One such effort is the recently announced Clean Energy Manufacturing Innovation Institute on Smart Manufacturing. Smart Manufacturing represents an emerging opportunity faced broadly by the U.S. manufacturing sector to merge information and communications technologies with the manufacturing environment for the real-time management of energy, productivity, and costs in American factories all across the country. Smart Manufacturing was recently identified by private sector and university leaders in the White House’s Advanced Manufacturing Partnership 2.0 as one of the highest priority manufacturing technology areas in need of federal investment.

The most recent analysis of DOE’s manufacturing technology R&D estimated that in 2009, technologies developed with DOE’s support were responsible for saving over 53 trillion Btu. In addition to these energy savings, industrial facility management programs focused on energy-efficient production were able to save 35 trillion Btu and helped businesses save $218 million in energy cost.[38] In addition to saving energy, these technologies allow manufacturers to increase productivity, reduce resource consumption, decrease emissions, and enhance product quality, making U.S. manufacturers more competitive globally.

2.1.1.2 Securing Energy Productivity: Performance Information and Product Standards

To ensure widespread access to productivity gains from continuing technological advances, the federal government sets energy performance standards for many types of appliances and equipment. Efforts to gain consensus between manufacturers, consumers and other stakeholders, federal agencies (including DOE, EPA, and Department of Transportation (DOT)) have established market-based programs and finalized rules to promote efficient products. DOE's appliance standards program sets minimum energy efficiency standards for approximately 60 categories of appliances and equipment used in homes, businesses, and other applications. The ten energy efficiency standards DOE finalized in 2014 alone will save U.S. families and businesses an estimated $67 billion in electricity bills through 2030 and will reduce U.S. energy use by nearly 4.9 quads per year. DOE also determines mandatory efficiency requirements for new federal, commercial, and residential buildings and develops energy efficiency standards for manufactured homes.[39]

In the transportation sector, fuel economy and greenhouse gas emission standards for light-duty vehicles finalized in 2010 and 2012 by EPA and DOT are projected to save families more than $1.7 trillion in fuel costs.[40] EPA and DOT have also proposed standards to further improve fuel economy in heavy-duty vehicles that could reduce fuel costs by $170 billion.[41]

The federal government also secured energy productivity gains by partnering with industry to voluntarily identify energy-efficient projects. The ENERGY STAR® program now features 16,000 partners from across every sector of the U.S. economy, with 70 different product categories and estimated customer savings of nearly $300 billion.[42]

The federal government has the ability to continue its work convening industry experts to develop recognized standards for how energy savings are calculated from a wide variety of measures. This will help ensure that policymakers, financiers, and customers can be confident that investments supporting energy productivity will reliably reduce energy use and save money. The *Quadrennial Energy Review* (QER) released in early 2015 recommended that DOE accelerate

38 U.S. Department of Energy Industrial Technologies Program, Industrial Technologies Program: Summary of Program Results for CY 2009 (Washington, D.C.: U.S. Department of Energy, 2009), accessed July 2015, http://www1.eere.energy.gov/manufacturing/about/pdfs/impacts2009_full_report.pdf.

39 U.S. Department of Energy Office of Energy Efficiency and Renewable Energy, "Regulations & Rulemaking", last updated July 28, 2014, https://www.energycodes.gov/regulations.

40 U.S. Environmental Protection Agency, EPA and NHTSA Set Standards to Reduce Greenhouse Gases and Improve Fuel Economy for Model Years 2017-2025 Cars and Light Trucks, EPA-420-F-12-051 (Washington, D.C.: U.S. Environmental Protection Agency, 2012), accessed July 2015, http://www.epa.gov/otaq/climate/documents/420f12051.pdf.

41 U.S. Environmental Protection Agency, Cutting Carbon Pollution, Improving Fuel Efficiency, Saving Money, and Supporting Innovation for Trucks, EPA-420-F-15-900 (Washington, D.C.: U.S. Environmental Protection Agency, 2015), accessed July 2015, http://www.epa.gov/otaq/climate/documents/420f15900.pdf.

42 "About ENERGY STAR," Energy STAR, accessed July 2015, http://www.energystar.gov/about.

the development of uniform methods for measuring energy savings and promote widespread adoption of these methods in public and private efficiency programs.[43] This effort will reduce information barriers to efficiency investments, making it easier for consumers to reduce their energy bills.

2.1.1.3 Setting the Financial Foundation for Energy Productivity: Tax Policy

Tax policy can be a powerful instrument for the federal government to influence decision makers and transform the economy. Taxes may discourage individuals and business from actions that have negative economic and environmental consequences, while tax credits can encourage outcomes, such as private-sector R&D or capital investments, with positive effects for society. Smart, well-directed national tax policy is a tool the federal government could further employ if the United States is to double energy productivity by 2030. Specific examples follow for households and private-sector R&D. As proposed, the FY 2016 Federal budget includes research and clean energy incentives, including the Research and Experimentation Tax Credit, the renewable energy Production Tax Credit, and the Investment Tax Credit.[44]

2.1.1.3.1 Tax Policy for Households

Individual tax credits for residential energy efficiency and passive solar investments can increase the adoption of technologies that will reduce household energy use beyond what minimum efficiency standards and building codes require. Federal tax incentives have been shown to be successful in transforming the efficiency of residential appliances and new construction. Between 2006 and 2009, a targeted tax credit for builders aimed at increasing the amount of energy-efficient new construction was able to quadruple the number of homes built that are twice as efficient as the required building energy code. Another targeted tax credit for manufacturers was instrumental in doubling the market share of energy-efficient clothes washers in just two years.[45]

A variety of federal tax credits is available for retrofit investments in energy-efficient and clean energy technologies, specifically geothermal heat pumps. However, these tax credits are available only for owner-occupied housing and cannot be claimed for rental properties, which constitute over 33 percent of households.[46] Tax credits that include rental properties could spur a transformation similar to what is occurring in owner-occupied housing. This tax credit could be combined with informational programs, including policies that require building owners to disclose energy use to further incentivize equipment upgrades in rental properties.

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

44 Office of Management and Budget, Fiscal Year 2016 Budget of the U.S. Government (Washington, D.C.: U.S. Government Printing Office, 2015), accessed July 2015, https://www.whitehouse.gov/sites/default/files/omb/budget/fy2016/assets/budget.pdf.

45 Rachel Gold and Steven Nadel, Energy Efficiency Tax Incentives, 2005–2011: How Have They Performed? (Washington, D.C.: American Council for an Energy-Efficient Economy, 2011), accessed July 2015, http://aceee.org/sites/default/files/pdf/white-paper/Tax%20incentive%20white%20paper.pdf.

46 U.S. Census Bureau, 2009-2013 5-Year American Community Survey, accessed July 2015, http://www.census.gov/programs-surveys/acs/data.html.

2.1.1.3.2 Tax Policy for Private-Sector R&D

The federal government could support the development of advanced manufacturing through tax credits. One example of such a proposal is from the President's Council of Advisors on Science and Technology in 2011 that recommended reforming corporate income taxes and permanently extending and increasing the R&D tax credit.[47]

2.1.1.3.3 Tax Policy for Clean Energy Technologies

Stable and refundable tax credits for the production of renewable energy could provide a strong, consistent incentive to encourage investments in renewable energy sources such as wind and solar, create jobs, and support U.S. companies. These new investments, in addition to increased generation of electricity from noncombustible renewables, represent potential gains in energy productivity for the overall economy. Conversely, cyclic or unpredictable tax credits can have an adverse effect on the development of renewable energy. Additionally, the federal government can pursue new tax credits for installation of alternative fuel equipment. Customers may be more likely to adopt electric vehicle technology with faster charging, but direct current (DC), fast-charging technology is currently expensive. As is done with the amenity model where businesses provide no-cost chargers to attract customers, the government could provide tax incentives to businesses that install fast-charging technology, especially during new construction. In all cases, the stability and predictability of renewable energy tax policy is key to its effectiveness.

2.1.1.4 Workforce Training

Some DOE programs, such as the Industrial Assessment Center (IAC) program[48] and the Solar Ready Vets program,[49] support the type of workforce training that will be integral to meeting the energy productivity goal. The federal government should continue and expand on its partnerships with community and technical colleges, universities, and trade organizations to advance curricula and skills for training the next generation of leaders in energy productivity and clean energy manufacturing.

In September 2014, DOE's SunShot Initiative launched the Solar Ready Vets program to connect the nation's skilled veterans with the solar energy industry, preparing them for careers as solar photovoltaic (PV) system installers, sales representatives, system inspectors, and in other industry-related occupations. Solar Ready Vets trains active military personnel—who are "transitioning military" status—within a few months of leaving military service and becoming veterans. The initiative is

47 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.

48 "Industrial Assessment Centers (IACs)," U.S. Department of Energy, accessed July 2015, http://energy.gov/eere/amo/industrial-assessment-centers-iacs.

49 "Solar Ready Vets," U.S. Department of Energy, accessed July 2015, http://energy.gov/eere/sunshot/solar-ready-vets.

enabled by the DOD's SkillBridge initiative, which allows exiting military personnel to pursue civilian job training, employment skills training, apprenticeships, and internships up to six months prior to their separation.

DOE's IACs train the next generation of energy-savvy engineers, more than 60 percent of whom pursue energy-related careers upon graduation. IAC assessments are in-depth evaluations of a facility conducted by engineering faculty with junior and senior college students, and graduate students from participating universities. Small-and medium-sized manufacturers may be eligible to receive a no-cost assessment provided by IACs. Over 16,000 IAC assessments have been conducted. Typically, IACs identify more than $130,000 in potential annual savings opportunities for every manufacturer assessed, nearly $50,000 of which is implemented during the first year following the assessment.

2.1.1.5 Implementing Strategies for Energy Productivity: Demonstrations and Leading by Example

The federal government is the single largest consumer of energy in the U.S. economy, but its use of 0.96 quadrillion Btu in FY 2014 was the lowest since tracking began in 1975.[50] Other federal building and facility accomplishments include reducing Scope 1 and 2 greenhouse gas emissions by 17.4 percent, using 8.8 percent renewable electricity, reducing potable water use by 21 percent,[51] and reducing the energy use per square foot of building space by 21 percent. By expanding its use of proven strategies to improve energy efficiency, the federal government can provide public services at lower cost, saving taxpayer dollars and helping realize the benefits of doubled energy productivity. Through Executive Order 13693, President Obama directed federal agencies to reduce energy intensity (Btu/gross square foot) in federal buildings by 2.5 percent per year from an FY 2015 baseline through FY 2025.[52] Executive vehicle fleets also have been directed to achieve maximum fuel efficiency.[53]

The federal government has expanded and extended the Presidential Performance Contracting Challenge—one tool to achieve the savings goal—to deploy $4 billion in energy-saving and renewable energy projects at government facilities through 2016. DOE's FEMP will continue to support the challenge by working with agencies to meet the $4 billion goal and by helping agencies continue to accelerate their use of performance contracts to meet future energy investment needs and goals. FEMP will also share and rely on best practices from the challenge to partner with other government and private-sector stakeholders and partners to accelerate their use of performance contracts.[54]

50 "Federal Comprehensive Annual Energy Performance Data," U.S. Department of Energy, accessed July 2015, http://www.energy.gov/eere/femp/federal-facility-annual-energy-reports-and-performance.

51 Chris Tremper, "Federal Progress toward Energy/Sustainability Goals" (presented June 10, 2014), accessed July 2015, http://energy.gov/sites/prod/files/2015/06/f22/facility_sustainability_goals.pdf.

52 Executive Order 13693—Planning for Federal Sustainability in the Next Decade, 80 Fed. Reg. 57 (March 25, 2015), accessed July 2015, http://www.gpo.gov/fdsys/pkg/FR-2015-03-25/pdf/2015-07016.pdf.

53 The White House Office of the Press Secretary, "Presidential Memorandum--Federal Fleet Performance," news release, May 24, 2011, https://www.whitehouse.gov/the-press-office/2011/05/24/presidential-memorandum-federal-fleet-performance.

54 "Federal Energy Management Program," U.S. Department of Energy, accessed July 2015, http://www.energy.gov/eere/femp/federal-energy-management-program.

For technologies and systems that have the potential to reduce energy costs but require further demonstration before becoming market-ready, the federal government leverages its full portfolio of facilities as testbeds for innovation. The General Services Administration's Green Proving Ground program leverages government real estate and facilities to evaluate sustainable building technologies in the pre- or early-commercial stages of development and to provide recommendations on their deployment.[55] DOD's Installation Energy Test Bed program features projects to demonstrate emerging technologies for building efficiency, energy management, smart microgrids, energy storage and distributed renewable generation. These projects will help identify technologies that can be adopted at government and private facilities across the United States while simultaneously helping DOD reduce its facility energy bill, which totals roughly $4 billion per year.[56]

Programs across several agencies provide opportunities to deploy strategies to improve energy productivity:

- **Reducing Energy Costs in Multifamily Homes:** The U.S. Department of Housing and Urban Development provides the $25-million Multifamily Energy Innovation Fund, which enables affordable housing providers, technology firms, academic institutions, and philanthropic organizations to test new approaches to delivering cost-effective, residential energy efficiency upgrades.[57]
- **Improving Energy Productivity in Rural Communities:** As soon as the third quarter of 2015, the U.S. Department of Agriculture's Rural Utilities Service will have finalized a proposed update to its Energy Efficiency and Conservation Loan Program to provide up to $250 million for rural utilities to finance efficiency investments by businesses and homeowners across rural America.[58] The Department of Agriculture is also streamlining its Rural Energy for America Program to provide grants and loan guarantees directly to agricultural producers and rural small businesses for energy efficiency and renewable energy systems.[59] These programs will help reduce energy costs for rural households and businesses, allowing savings to be reinvested in local communities.
- **Improving Energy Productivity in Transportation:** Plug-in electric vehicles (PEVs), including plug-in hybrid electric vehicles (PHEVs) and all-electric vehicles (EVs), offer the potential of lower primary energy than conventional gasoline vehicles. The adoption of PEVs would benefit from introducing and refining new technologies for batteries, drivetrains, and other vehicle components. Expanding the number of charging stations and related infrastructure would also promote adoption of PEVs as well as enable new electricity supply and demand options by integrating PEVs with building energy use.
- **DOE's Workplace Charging Challenge:** This program, which seeks a tenfold increase in the number of employers providing workplace-charging stations, estimates that the employees of participating businesses are twenty times as

55 "What is GPG?" U.S. General Services Administration, last modified August 12, 2015, http://www.gsa.gov/portal/category/102575.

56 "Installation Energy Test Bed," The Strategic Environmental Research and Development Program and The Environmental Security Technology Certification Program, accessed July 2015, https://www.serdp-estcp.org/Featured-Initiatives/Installation-Energy.

57 "Multifamily Energy Innovation Fund," U.S. Department of Housing and Urban Development, accessed July 2015, http://portal.hud.gov/hudportal/HUD?src=/program_offices/housing/mfh/presrv/energy.

58 Executive Office of the President, The President's Climate Action Plan (Washington, D.C.: The White House, 2013), accessed July 2015, https://www.whitehouse.gov/sites/default/files/image/president27sclimateactionplan.pdf.

59 "Rural Energy for America Program Renewable Energy Systems & Energy Efficiency Improvement Loans & Grants," U.S. Department of Agriculture Rural Development, accessed July 2015, http://www.rd.usda.gov/programs-services/rural-energy-america-program-renewable-energy-systems-energy-efficiency.

likely to drive a PEV as the average worker. As of June 2014, the partner charging stations provided an estimated 6.7 million kilowatt-hours (kWh) annually or approximately 0.8 percent of estimated light-duty vehicle electricity use in 2014.

2.1.2 STATE GOVERNMENT

State governments possess a wide range of tools to drive energy productivity in state operations as well as in the private sector, and they can play an important role in supporting and leveraging local government-led efforts. The *Roadmap* highlights state strategies for increasing the energy productivity of buildings and transportation systems, enabling the smart grid, and improving energy productivity financing mechanisms. Workforce development programs offered by state universities and technical colleges are discussed in Section 2.5. Actions taken by state governments 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

2.1.2.1 Energy Efficiency Portfolio Resource Standards

Where appropriate, energy productivity improvements can come from state implementation of energy efficiency resource standards or energy efficiency portfolio standards. In general, portfolio standards establish performance targets for the amount of energy efficiency improvements achieved, which then allow market forces to identify the most cost-effective way(s) to achieve the targets. Currently, 26 states have an energy efficiency portfolio standard.[60]

2.1.2.2 Energy Productivity Financing

States can reduce barriers to business and household adoption of energy productivity technology by focusing on strategies to improve financing mechanisms.[61] One such strategy is to develop secondary markets for energy efficiency

60 Counts for both types of portfolio standards were obtained from http://www.dsireusa.org/. The figure for energy efficiency portfolio standards includes states with voluntary or underfunded goals, such as those for Delaware, Florida, Missouri, and Virginia. Other states have repealed (Indiana), have frozen (Ohio), or are considering repealing their energy efficiency portfolio standards (Michigan). Conversely, other states, such as Maryland and Pennsylvania, have extended theirs.

61 State and Local Energy Efficiency Action Network, Energy Efficiency Financing Program Implementation Primer (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/financing_primer_0.pdf.

loans, such as those provided under the Warehouse for Energy Efficiency Loans (WHEEL) program.[62] WHEEL is a public-private partnership sponsored by states, local governments, and utilities. It uses public funds and private capital to provide funding for energy improvement projects.

Other financing strategies involve using public funding to unlock private capital. For example, Connecticut's Property Assessed Clean Energy (C-PACE) program has used property assessed clean energy (PACE) financing.[63] Revolving loan funds are another source of financing for energy productivity. They offer long-term, low-interest rate financing for initiatives such as building efficiency retrofits and job creation. Revolving loan funds also support on-bill repayment, ESPCs, and public-private partnerships. Currently, 79 revolving loan funds programs across 44 states represent over $2 billion in financing.[64] Utilities, businesses, and lending institutions also have significant potential to improve access to financing for energy productivity investments, and these are discussed in subsequent sections.

The Keystone Home Energy Loan Program (Keystone HELP) is an example of a specialized loan program for improvements in home energy efficiency. Under the program, which is supported by the Pennsylvania Treasury Department and the Pennsylvania Department of Environmental Protection, homeowners seeking financing for their energy efficiency and renewable energy related home improvements can apply for low fixed-rate loans with repayment periods of up to ten years.[65] Under the program, homeowners have financed over $63 million in projects since the program began in 2006, and they have saved $2.3 million annually on utility bills.[66]

Finally, regulators can more effectively incentivize utility energy and water efficiency programs using a three-pronged approach that includes cost recovery, throughput incentives, and earnings opportunities.[67] Cost recovery options, such as escrow and rate riders, enable utilities to recover energy efficiency costs roughly when they occur. Throughput incentives address reduced energy and water sales from efficiency by decoupling sales from revenues. Earning opportunities, such as a share of energy and water efficiency program net benefits, could be provided to utilities as incentives for achieving energy efficiency program success.

62 "Warehouse for Energy Efficiency Loans (WHEEL)," National Association of State Energy Officials, accessed July 2015, http://www.naseo.org/wheel.

63 "C-PACE," Connecticut Green Bank, accessed July 2015, http://www.c-pace.com/.

64 National Association of State Energy Officials, State Energy Revolving Loan Funds (Arlington, VA: National Association of State Energy Officials, 2013), accessed July 2015, http://www.naseo.org/Data/Sites/1/documents/selfs/state_energy_rlf_report.pdf.

65 "Financing Program," EnergyLoan, accessed July 2015, http://www.energyloan.net/info/financing-program.

66 "Keystone Help," Pennsylvania Treasury, accessed July 2015, http://www.patreasury.gov/website-redesign/earn/keystonehelp/.

67 Dan York and Martin Kushler, The Old Model Isn't Working: Creating the Energy Utility for the 21st Century (Washington, D.C.: American Council for an Energy-Efficient Economy, 2011), accessed July 2015, http://aceee.org/files/pdf/white-paper/The_Old_Model_Isnt_Working.pdf.

FINANCING SUCCESS STORY

Massachusetts Leads by Example

The Commonwealth of Massachusetts, a DOE Better Buildings Challenge partner, in 2007 set ambitious energy savings targets for the Commonwealth to reduce energy use intensity 20 percent by 2012 and 35 percent by 2020, based on 2004 levels. However, in the wake of the national economic downturn in 2008, a steep decline in project financing from banks and energy service companies stranded a three-year pipeline of $237 million in energy efficiency projects. In 2010, Massachusetts responded by creating an innovative financing model called the Clean Energy Investment Program (CEIP). The program invests in projects using bond funding which is repaid from the energy savings generated by the projects. The bonds are obtained at the same time as general obligation bonds; however, Massachusetts leverages this low-cost financing without hitting the Commonwealth's general obligation debt limits.

In four years, CEIP mobilized 28 projects for more than $136 million across 15 million square feet of Commonwealth buildings with projected annual savings of $14.3 million over the life of the bond terms, which can often equal or sometimes exceed 20 years. These projects represent greater Commonwealth investment in energy efficiency than in the previous 25 years. The Commonwealth also has a pipeline of approximately $260 million for 74 ready-to-go energy efficiency projects, which will generate $22 million in annual savings over the terms of the contracts, typically 10–20 years. Massachusetts maintained the top spot on the American Council for an Energy-Efficient Economy's State Energy Efficiency Scorecard for four consecutive years, and it attributes its success in part to operationalizing its energy efficiency policies for its facilities via CEIP program financing. The Commonwealth plans to make CEIP financing available to additional energy retrofit initiatives.

The Commonwealth of Massachusetts is now working with 42 separate Commonwealth agencies to track, measure, and report energy savings annually. In all, 29 of the 42 agencies have seen energy reductions from the baseline, demonstrating that energy reductions are broad and have occurred across the majority of the Commonwealth's portfolio. In 2014, Massachusetts reduced energy use intensity by 7 percent as part of CEIP and other efforts, bringing total savings to 16 percent across its entire 65 million square feet portfolio of Commonwealth-owned buildings.

2.1.2.3 Combined Heat and Power

States have an important role in supporting the installation of new combined heat and power (CHP) capacity, a significant enabler of increased energy productivity. Achieving the national goal of 40 gigawatts (GW) of new, cost-effective CHP by 2020 would save energy users $10 billion per year, conserve one quad of energy, and result in $40 billion–$80 billion in new capital investment in manufacturing over the course of a decade.[68] States can support CHP installation through several strategies, including folding CHP requirements into energy efficiency portfolio standards (discussed in Section 2.1.2.1), reconsidering standby rate regimes that better align the economics of CHP facilities and utilities, and revising interconnection standards.[69]

The DOE's Advanced Manufacturing Office (AMO) provides CHP Technical Assistance Partnerships (CHP TAPs) that offer market analysis for CHP opportunities, education and outreach on the energy and non-energy benefits of CHP, and technical assistance to help end-users through the project development process. Between fiscal year (FY) 2009 and FY 2013, centers sponsored by the Advanced Manufacturing Office provided technical support to over 590 CHP projects. About 350 of those projects received "Technical Site Evaluations" (either alone or in conjunction with other support) while the rest were provided with other types of technical assistance, often on multiple occasions. Of those projects, more than 190 are currently under development or online with a total capacity of 1.54 GW.[70]

2.1.2.4 Smart Regional Transportation Solutions

Improving the energy productivity of regional transportation systems involves increasing both the energy efficiency of transportation modes and the economic benefits of transportation services. Transportation options that are more energy productive, such as multi-modal transportation options, can benefit the movement of goods and people. State transportation planning (as well as land use planning) provides opportunities to directly influence energy productivity and increase collaboration of state governments and communities. States can also provide support for electric vehicles, which may reduce primary energy use relative to conventional gasoline vehicles and which may have economic and other benefits. Opportunities for regional transportation organizations to incentivize reduced vehicle energy use are discussed in Section 2.1.3.

68 U.S. Department of Energy Advanced Manufacturing Office, Combined Heat and Power: A Clean Energy Solution, DOE/EE-0779 (Washington, D.C.: U.S. Department of Energy, 2012), accessed July 2015, http://www1.eere.energy.gov/manufacturing/distributedenergy/pdfs/chp_clean_energy_solution.pdf.

69 State and Local Energy Efficiency Action Network, Guide to the Successful Implementation of State Combined Heat and Power Policies (Washington, D.C.: U.S. Department of Energy Office of Energy Efficiency and Renewable Energy, 2013), accessed July 2015, http://www4.eere.energy.gov/seeaction/system/files/documents/see_action_chp_policies_guide.pdf.

70 Claudia Tighe, "CHP Deployment Program: AMO Technical Assistance Overview," (presented 2014), accessed July 2015, http://energy.gov/sites/prod/files/2014/06/f17/CHP%20Deployment%20Program.pdf.

TRANSPORTATION SUCCESS STORY

Los Angeles County Metropolitan Transportation Authority - Encouraging Consumer Acceptance of Energy Efficiency through Electric Vehicles

The Los Angeles County Metropolitan Transportation Authority (Metro) has a unique function among the nation's transportation agencies. It serves as the transportation planner and coordinator, designer, builder and operator for one of the country's largest, most populous counties. More than 9.6 million people – nearly one-third of California's residents – live, work, and play within its 1,433-square-mile service area. Metro recognizes the importance of energy efficiency, while ensuring that its transit and transportation network continues to be resilient in changing times. In 2011, Metro developed a comprehensive Energy Conservation and Management Plan (Energy Plan) that provides a blueprint for Metro's overall energy management and use. The Energy Plan incorporates elements of the Metro Board-adopted Energy and Sustainability and Renewable Energy Policies. By 2020, Metro's goal is 33 percent renewable energy use, and the agency is well on its way to hitting that target. Metro is now at 25 percent. The emergence of electric vehicles as an alternative type of personal transportation influenced how Metro plans for an integrated multi-modal transportation network. In 2013, Metro deployed, through a California Energy Commission (CEC) funded pilot program, twenty electric vehicle charging stations at five of Metro's park and ride locations. This type of electric vehicle charger network is the first of its kind that is operated and maintained by a transit agency in the United States.

The placement of electric vehicle chargers at Metro park and ride locations was strategic. Charge stations at Metro park and ride facilities provide much needed infrastructure to Plug-In Electric Vehicle (PEV) users, but also provide those users with connectivity to Metro's other modes of transportation. This powerful link enables important consumer behavioral changes by blending two low-carbon transportation options: PEV and public transportation via rail and any of Metro's natural gas fueled buses. Additionally, by placing PEV infrastructure at Metro transit stations, Metro provides visual reinforcement to a large number of potential PEV adopters that there is a charging network readily available. Further, connected through a support network that subscribes EV charger users, collects payments, and provides operations and maintenance support, Metro's electric vehicle charger stations provide a seamless integrated mobility solution.

Using Metro's approach to incorporating EV chargers into its park and ride stations as a fundamental strategy, Southern California Edison has successfully applied for a tariff to fund extensive deployment of electric vehicle chargers across Southern California, ensuring that the transit and electric vehicle nexus continue to be a viable option in avoiding trips and traffic congestion in Southern California roads and highways. Through another CEC grant, Metro is currently expanding its EV charger network to an additional five park and ride locations. It is also leveraging local fiscal year 2016 funding to deploy EV chargers at four rail divisions and 11 bus divisions for workplace charging. Metro will ultimately deploy electric vehicle chargers throughout its system and workplace locations.

Metro continues to explore innovative ideas to ensure energy resiliency, including powering EV chargers with renewable energy sources (such as solar panels connected to deployable storage systems) and using those chargers as a source of emergency power. Metro's procurement to use biomethane as bus fleet fuel (instead of fossil natural gas) will further enhance Metro's greenhouse gas emissions reduction efforts for the Los Angeles region. Metro currently produces carbon credits generated through its dispensing of fossil natural gas. In the future, carbon credits through the use of biomethane and electricity as propulsion power (through its EV chargers and its rail network) can be sold along with Metro's current carbon credits to reinvest in energy efficiency, renewable energy, and energy resilience initiatives.

More information on Metro's EV charger program can be obtained at www.metro.net/ev. Metro's Energy and Resource Management Programs can be obtained at www.metro.net/ecsd.

2.1.2.5 Adoption and Enforcement of Building Codes

Building energy efficiency codes provide the foundation for increasing the energy productivity of buildings. Existing codes are estimated to yield cumulative benefits of 44 quadrillion Btu, which is more than twice as much energy as all households in the U.S. use in a year, and $230 billion in customer utility bill savings by 2040.[71] Expanding state adoption of building energy codes,[72] as well as increasing the stringency, enforcement and compliance with the codes themselves, will yield additional energy productivity benefits, while reducing utility bills and increasing customers' comfort within their homes and buildings. Utilities can play important roles in developing and funding building code programs. For instance, utilities provided partial funding for Ohio's Energy Code Ambassadors Program (ECAP). ECAP seeks to increase building code enforcement by directly connecting local code officials with trained, experienced code officials.[73] Washington, with a 2013 compliance rate of 96 percent,[74] partnered with utilities to fund much of its work with building codes.

2.1.3 LOCAL GOVERNMENT

Local governments are critical sources of policies and other strategies for meeting the goal of doubling energy productivity. In addition to setting policies that affect individual businesses and citizen groups, local governments have the opportunity to affect the types of systematic changes necessary to develop energy-productive communities. In particular, land use policy decisions at the local level can unlock energy productivity potential found at the intersection of transportation and the built environment. These decisions can affect how much citizens must spend on energy to support their daily routines, and their impacts last for decades.

Participants in the Accelerate Energy Productivity 2030 regional dialogues confirmed that a multitude of energy productivity actions are available to local leaders, depending on the local characteristics of geography, population density, energy resources, and economy. Characteristics of energy-efficient built environments include building density and mixed-use development (often referred to as "smart growth"), sensitivity to microclimatic factors, and the availability of distributed energy resources. Actions by local governments contribute to all six energy productivity wedges:

71 Livingston, O.V., D.B. Elliott, P.C. Cole, R. Bartlett, Building Energy Codes Program: National Benefits Assessment, 1992 2040 (Richland, WA: Pacific Northwest National Laboratory, 2014), accessed July 2015, https://www.energycodes.gov/sites/default/files/documents/BenefitsReport_Final_March20142.pdf.

72 In home rule states, codes must be adopted by the local government.

73 U.S. Department of Energy Office of Energy Efficiency and Renewable Energy, Achieving Energy Savings and Emission Reductions from Building Energy Codes: A Primer for State Planning (Washington, D.C.: U.S. Department of Energy, 2015), accessed July 2015, https://www.energycodes.gov/sites/default/files/documents/Codes_Energy_Savings_State_Primer.pdf.

74 Northwest Energy Efficiency Alliance. Washington Residential Energy Code Compliance, *Report #E13-251*, prepared by the Cadmus Group, Inc. (Portland, OR: Northwest Energy Efficiency Alliance, 2013), accessed July 2015, http://neea.org/docs/default-source/reports/washington-residential-energy-code-compliance.pdf?sfvrsn=11

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

2.1.3.1 Local Ordinances to Facilitate Distributed Generation

Promotion of distributed generation sources (e.g., cogeneration, solar photovoltaics, and wind power) can be an effective lever that local communities can use to improve their energy productivity through increased energy-efficient power generation, transmission, and distribution. Establishing installation targets, creating PACE programs, and implementing property and sales tax incentives can facilitate distributed generation. In addition to creating new ordinances or other policies, local governments can review existing ordinances to determine which, if any, inadvertently hinder distributed generation (e.g., ordinances that may restrict installation of solar photovoltaic systems).

One strategy to encourage the development of distributed generation is for local communities to support solar cooperatives, by which members collectively purchase solar energy systems to achieve discounted installation and equipment costs. Community solar initiatives that have appeared in municipalities across the United States have taken different forms based on the motivation of the members.[75] There may also be opportunities for community-based solar on under-utilized land.

And, local communities can complement ordinances that support the installation of distributed electricity generation by encouraging construction and retrofit of ultra-efficient buildings. Local policies such as permitting and building code enforcement can be instrumental in integrating energy considerations early in project planning. These considerations can include passive solar design and siting and the integration of building designs among architects, engineers, contractors, and developers.

75 The applicability of community solar projects will vary by state. For example, certain state laws may prohibit third-party purchase agreements, which significantly impact the viability of solar for businesses and communities. See Jason Coughlin, Jennifer Grove, Linda Irvine, Janet F. Jacobs, Sarah Johnson Phillips, Leslie Moynihan, and Joseph Wiedman, *A Guide to Community Solar: Utility, Private, and Non-Profit Project Development*, DOE/GO-102011-3189 (Golden, CO: National Renewable Energy Laboratory, 2011), accessed July 2015, http://www.nrel.gov/docs/fy11osti/49930.pdf.

PUBLIC BUILDING SUCCESS STORY

Washington State Drives Energy Efficiency through Benchmarking Public Buildings

The Washington State Department of Commerce's State Energy Office is a leader in providing energy policy support, analysis, and information for the Governor, Legislature, and other stakeholders on key energy efficiency issues. Despite this expertise and strong legislative support, participation in benchmarking public buildings remained extremely low. The majority of public facilities were not benchmarked, and those that were eventually stopped reporting because monthly manual entries were time consuming, there was no compliance enforcement, and there was no apparent value to tracking this consumption data. In early 2014, less than 7 percent of the required benchmarking sites within the state's forty nine executive and small cabinet agencies were populating current data within Portfolio Manager, a free web-based tool created by the State to track and report building energy use.

A second barrier to achieving 100 percent benchmarking compliance was the lack of an internal method to determine how many sites that were required to report benchmarking data actually existed. Because of the way the initial 2009 energy efficiency law was written, large groups of buildings residing on a master -metered campus could be benchmarked as a single site. While that was a logical way to capture data for campuses without having to expend money on sub-meters, it was impossible to track because the State Facility Inventory System did not provide campus groupings.

In 2014, the State Energy office was directed by Executive Order 14-04—the *Washington Carbon Pollution Reduction and Clean Energy Action*—to increase public building efficiency. This order brought together a broad group of agencies that agreed achieving 100 percent benchmarking compliance was a necessary step towards increasing public building efficiency. With support from a U.S. Department of Energy State Energy Program Competitive Awards grant, the State created the Interagency Energy Workgroup and provided dedicated staffing support to address the lack of a centralized system for benchmarking and compliance. This support included the state Department of Enterprise Services and Office of Financial Management, and

Washington State University (WSU). The Interagency Energy Workgroup created and promoted a process for increasing energy efficiency in public buildings. However, the lack of current benchmarking data was a key challenge to implementing the overall process, so compiling benchmarking data became a primary objective.

Initial efforts focused on completing benchmarking via a centralized process through partnership with utilities; as a result, benchmarking compliance increased from 7 to 37 percent. After determining that this centralized process was too cumbersome, the State Energy Office led an effort supported by WSU and the Smart Buildings Center to identify exactly how many required “target sites” existed within the state Executive agencies. This effort involved high-level mapping and assumptions using the Facilities Inventory System database to categorize similar WSU campuses and compare those sites to data found within the Portfolio Manager. Several months later, the first “Benchmarking Yardstick” was presented as a rough assessment of compliance, and indicated that approximately 25 percent of required Executive agency sites were benchmarked. This first yardstick was presented to the Governor’s Office by the directors of the Department of Commerce and Department of Enterprise Services, creating high-level awareness and further amplifying progress.

With support from the Governor’s Office, the Interagency Energy Workgroup expanded its efforts and subsequently hosted a well-attended webinar, created a set of instructions specific to benchmarking, and distributed an Agency Facility Status report. The report identified the buildings or campuses that were required to benchmark, and provided a survey whereby each agency could confirm or correct their campus groupings, building conditioning status, and utility payment. With the survey results in hand, for the first time the State was able to identify that there were 219 Target Sites operated by Executive agencies that were required to be benchmarked. These 219 target sites included energy consumption for over 2,000 individual buildings.

Washington State knew there was inherent value in the ability to evaluate building stocks’ energy intensity and track changes in energy consumption over time, but until these recent efforts was unable to obtain the participation needed to make the energy efficiency program as effective as possible. the work undertaken by the Interagency Energy Workgroup allowed Washington State Executive Agencies to increase their benchmarking compliance from less than 7 percent in 2009 to over 80 percent by 2014. Further efforts are underway to perform data quality assessment and data analytics using this new benchmarking data, which can point the State towards the best opportunities for energy efficiency gains—a capability not previously possible.

2.1.3.2 Building Energy Disclosure Ordinances

Communities typically lack actionable information on how residents use energy to interact with one another and with their built environment. Advancing transparency of building energy use is an important established strategy for accelerating energy efficiency in cities.[76] Ordinances regarding disclosure of building energy use are one way to provide transparency about where, when, and how communities use energy. Atlanta, Austin, New York, Minneapolis, and Philadelphia (see Figure 6) have enacted disclosure ordinances regarding energy use in buildings. All told across the United States, disclosure ordinances covered more than 45,000 properties and 4.3 billion square feet in 2013.[77]

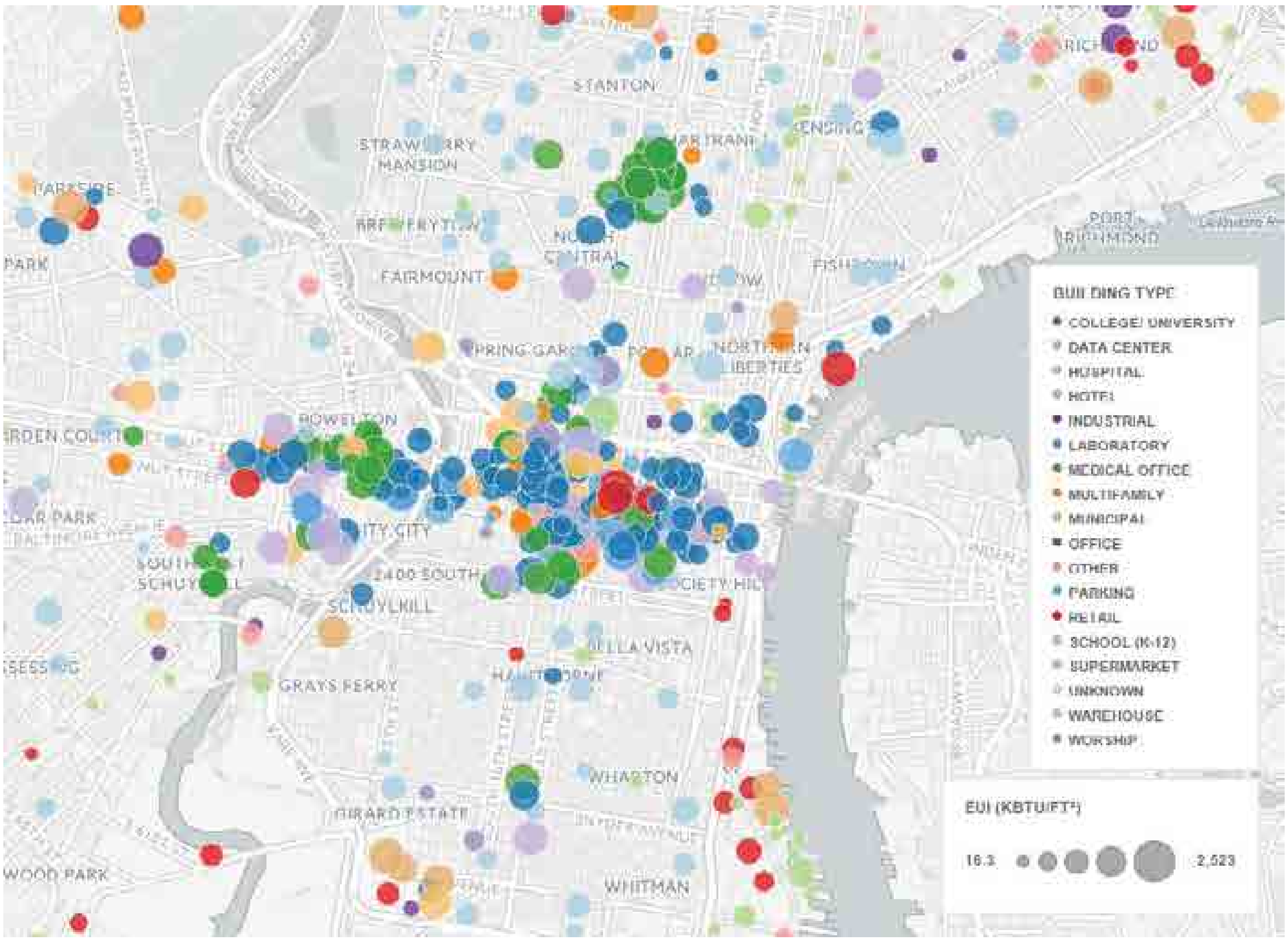


Figure 6. Philadelphia's Building Energy Data Mapping Platform

76 "Frequently Asked Questions," The City Energy Project, accessed July 2015, http://www.cityenergyproject.org/faq/.

77 Andrew Burr, "Building Energy Benchmarking and Disclosure: U.S. Policy Overview" (presented at the U.S. Department of Energy Better Buildings Summit, May 30, 2013), accessed July 2015, http://www1.eere.energy.gov/wip/solutioncenter/pdfs/bbs2013_burr_overview.pdf.

Disclosure of energy data alone has been associated with a 3 percent reduction in utility expenditures.[78] Energy disclosure ordinances help local governments benchmark building energy performance and efficiently target energy productivity improvements. New York City's benchmarking analysis found that buildings serving similar purposes varied in their energy by a factor of three to seven.[79]

Buildings that are more energy productive have higher occupancy levels, and they command higher rental and sales premiums than their less productive counterparts do.[80] By facilitating transparent energy use data and benchmarking, building energy disclosure ordinances can help make communities more economically competitive.

2.1.3.3 Creating Advanced Manufacturing Ecosystems

Local initiatives can help build the foundation for enabling growth of innovative businesses, such as advanced manufacturing. For local policymakers to more effectively foster the growth of new businesses, such as advanced manufacturing, a new type of organizational structure has emerged: the "startup delivery unit." Using a startup delivery unit, which is comprised of a rotating assignment of eight to twelve public- and private-sector employees, local policymakers can think strategically about the talent, infrastructure, capital, and networks required to foster the growth of advanced manufacturing businesses.[81] Successful local policies can focus on establishing enabling structures to meet the needs of entrepreneurs—rather than defining specific resources—and bringing together and managing diverse sets of stakeholders, which include businesses, universities, and multiple levels of government.

Local governments could also look to partnering with other local and state counterparts to expand available resources in order to attract new businesses that provide energy productivity-enabling products or services. This strategy is modeled on efforts to promote entrepreneurship and start-up activity as embodied by Silicon Valley in California. One important feature of successful local partnerships is fostering interaction between entrepreneurs and local colleges and universities. For example, the City of New York challenged top applied science and engineering institutions to propose a new campus situated on city-owned land; the result is Cornell Tech, a partnership between Cornell University and the Technion – Israel Institute of Technology.[82] Other local initiatives for supporting energy innovation clusters include public funding instruments for early-stage businesses and creating a campus for entrepreneurs.

78 Karen Palmer and Margaret Walls, *Does Information Provision Shrink the Energy Efficiency Gap? A Cross-City Comparison of Commercial Building Benchmarking and Disclosure Laws* (Washington, D.C.: Resources for the Future, 2015), accessed July 2015, http://www.rff.org/RFF/Documents/RFF-DP-15-12.pdf.

79 PLANYC, *New York City Local Law 84 Benchmarking Report* (New York: Mayor's Office of Long-Term Planning & Sustainability, 2012), accessed July 2015, http://www.nyc.gov/html/gbee/downloads/pdf/nyc_ll84_benchmarking_report_2012.pdf.

80 Institute for Market Transformation, *Energy Benchmarking and Transparency Benefits* (Washington, D.C.: Institute for Market Transformation, 2015), accessed July 2015, http://www.imt.org/uploads/resources/files/IMTBenefitsofBenchmarking_Online_June2015.pdf.

81 Julian Kirchherr, Gundbert Scherf, and Katrin Suder. (New York: McKinsey & Company, 2014), accessed July 2015, Julian Kirchherr, Gundbert Scherf, and Katrin Suder. Creating growth clusters: What role for local government? (New York: McKinsey & Company, 2014), accessed July 2015, http://www.compete.org/storage/images/uploads/File/PDF%20Files/Creating-growth-clusters-what-role-for-local-government%20(2).pdf.

82 For more information, see tech.cornell.edu.

2.1.3.4 The Local Built Environment-Transportation Nexus

Opportunities to increase energy productivity also exist through improved design of our built environment, which is estimated to affect 65 - 70 percent of energy use.[83] By better matching the ways energy is used for transportation and within buildings to the design of our communities, more productive uses of energy can be uncovered. The relationship between energy use and the built environment is complex and while physical features of a place certainly play a role, energy use may ultimately be determined by human behavior. For this reason, strategies to improve the built environment and transportation policies often require consensus or partnerships between those responsible for publicly owned infrastructure and those responsible for privately owned residential and commercial buildings.[84] *Envision Charlotte* is an example of an initiative that connects local government, utilities, private businesses, and higher education institutions in an effort to drive dramatic reductions in local energy use (20 percent over five years in Uptown Charlotte office buildings) while growing a vibrant economy. Reductions in building energy use are sought through participation in Duke Energy's Smart Energy in Offices program, which provides support for benchmarking of energy use and the identification and implementation of energy efficiency improvements.[85] Over 98 percent of the eligible building area is participating in *Envision Charlotte* programs, and as of 2012, 55 building tenants have committed to meeting the 20 percent reduction goal.[86]

Many other local actions increase the energy productivity associated with existing buildings. The City of Atlanta's Sustainable Home Initiative in the New Economy (SHINE) partners with Georgia Power and the ENERGY STAR® program to offer home energy assessments and rebates for cost-effective energy efficiency retrofits.[87] The SHINE program, along with similar initiatives in the Southeast, was found to be associated with increases of 349 new jobs and nearly $78 million in economic output.[88]

Other opportunities to advance energy productivity include (1) increasing the availability and accessibility of non-motorized transportation, mass transit options, and carpooling and (2) fostering vibrant communities by encouraging density and mixed-use development to reduce the distances between activities. The Transportation Research Board

83 J.O. Lamm, E*nergy in physical planning: a method for developing the municipality master plan with regard to energy criteria*, Document D14:1986 (Stockholm: Swedish Council for Building Research, 1986).

84 William P. Anderson, Pavlos S. Kanaroglou, and Eric J. Miller, "Urban Form, Energy and the Environment: A Review of Issues, Evidence and Policy," *Urban Studies* 33:1 (1996): 7–35, accessed July 2015, http://dx.doi.org/10.1080/00420989650012095.

85 "Smart Energy in Offices," Duke Energy, accessed July 2015, http://www.smartenergyinoffices.com/.

86 Envision Charlotte, *Envision Charlotte Annual Report 2012* (Charlotte, NC: Envision Charlotte, 2012), accessed July 2015, http://www.envisioncharlotte.com/wp-content/uploads/pdf/Annual-Report-2012.pdf.

87 Brad Turner, "*City of Atlanta Introduces Shine Program*," Atlanta Building News, April 2010, accessed July 2015, http://www.naylornetwork.com/gah-nwl/articles/abn.asp?aid=64603&projid=4172.

88 Southeast Energy Efficiency Alliance, *The Economic Impact of EE Investments in the Southeast* (Atlanta: Southeast Energy Efficiency Alliance, 2013), accessed July 2015, http://www.seealliance.org/wp-content/uploads/SEEA-EPS-EE-Report.pdf.

concluded that (1) developing at higher residential and employment densities would reduce vehicle miles traveled and (2) direct and indirect reductions in transportation energy use are possible through more compact, mixed-use development. Specifically, a doubling of metropolitan residential density combined with demand management measures could reduce household vehicle miles traveled by as much as 25 percent.[89] The Transportation Research Board also identified the ability of regional transportation organizations to incentivize more-compact developments and coupling development with transit.

89 Transportation Research Board, *Driving and the Built Environment: The Effects of Compact Development on Motorized Travel, Energy Use, and CO2 Emissions* (Washington, D.C.: National Academies Press, 2009), accessed July 2015, http://www.nap.edu/catalog/12747/driving-and-the-built-environment-the-effects-of-compact-development.

CITY SUCCESS STORY

Atlanta Leverages Public-Private Partnerships

In November 2011 the City of Atlanta, Georgia, used a public-private partnership to launch the Atlanta Better Buildings Challenge (ABBC), an initiative to engage downtown businesses in reducing energy and water consumption in more than 40 million square feet of buildings by at least 20 percent by 2020, and a goal of becoming one of the country's 10 most sustainable cities. The Mayor's Office of Sustainability championed the initiative, which is aligned with Atlanta's sustainability plan, *Power to Change*, released in the fall of 2010. *Power to Change* lays out a plan for continuous improvement in sustainability practices through policies and activities that balance economic growth with environmental protection while being mindful of social justice.

Atlanta used a multi-pronged outreach approach to develop, establish, and market the ABBC. Atlanta convened meetings to develop the initiative, established a dedicated ABBC website, created marketing materials for interested participants, and designed public relations materials to inform the press and public about the initiative.

The City's primary partners in developing and implementing the ABBC were Central Atlanta Progress, a non-profit corporation of Atlanta business leaders; property owners; institutions committed to enhancing the environmental sustainability and economic vitality of Downtown Atlanta; and the Atlanta Downtown Improvement District, a public-private partnership funded through a community improvement district in which commercial property owners pay special assessments to support capital projects and programs.

Building owners and managers joined the ABBC by pledging to save energy and water in their selected buildings. Through the ABBC network of partners, participants were provided with tools and incentives such as guidance on making the case for energy upgrades, free building assessments, energy efficiency implementation technical assistance, education and training courses, access to project financing opportunities, and public recognition. The City is currently pursuing a performance contract to finance public building retrofit projects, and community participants will have access to financing options.

The City of Atlanta partnered with Georgia Power to streamline the sharing of energy data for energy consumed by participants in the Atlanta Better Buildings Challenge program. The city worked with its Department of Watershed Management to gain automatic access to data about facility-level water consumption. Atlanta also helped participants benchmark energy use in their buildings and provided software that automatically feeds energy use data into ENERGY STAR® Portfolio Manager, a no-cost web-based tool for tracking and reporting building energy use. Once collected, the aggregated participant energy and water data are displayed on a public-facing dashboard showing real-time progress against program milestones.

Since launching the challenge in 2011, Atlanta has been on track to meet its energy and water savings goals, and it continues to expand its goals by engaging additional private-sector partners to commit their buildings to energy improvements. In 2014, Atlanta buildings participating in the pilot saved 163 million gallons relative to their baseline consumption, enough water to fill 570 Olympic-sized swimming pools. One of the key benefits of this pilot program is being able to show participants the impact of their behavior based and infrastructure-based efforts.

The floor area of city buildings participating in the challenge increased from 40 million to 100 million square feet in four years. These facilities are reporting their energy data annually. And, they have collectively reduced their energy use intensity by 11 percent from a 2009 baseline and have improved their water performance by 20 percent from a 2010 baseline. Nearly a quarter of the 350 participating buildings have already achieved 20 percent savings. Annually, the city is using an average of 2.5 percent less energy and consuming 4 percent less water. Atlanta publicly recognized the program participants for their progress in achieving milestones and reaching goals through various marketing and public relations initiatives, including an annual recognition event supported by the city's mayor.

For more information, see www.atlantabbc.com.

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