MAWC 41

Exhibit No.:	
Issues:	Main Break Expense, Demand-Side Water Efficiency, Water Loss, Consolidated Tariffs, Utility Locating Service, Flood Expense, Local 335 Unfilled Jobs and Valve Maintenance
Witness:	Philip C. Wood
Exhibit Type:	Rebuttal
Sponsoring Party:	Missouri-American Water Company
Case No.:	WR-2015-0301 SR-2015-0302
Date:	February 11, 2016

MISSOURI PUBLIC SERVICE COMMISSION

CASE NO. WR-2015-0301
CASE NO. SR-2015-0302

REBUTTAL TESTIMONY

OF

PHILIP C. WOOD

ON BEHALF OF

MISSOURI-AMERICAN WATER COMPANY

BEFORE THE PUBLIC SERVICE COMMISSION

OF THE STATE OF MISSOURI

IN THE MATTER OF MISSOURI-AMERICAN WATER COMPANY FOR AUTHORITY TO FILE TARIFFS REFLECTING INCREASED RATES FOR WATER AND SEWER SERVICE	)))))	**CASE NO. WR-2015-0301** **CASE NO. SR-2015-0302**

AFFIDAVIT OF PHILIP C. WOOD

Philip C. Wood, being first duly sworn, deposes and says that he is the witness who sponsors the accompanying testimony entitled "Rebuttal Testimony of Philip C. Wood"; that said testimony and schedules were prepared by him and/or under his direction and supervision; that if inquiries were made as to the facts in said testimony and schedules, he would respond as therein set forth; and that the aforesaid testimony and schedules are true and correct to the best of his knowledge.

Philip C. Wood

State of Missouri
County of St. Louis
SUBSCRIBED and sworn to
Before me this 9th **day of** February **2016.**

Donna S. Singler
Notary Public

My commission expires: July 17, 2016

DONNA S. SINGLER
Notary Public, Notary Seal
State of Missouri
St. Louis County
Commission # 12368409
My Commission Expires July 17, 2016

REBUTTAL TESTIMONY
PHILIP C. WOOD
MISSOURI-AMERICAN WATER COMPANY
CASE NO. WR-2015-0301
CASE NO. SR-2015-0302

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REBUTTAL TESTIMONY

PHILIP C. WOOD

I. INTRODUCTION

Q. PLEASE STATE YOUR NAME AND BUSINESS ADDRESS.

A. My name is Philip C. Wood, and my business address is 727 Craig Road, St. Louis, MO 63141.

Q. HAVE YOU PREVIOUSLY SUBMITTED TESTIMONY IN THIS PROCEEDING?

A. Yes, I have submitted direct testimony in this proceeding on behalf of Missouri American Water Company (Missouri American, MAWC, or Company)

Q. WHAT IS THE PURPOSE OF YOUR REBUTTAL TESTIMONY?

A. I will address the following issues which were raised in the Staff Report or Direct Testimony of some of the Interveners:

- Main Break Expense
- Demand-Side Water Efficiency
- Water Loss
- Consolidated Tariffs
- Utility Locating Services
- Flood Expense

- Unfilled jobs discussed in Alan Ratermann's, UMUA Local 335, direct testimony
- Valve Maintenance discussed in Alan Ratermann's, UMUA Local 335, direct testimony

II. MAIN BREAK EXPENSE

Q. WHY IS THE PSC STAFF'S CALCULATION NOT AN ACCURATE REPRESENTATION OF MAIN BREAK COSTS?

A. Staff's proposed adjustment utilized the 2014 cost per main break of $2,826, based on an average of 807 main breaks and annualized cost of $2,279,604.

Missouri-American believes that a three year average cost should be utilized when calculating total expense and cost per main break, as this more appropriately reflects main break expense. In reviewing of the costs year over year, we do not have a declining trend in the cost per break. In 2012 to 2013 MAWC's cost per break increased ($3,087, $3,897, respectively), decreased in 2014 ($2,901), and for 2015, it has increased ($3,806).

Q. WHAT WOULD BE YOUR RECOMMENDATION OF TOTAL BREAK COSTS ASSUMING REMOVAL OF THE POLAR VORTEX?

A. Missouri American recalculated its main break expense adjustment utilizing the updated 807 average count of main breaks per year (normalizing the polar vortex in 2014), applied a three year average ('12-'14) calculation of cost per incident of $3,306, to determine average three year annual expense of $2,666,683. See below for comparison of the original filed amount, PSC Staff adjustment, and the MAWC rebuttal recommendation.

	MOAW as filed	2014 PSC Staff Adjustment	MOAW Rebuttal 2014 Average	MOAW 2015
	Includes polar vortex. 2014 Quantity and cost per break.	Remove Jan-Mar '14. Polar Vortex quantity and cost, and replace with Avg Jan-Mar for '11-'13. Total cost is using only 2014 avg. cost per break	Remove Jan-Mar '14 Polar Vortex quantity and replace with Avg Jan-Mar for '11-'13. Cost per break is average of '12-'14. *See below	
Count of Breaks	1118	807	807	545
Cost Per Break	$2,826	$2,826	$3,306	$3,806
Total Cost	$3,159,468	$2,279,604	$2,666,683	$2,074,271

	FY2012	FY2013	FY2014	3 Yr. Avg
Total Costs	$2,707,833	$3,191,892	$2,100,324	$2,666,683
Number of Main Incidents	877	819	724	807
Cost Per Main Incident	$3,087	$3,897	$2,901	$3,306
	**removed $718,628 from the 2012 expense file as a result of locate services		**Added $83,915 to the 2014 expense file for updated contracted services. Adjusted polar vortex (Jan-Mar) main break quantity with avg of Jan-Mar '11-'13. The polar vortex did not impact the cost per main break. $2901 is the actual cost for all breaks in 2014.	

III. DEMAND-SIDE WATER EFFICIENCY

Q. WHAT EFFORTS HAS MAWC TAKEN TO IMPROVE WATER EFFICIENCY?

A. MAWC is engaged in a broad array of efforts to become more efficient. The Company's efforts to improve water and energy efficiency cover a wide range and include supply-side practices, such as improved pump efficiency, leak detection, and infrastructure replacement and repair programs, as well as demand-side strategies, such as customer efficiency and public education programs.

Q. WHAT IS THE DEPARTMENT OF ENERGY'S RECOMMENDATION TO IMPROVE DEMAND-SIDE ENERGY AND WATER EFFICIENCY?

A. The Department of Energy ("DE") is recommends increasing spending in energy and water efficiency and conservation, Specifically, the DE witness Mr. Hyman recommends that the Commission should require MAWC to encourage greater demand-side (customer) efficiency with expenditures targeting 0.5 percent (0.5%) of the Company's annual average total revenue, funded through a regulatory asset account.

Q. DO YOU AGREE WITH THE DE'S RECOMMENDATION?

A. No, I do not.

Q. WHAT CONCERNS DO YOU HAVE WITH THE DE'S RECOMMENDATION?

A. The DE's demand-side efficiency recommendations ignore two threshold concerns. First, while DE recommends increasing spending in energy and water efficiency and conservation, MAWC's current rate structure creates disincentives to promote demand-side efficiency. As MAWC witness Ms. Tinsley has explained, more than 75 percent of MAWC's revenue comes from volumetric sales – the usage charge on customers' bills. However, about 91 percent of our costs are fixed – not related to the amount of water we sell. Because MAWC's revenues are directly tied to the amount of water that it sells, the Company's rate structure implicitly encourages water use and penalizes MAWC for encouraging conservation. Second, MAWC believes that setting aside an arbitrary amount (0.5%) of average would be premature at this point. Investments to improve water and energy efficiency need to be planned, staffed, and assessed (reasonable, measurable and cost effective) before implemented.

Q. HOW DOES MAWC PROPOSE TO ADDRESS THE FIRST CONCERN?

A. MAWC has proposed a Revenue Stabilization Mechanism ("RSM"), a revenue adjustment mechanism that adjusts rates periodically to ensure that a utility's revenue will be sufficient to cover its fixed costs regardless of throughput, while providing an incentive for customers to use water more efficiently. If the RSM is approved, MAWC will have the proper incentive(s) to support and promote reasonable demand side water efficiency programs (including supportive rate designs that improve water and energy efficiency). Without the RSM, the recommended demand side management programs and rate design proposals would create misaligned and contrary incentives.

Q. HOW DOES MAWC PROPOSE TO ADDRESS THE SECOND CONCERN THAT YOU HAVE RAISED?

MAWC recommends that supply-side and demand-side investments to improve water and energy efficiency need to be planned, staffed, assessed (reasonable, measurable and cost effective), and communicated to customers and other stakeholders to gain acceptance and momentum before implemented. The Company's assessment and prioritization of investments to improve water (and energy) efficiency may include positive and negative externalities. Ultimately, the incremental value of the investment should exceed the incremental cost. The initiatives recommended in Mr. Hyman's testimony may all be worthwhile investments to encourage demand-side efficiency. However, these recommendations should be part of a comprehensive solution that (1) eliminates the current disincentives in our rate structure to promote water and energy efficiency and that evaluates and (2) communicates the "value is greater than cost" investments that would implemented.

Q. CAN YOU POINT TO ADDITIONAL SUPPORT FOR MAWC'S RECOMMENDATIONS?

A. Yes, I can. The U.S. Department of Energy recently published "Accelerate Energy Productivity 2030: A Strategic Roadmap for American Energy Innovation, Economic Growth, and Competitiveness."[1] The U.S. Department of Energy explains that:

U.S. Department of Energy (2015). Accelerate Energy Productivity 2030: A Strategic Roadmap for American Energy Innovation, Economic Growth, and Competitiveness. Prepared by Keyser, D.; Mayernik, J., M.; McMillan, C. of National Renewable Energy Laboratory; Agan, J.; Kempkey, N.; Zweig, J. of U.S. Department of Energy.

> Water utilities have the same financial conundrum as energy utilities do when it comes to incenting water and energy efficiency. Concerns over cost recovery and losses of sales limit the financial viability of energy and water efficiency programs. Under most rate structures, there are no water efficiency incentives, as recovery of fixed costs is dependent on volume of water sold. This clashes with an ever-increasing need to be more resource efficient given the realities of water scarcity, stressed water systems and droughts, as well as rising energy costs.
>
> Decoupling, and other investment recovery reforms, is vital to ensuring that water and wastewater utilities have the incentives and the tools to reduce water and energy consumption. By separating volumes of water sold, from rates charged, decoupling enables water companies to help customers use less water and therefore save more energy. Likewise, investment recovery reform can help accelerate the replacement of aging leaking water mains, thus reducing energy waste. These regulatory reforms will ultimately minimize energy costs and reduce carbon emissions related to water and wastewater services.

Accelerate Energy Productivity 2030 (pp. 70-71) (2015).

I have attached the complete US Department of Energy Report for ease of reference as an exhibit to my rebuttal testimony.

IV. <u>WATER LOSS</u>

Q. DO YOU AGREE WITH MR. MERCIEL'S SUGGESTION ON TAKING FIVE-YEAR AVERAGES OF PRODUCTION LEVELS AS FOUND IN THIS CASE, OR OTHER AVAILABLE INFORMATION FOR SYSTEMS OWNED LESS THAN FIVE YEARS, TO BE REASONABLE; AND THEN CONDUCT FURTHER STUDY OF SOME SYSTEMS; AND THEN WORK WITH MAWC TO AGREE ON IDENTIFYING WATER LOSS PROBLEMS, AND UNDERTAKING OF SOLUTIONS TO RESOLVE THEM, WITH COST ADJUSTMENTS AS APPROPRIATE?

A. MAWC agrees with Mr. Merciel's recommendation.

V. <u>CONSOLIDATED TARIFFS</u>

Q. MR. WOOD, WHAT IS THE ISSUE REGARDING CONSOLIDATED TARIFFS?

A. In this case, the Company has proposed to eliminate the separate water tariffs (rules and regulations only) for newly acquired water systems and consolidate them in its existing consolidated water tariff, MoPSC No. 13. It is my understanding that Staff does not have an objection to this consolidation of the water tariffs for purposes of rules and regulations. With respect to the wastewater tariff rules and regulations, the Company has created a complete new wastewater tariff that it proposes to apply to most of its existing wastewater service districts. While Staff supports tariff consolidation when it is possible and practical, it has concerns that the new tariff rules will reasonably apply to multiple service areas, some of which have different operations requirements. (Staff Report, p. 97) As a result, Staff recommends that consolidation of the sewer tariff be accomplished outside the time constraints of the rate case in order to allow for a more thorough review and refinement of the proposed consolidated sewer tariff.

Q. WHAT IS THE COMPANY'S RESPONSE TO STAFF'S RECOMMENDATION REGARDING THE CONSOLIDATED WASTEWATER TARIFF?

A. The Company does not object to Staff's recommendation that the consolidated sewer tariff be reviewed and established in a collaborative proceeding that is conducted after the conclusion of this rate case.

VI. UTILITY LOCATING SERVICE

Q. MISSOURI PSC SUBMITTED DR REQUESTS W0337 AND W0337.1, WHAT IS STATUS?

A. DR responses W0337 and W0337.1 were submitted to PSC on 12/18/2015 and 12/23/2015, respectively.

VII. FLOOD EXPENSE

Q. WHAT EXPENSES DID MAWC INCUR AS A RESULT OF THE DECEMBER 2015 FLOOD?

A. A summary of the expenses were provided in response to Missouri PSC DR W0393. An estimated $516,928 will be expensed and $1,219,071 in capital.

VIII. <u>RESPONSE TO UWUA LOCAL 335 UNFILLED JOBS CONCERN</u>

Q. WHAT CONCERNS DOES LOCAL 335 HAVE IN REGARDS TO FILLING VACATED ROLES?

A. Local 335 has asked for reasoning why less bargaining unit employees are employed now compared to December 31, 2010 and why no one has been hired into the shop mechanic helper classification.

Q. HOW DOES MAWC DECIDE WHEN TO FILL VACATED ROLES?

A. MAWC fills positions as business needs dictate. The 'shop mechanic helper' classification has not been used recently since the company is able to hire qualified, trained shop mechanic candidates with multiple years of experience. MAWC continually evaluates the business to identify cost savings and efficiencies. Reductions in the workforce may occur when it is determined there is a more efficient way to perform operations, for example, replacing obsolete equipment and automating processes.

Q. IS MAWC STAFFED APPROPRIATELY TO OPERATE EFFECTIVELY AND PROVIDE SAFE WATER?

A. Yes, MAWC is staffed to perform business operations. MAWC provides safe and adequate service, meets the high standards required by Missouri

Department of Natural Resources, the Partnership for Safe Water, and continues to receive high customer satisfaction ratings.

Q. HOW IS MAWC ADDRESSING VACANT POSITIONS DUE TO UPCOMING RETIREMENTS?

A. MAWC is aware of the aging workforce issue that faces all industries and is replacing retiring employees as needed. We continually evaluate and train employees to meet the high standards required by MAWC (as stated in Mr. Ratermann's testimony).

IX. RESPONSE TO UWUA LOCAL 335 VALVE MAINTENANCE CONCERN

Q. WHAT CONCERNS DOES LOCAL 335 HAVE RELATIVE TO VALVE MAINTENANCE?

A. Local 335 recommends implementation of a valve maintenance program to ensure proper operating condition of valves.

Q. WHAT IS REQUIRED RELATIVE TO IMPLEMENTATION OF A VALVE MAINTENANCE PROGRAM?

A. American Water does have a recommended practice for valve exercising, but there is no requirement that any subsidiary adopt the practice nor is there a Commission regulation or requirement. MAWC is free to adopt all or part of this practice to meet its needs. The benefit and cost of such a program is important in considering how to best maintain a program.

Q. WHAT VALVE EXERCISING DOES MAWC CONDUCT?

A. The St. Louis/St. Charles County distribution system contains 90,000+ valves and MAWC performs valve maintenance on several fronts. The most common form of valve maintenance occurs because valves are operated in response to the thousands of main breaks that occur annually in St. Louis. Each break may require anywhere from 2 to over 4 valves (in some cases) to be operated in order to shut down the leak. Valve maintenance also occurs because valves are operated during obsolete main replacement and relocation projects when connections are made. MAWC also assigns valve maintenance work (repairing known broken valves) as fill in work for crews when main breaks are at low levels. Although records are not kept specifically to track the number of valves operated, it is estimated that 10,000 valves are operated annually.

Q. WHAT WAS THE OUTCOME OF THE FEBRUARY 2012 MOU WITH UWUA LOCAL 335?

A. Requirements of the February 2012 Memorandum of Understanding (MOU) regarding a valve maintenance program were fulfilled. A business case concerning the benefits and costs of implementing a systemic valve maintenance program in St. Louis County was completed and reviewed with union leadership on Oct. 31, 2012. Based on this evaluation, a valve program would require 10 distribution field workers and 2 management employees and 7 vehicles. This would come at significant cost to our rate payers with questionable measurable benefit, when our primary strategy is focused on continued investment to replace aging water mains and distribution system equipment. At least during the first cycle through the program, we would likely incur additional maintenance and capital costs from repairing or replacing valves that were damaged during the operation of them.

Q. DOES THIS CONCLUDE YOUR REBUTTAL TESTIMONY?

A. Yes, it does.

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.

This document was final as of September 16, 2015.

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U.S. Department of Energy. (2015). *Accelerate Energy Productivity 2030: A Strategic Roadmap for American Energy Innovation, Economic Growth, and Competitiveness.* Prepared by Keyser, D.; Mayernik, J., M.; McMillan, C. of National Renewable Energy Laboratory; Agan, J.; Kempkey, N.; Zweig, J. of U.S. Department of Energy.

FOR MORE INFORMATION

Regarding *Accelerate Energy Productivity 2030: A Strategic Roadmap for American Energy Innovation, Economic Growth, and Competitiveness*, please contact:

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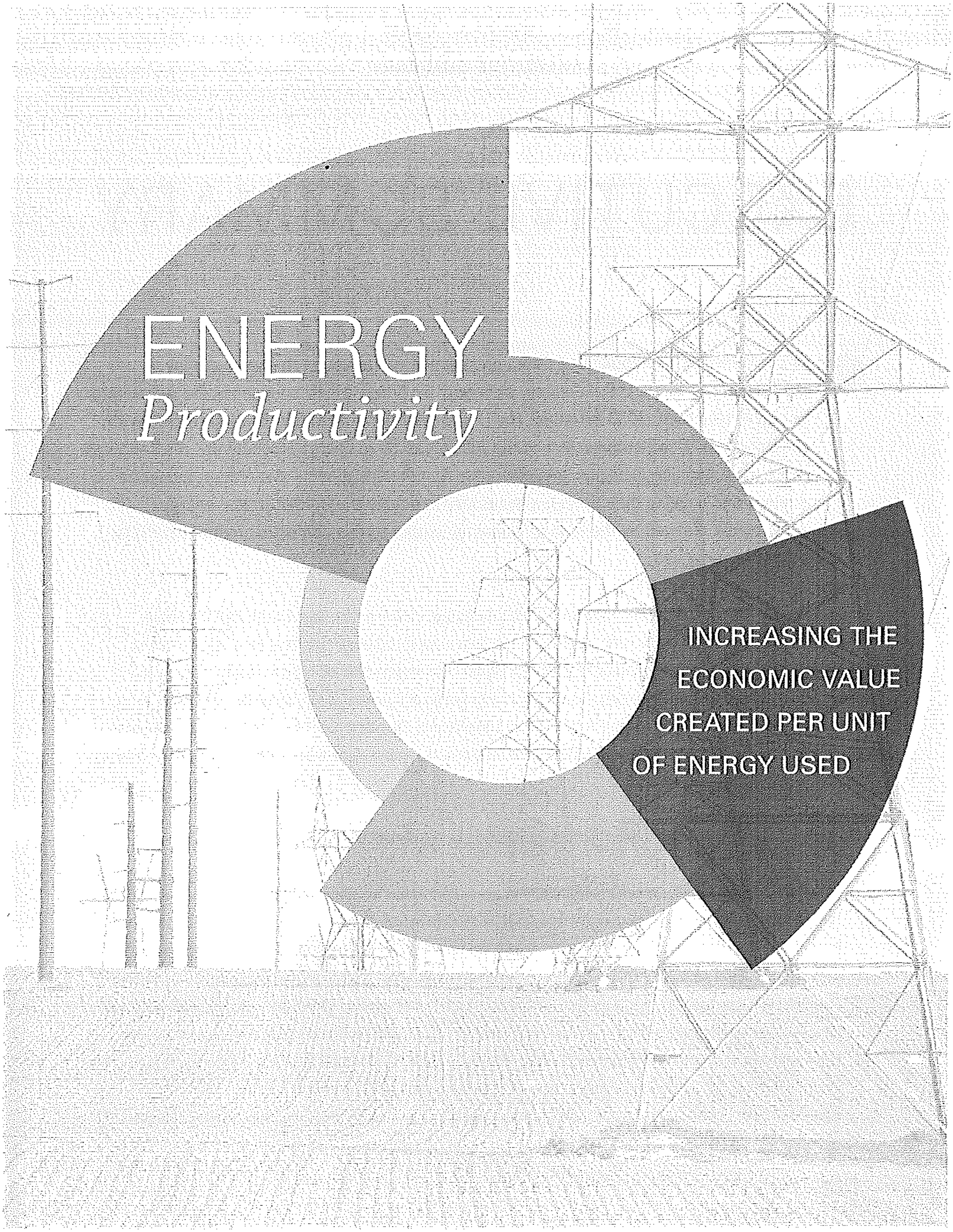

ENERGY
Productivity
INCREASING THE ECONOMIC VALUE CREATED PER UNIT OF ENERGY USED

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, the Energy Information Administration's (EIA) *Annual Energy Outlook* (AEO) 2015 projections are $21.7 trillion and 103 quads Btu in 2030. Thus, in 2030, the *Roadmap* scenario achieves 3.6 percent higher GDP and 24 percent lower primary energy use than AEO 2015 projections. 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.

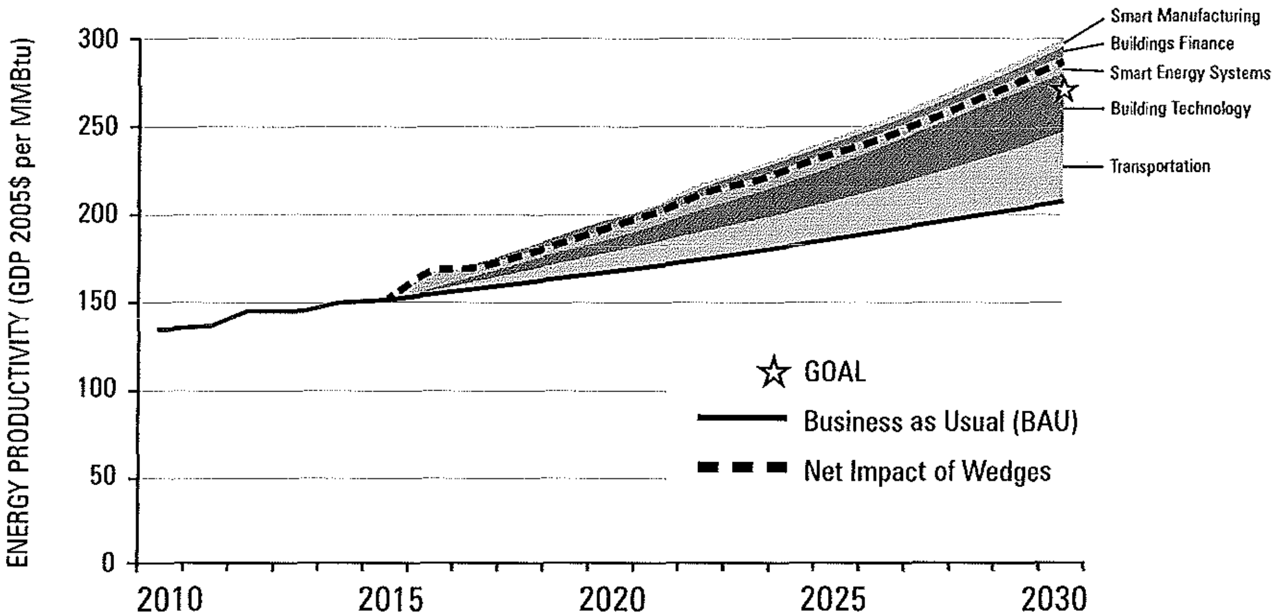


Figure 1. Estimated Energy Productivity Benefits to 2030

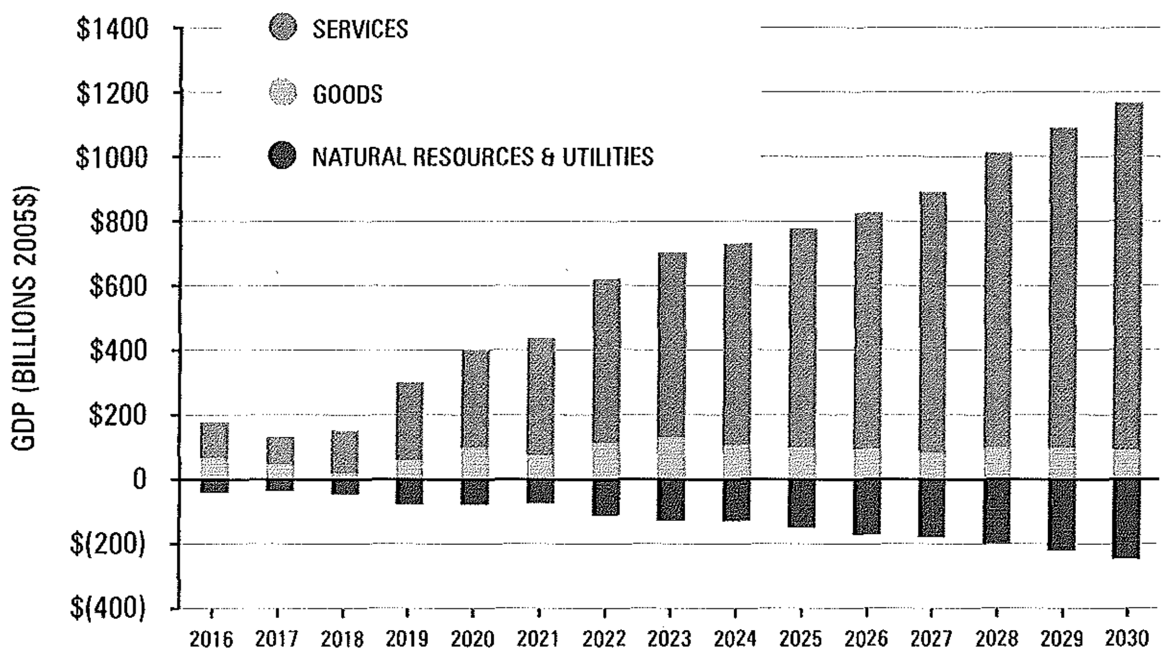


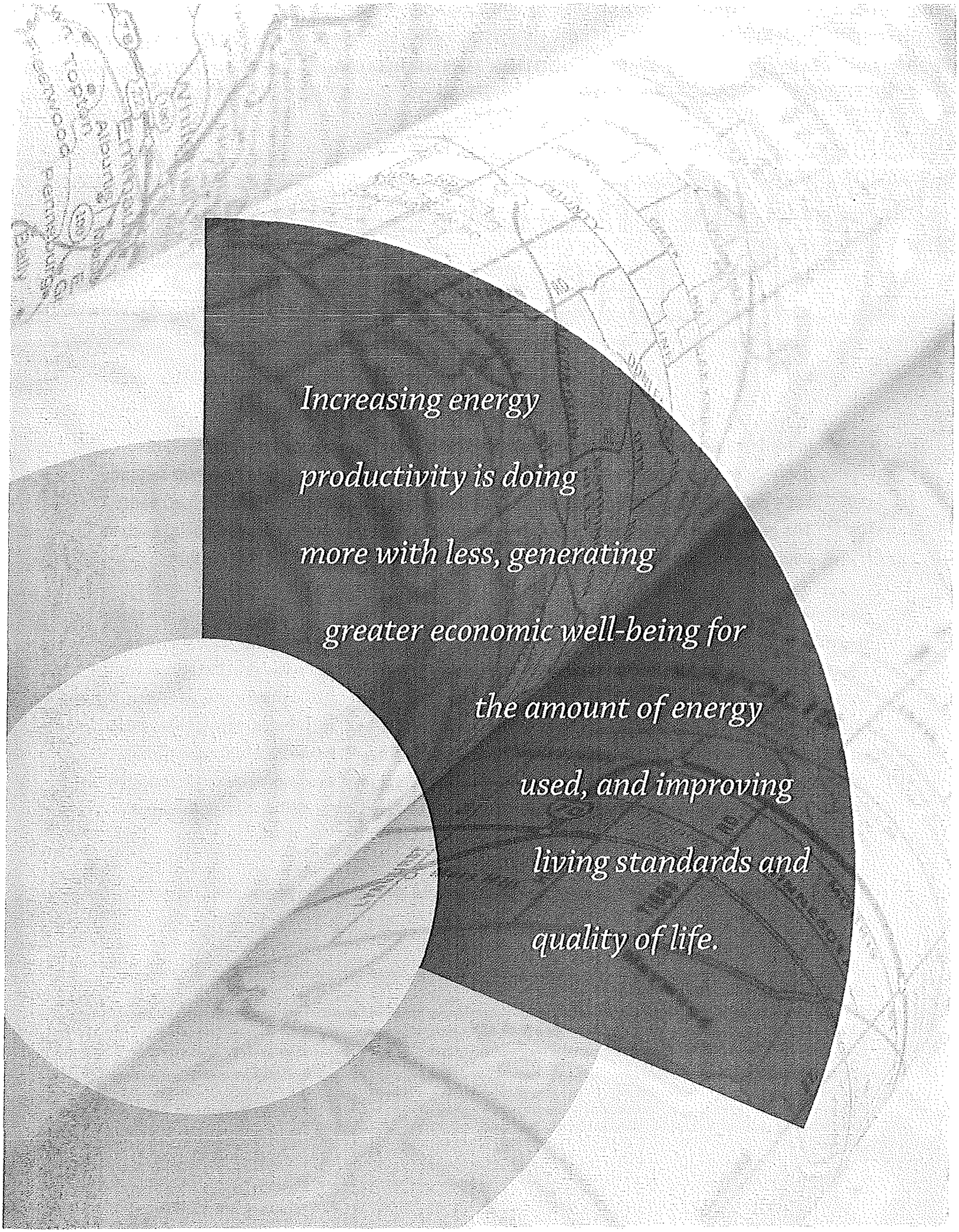
Figure 2. Estimated Changes to GDP by Sector

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 $51 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."[4] 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.[5]

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."[6] 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.[7] The recent

4 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.

5 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.

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

7 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[8] in 2015 due to effects of the recession is estimated to be between 5.3 percent and 7.7 percent.[9] 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.[10]
- 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.[11]
- 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.[12]
- 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.[13]

8 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.

9 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.

10 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.

11 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.

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

13 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,[14] 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,[15] the energy productivity analysis completed here implicitly includes structural, efficiency-

14 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.

15 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.

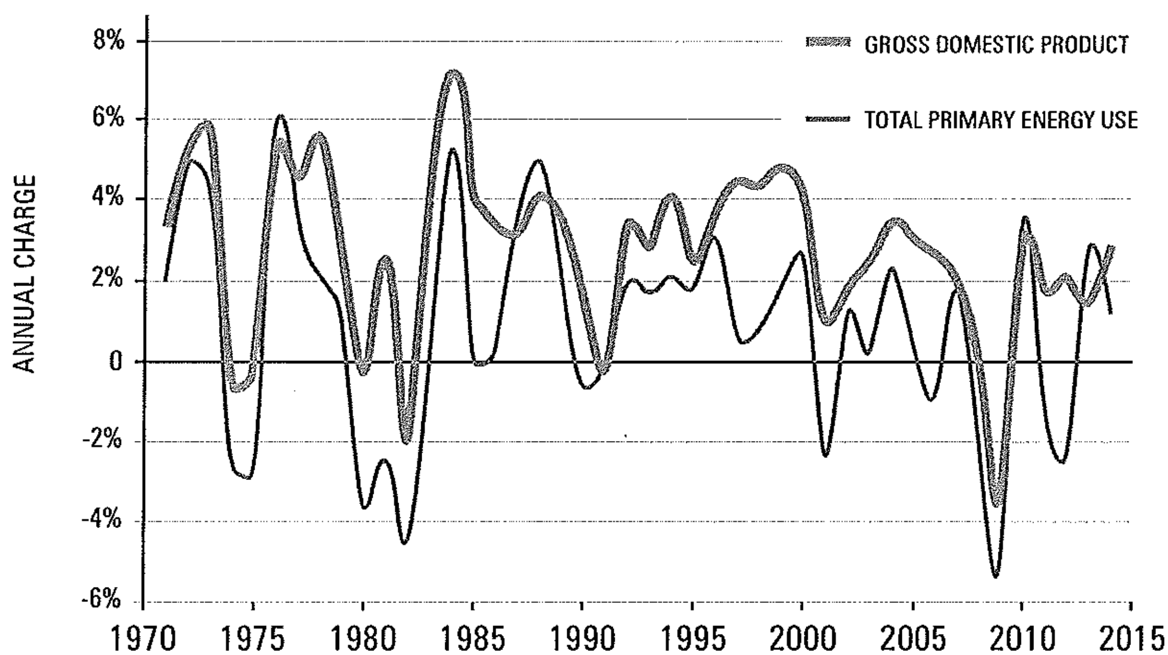


Figure 3. U.S. Total Primary Energy and Real GDP (1971–2014)[16]

16 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[17]) in GDP for each MMBtu used.[18]

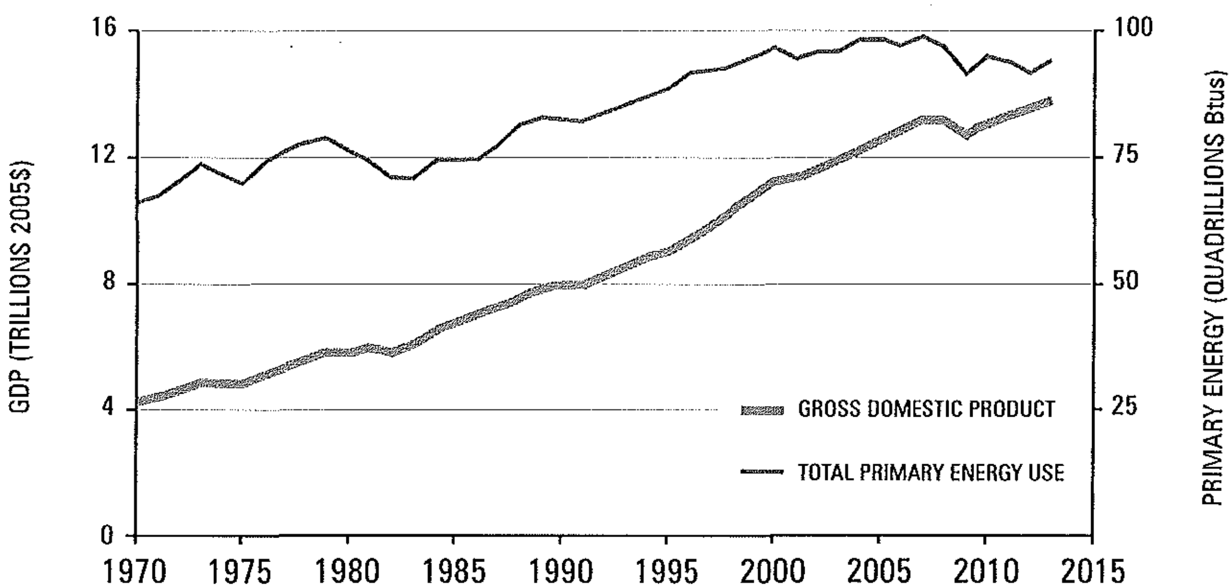


Figure 4. U.S. GDP and Total Primary Energy Use (1970–2014)

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

18 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.

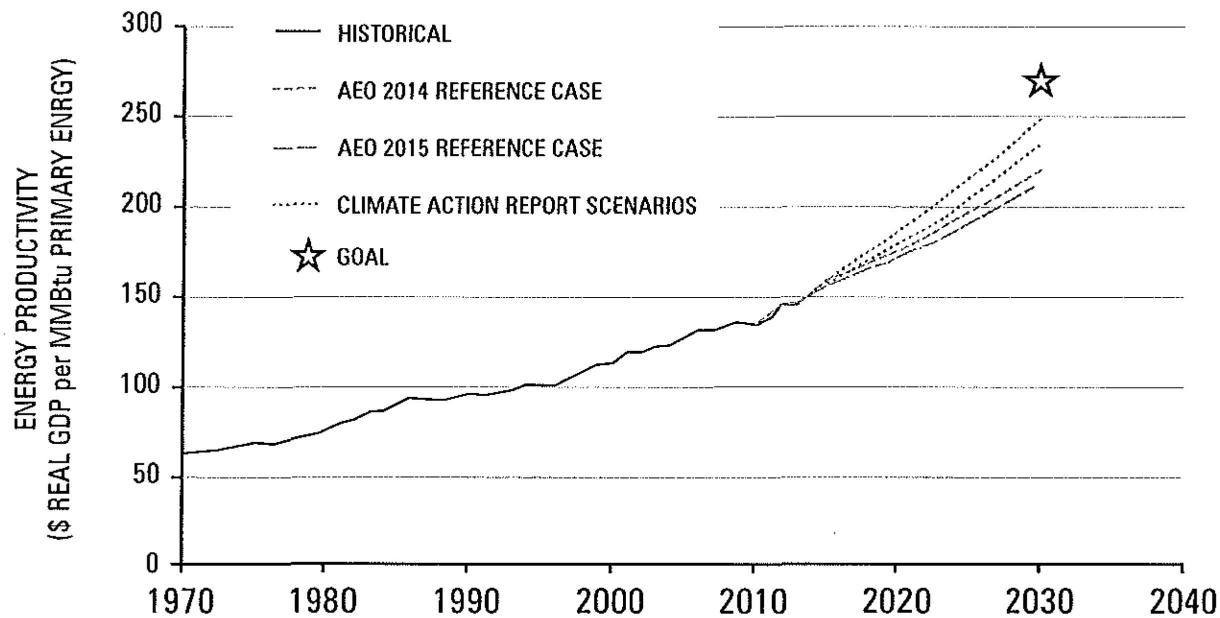


Figure 5. Historical and Projected Energy Productivity (1970–2030)

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.[19]

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

Actions identified in the 2014 *Climate Action Report*[20] 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[21] 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.[22] 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[23] 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

20 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.

21 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.

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

23 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.

recommendations for accelerating energy innovation through research, development, demonstration, and deployment. The Bipartisan Policy Center also has issued a report that includes recommendations for improving the nation's energy productivity.[24] 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.[25]

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.[26] 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).

24 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/.

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

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

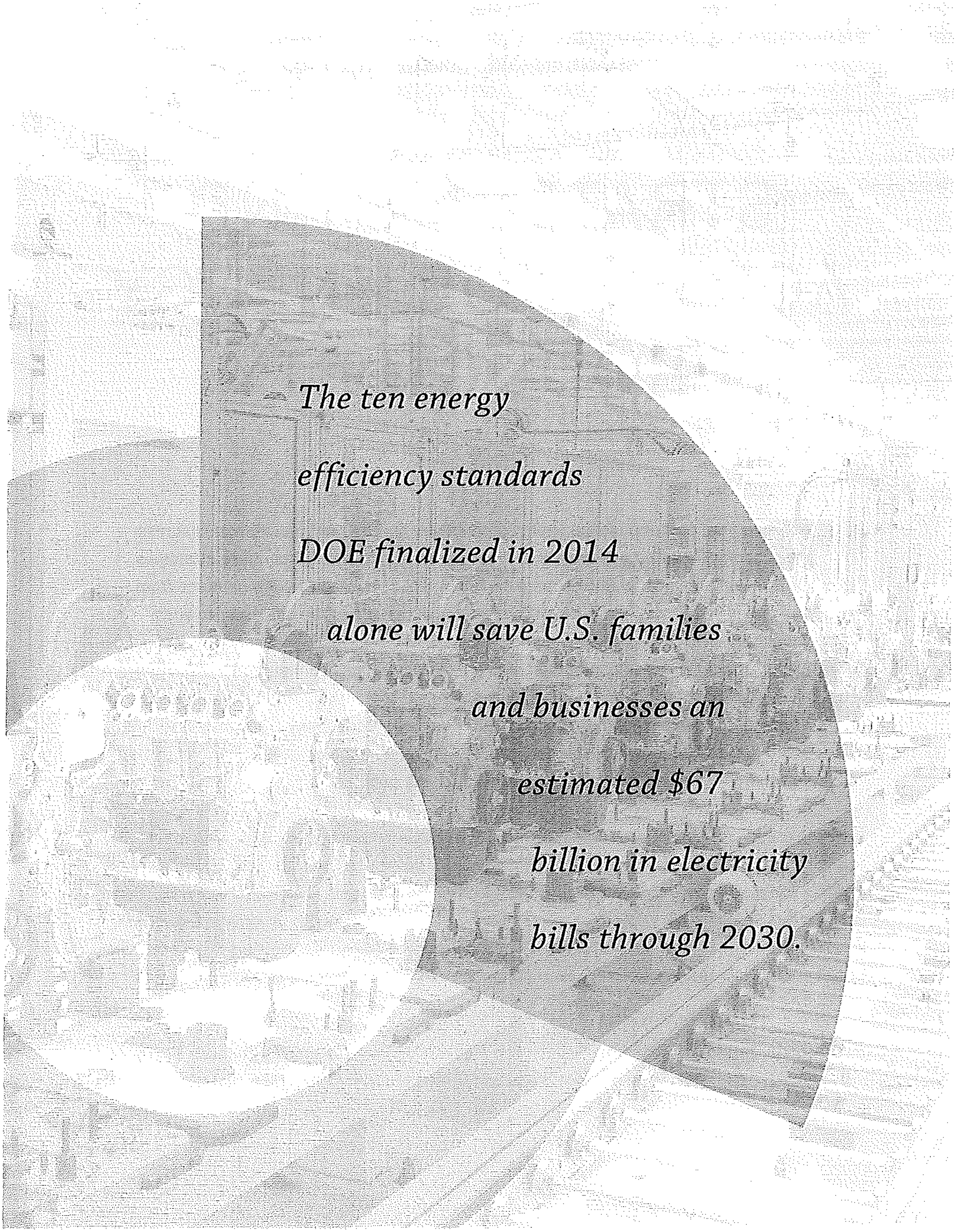
1.3.2 PROGRAMS TO DEPLOY INNOVATIVE TECHNOLOGIES

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.[27] This reduction of absolute energy use contributes directly to increasing energy productivity.

27 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.

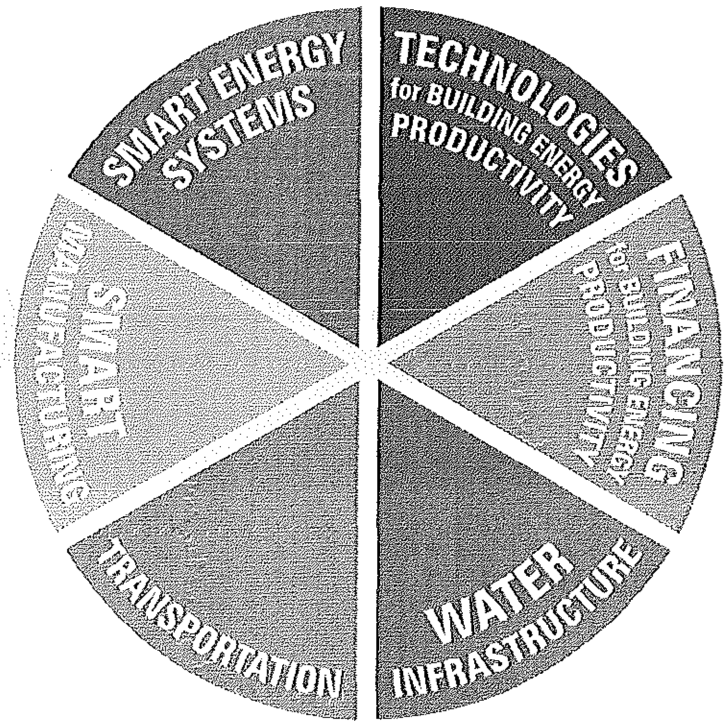


Table 1. Analysis Sources and Inputs: Summary Description of Energy Productivity Wedges

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.

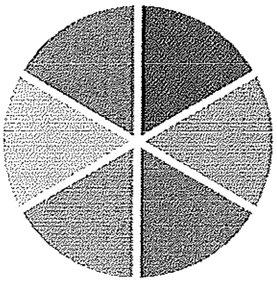
2.1.1 FEDERAL GOVERNMENT

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.[28]

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

28 "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*[29], "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.[30] 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.

29 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.

30 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).[31]

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.[32]

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.[33] 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.[34] Federal policies incentivizing the conversion of all Class 8 vehicles[35] into "SuperTrucks" could save the United States $30 billion in annual fuel costs.[36]

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31 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.

32 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.

33 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.

34 "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.

35 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.

36 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.[37] 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.[38]

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.[39] EPA and DOT have also proposed standards to further improve fuel economy in heavy-duty vehicles that could reduce fuel costs by $170 billion.[40]

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.[41]

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

37 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.

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

39 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.

40 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.

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

use and save money. The *Quadrennial Energy Review* (QER) released in early 2015 recommended that DOE accelerate the development of uniform methods for measuring energy savings and promote widespread adoption of these methods in public and private efficiency programs.[42] 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.[43]

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.[44]

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.[45] 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

42 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.

43 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.

44 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.

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

policies that require building owners to disclose energy use to further incentivize equipment upgrades in rental properties.

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.[46]

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[47] and the Solar Ready Vets program,[48] 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

46 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.

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

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

"transitioning military" status—within a few months of leaving military service and becoming veterans. The initiative is 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.[49] 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,[50] 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.[51] Executive vehicle fleets also have been directed to achieve maximum fuel efficiency.[52]

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.[53]

49 "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.

50 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.

51 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.

52 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.

53 "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.[54] 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.[55]

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.[56]
- **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.[57] 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.[58] 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

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

55 "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.

56 "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.

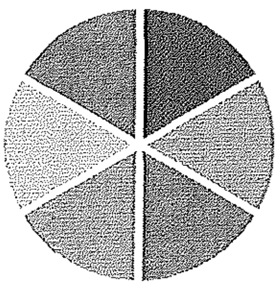
57 Executive Office of the President, The President's Climate Action Plan (Washington, D.C.: The White House, 2013), accessed July 2015, https://www.whitehouse.gov/sites/default/files/image/president27sclimateactionplan.pdf.

58 "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.[59]

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.[60] One such strategy is to develop secondary markets for energy efficiency

59 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.

60 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.[61] 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.[62] 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.[63] 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.[64] 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.[65]

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.[66] 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.

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

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

63 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.

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

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

66 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.

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

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.[67] 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.[68]

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.[69]

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.

67 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.

68 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.

69 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.

Reference to any non-Federal entity does not constitute an endorsement on the part of the Department of Energy or U.S. Government

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.[70] Expanding state adoption of building energy codes,[71] 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.[72] Washington, with a 2013 compliance rate of 96 percent,[73] 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.

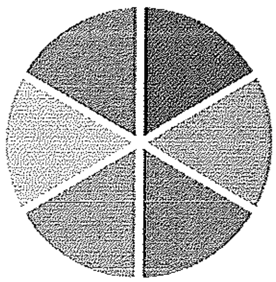
Participants in the Accelerate Energy Productivity 2030 regional dialogues confirmed that a multitude of energy productivity actions are available to local leaders, depending on the local characteristics of geography, population density, energy resources, and economy. Characteristics of energy-efficient 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:

70 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.

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

72 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.

73 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



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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.[74] 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.

74 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.

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

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.[75] 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.[76]

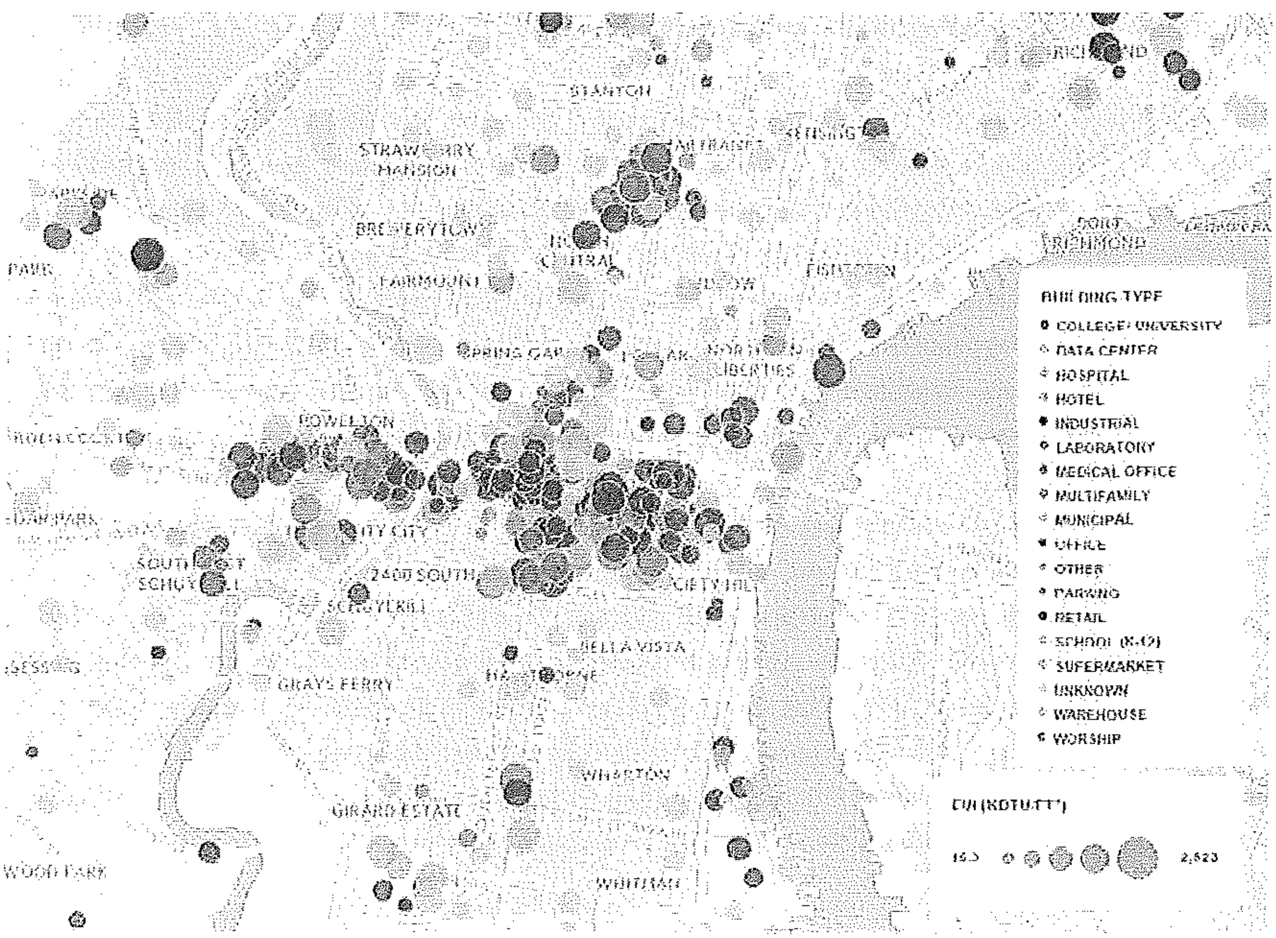


Figure 6. Philadelphia's Building Energy Data Mapping Platform

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

76 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.[77] 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.[78]

Buildings that are more energy productive have higher occupancy levels, and they command higher rental and sales premiums than their less productive counterparts do.[79] 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.[80] 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.[81] Other local initiatives for supporting energy innovation clusters include public funding instruments for early-stage businesses and creating a campus for entrepreneurs.

77 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.

78 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.

79 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.

80 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.

81 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.[82] 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.[83] *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.[84] 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.[85]

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.[86] 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.[87]

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

82 J.O. Lamm, *Energy 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).

83 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.

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

85 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.

86 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.

87 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.[88] The Transportation Research Board also identified the ability of regional transportation organizations to incentivize more-compact developments and coupling development with transit.

88 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.

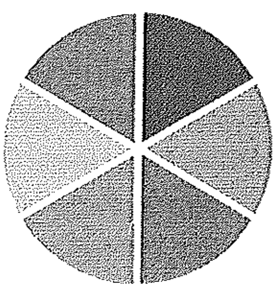
For more information, see www.atlantabbc.com.

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

2.2 Business

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

Lack of funding is a common barrier to reducing energy costs in businesses; the most significant financial barriers are insufficient internal capital budgets and competition with other capital investments.[89] To more clearly target recommended strategies, the *Roadmap* separates businesses into commercial (i.e., businesses that provide services and have lower energy intensities) and industrial groups (i.e., businesses that produce physical goods and have higher energy intensities). Both groups have the opportunity to encourage gains in energy productivity for their customers while offering them innovative products and services. Actions by businesses contribute to all six energy productivity wedges.



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2.2.1 COMMERCIAL BUSINESSES

2.2.1.1 New Financing Models

The investments needed across all sectors of the economy to increase energy productivity will require both existing and new innovations in financing mechanisms. Financing of investments is a barrier to increasing energy productivity for households, industrial businesses, and commercial businesses.[90] Together with strategies implemented by government

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

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

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

Small commercial buildings are an untapped source of energy productivity improvements, as is apparent in the potential investment value and energy savings for them; the investment value of the market for small building energy retrofits is estimated at $36.5 billion, with associated potential energy and utility bill savings of 420 trillion Btu and $138 billion, respectively.[91] The approaches required for tapping this potential differ from large enterprises and large commercial buildings, but public-private partnerships such as PACE financing and on-bill financing are examples of strategies to overcome the barriers for this market segment. As of January 2014, on-bill financing programs were operating or preparing to launch at least 25 U.S. states as well as in Canada and the United Kingdom. In aggregate, the 30 programs reviewed for a study done through SEE Action have delivered over $1.8 billion of financing to consumers for energy improvements.[92] Specific improvements for financing of small building energy efficiency projects include developing turnkey solutions, expanding contractor-led programs, and improving underwriting and program execution.[93]

2.2.1.2 Workforce Training

Increasing the energy efficiency of buildings is essential to meeting the energy productivity goal, yet building and construction contractors, and building trades professionals often lack awareness of the potential growth of the energy efficiency services sector, and more workers with energy efficiency qualifications are needed.[94] An instrumental strategy for overcoming this barrier is to incorporate energy efficiency into existing union and trade organization training programs, especially in ways that teach whole-building approaches to efficiency.[95] These organizations can also team with community and technical colleges, universities, and public utility commissions to effectively address the efficiency workforce education and training needs. For example, Pulaski Technical College in Arkansas offers energy efficiency courses for continuing education credits to professionals in the building trades.[96]

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

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

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

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

95 Goldman et al. (2010).

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

BUSINESS SUCCESS STORY

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

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

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

EXAMPLE: OVERCOMING THE SMB RESOURCE AVAILABILITY BARRIER

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

EXAMPLE: OVERCOMING THE COST CONSTRAINT FOR SMBs

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

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

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

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

2.2.2 INDUSTRIAL BUSINESSES

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

In addition to increasing output using the same or less energy, energy productivity for industrial businesses can lead to substantial non-energy benefits or "co-benefits"[97] including reduced operations and maintenance costs, increased product quality, and improved worker health and safety. However, these co-benefits are often missing from the business case for projects that may increase a company's energy productivity. Getting funding for these projects may involve strategies such as having a separate capital account for proposed energy efficiency and energy productivity projects, or incorporating estimates of the value of energy productivity co-benefits.

The DOE's Better Plants Program (Better Plants) calls on its participants to demonstrate their commitment to increasing energy efficiency by voluntarily reducing their energy intensity by 25 percent over ten years. As of fall 2014, the 143 participants, representing nearly 11 percent of the total U.S. manufacturing footprint, reported cumulative savings of 320 trillion Btu and $1.7 billion in energy costs; this is enough energy to power the entire state of Vermont for over two years.[98] Building on the success of its participants, Better Plants started a pilot program to improve coordination of energy management practices between companies and their supply chains. For some manufacturers, much of the energy footprints of their products can be traced back to the materials and processes of their suppliers. Better Plants offers participating suppliers technical assistance, energy management training, and priority access to no-cost energy audits through DOE's IACs.[99] Johnson Controls, a Better Plants participant, achieved an annual energy intensity improvement of 8 percent,[100] and it is expanding its own supplier efficiency program by 60 suppliers by 2018. The company's program uses its own energy experts to train suppliers on identifying and implementing cost-effective energy efficiency investments. These efforts have helped suppliers achieve energy savings of 5-10 percent on investments with less than a two-year payback.[101]

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

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

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

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

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

Small and medium enterprises that lack internal expertise in evaluating projects to increase energy productivity may find it beneficial to hire external assistance. Energy service companies can be a valuable partner in realizing reductions in energy use. They provide customers with guaranteed energy savings in return for payment from a portion of the achieved savings. Customers of energy service companies saved an estimated 33.7 terawatt-hours of electricity in 2012, equivalent to 2.5 percent of U.S. commercial electricity retail sales.[102]

2.2.2.1 Public-Private Partnerships

Partnerships between private business, government and universities for clean energy technologies are important enablers for meeting the energy productivity goal. Public-private partnerships can help increase access to capital, facilitate use of shared infrastructure, and lower technical risks. One notable example is the National Network of Manufacturing Innovation (NNMI), which focuses on R&D of foundational technologies that have potentially transformational technical and productivity impacts for the U.S. industrial sector. NNMI has established five institutes each of which focuses on a promising manufacturing approach or technology. For example, the institute Lightweight Innovations for Tomorrow (LIFT), which focuses on lightweight technology, has a project to reduce the wall thickness of ductile iron cast parts by 50 percent which could result in weight savings of 30–50 percent and associated energy efficiency benefits.[103] These institutes begin with federal support, but they are expected to operate with private-sector funding and without further federal funding after five years.

High-performance computing is another example where industry and public sector resources can join to increase energy productivity. Public-private partnerships in this space could further empower small and large businesses to harness the power of, as well as the modeling and simulation capabilities from, the national laboratory system—to improve R&D, reduce the time required to bring a product to market, and optimize production and supply processes.[104]

The Oak Ridge National Laboratory Manufacturing Demonstration Facility offers shared RD&D infrastructure for additive manufacturing and low-cost carbon fiber, which could be significant enablers of energy productivity, particularly in transportation applications and other technology areas.[105] The facility provides industries with the types of technical expertise and state-of-the-art technology that reduce risk and accelerate the commercialization of innovative new processes and products.

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

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

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

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

SMALL BUSINESS SUCCESS STORIES

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

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

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

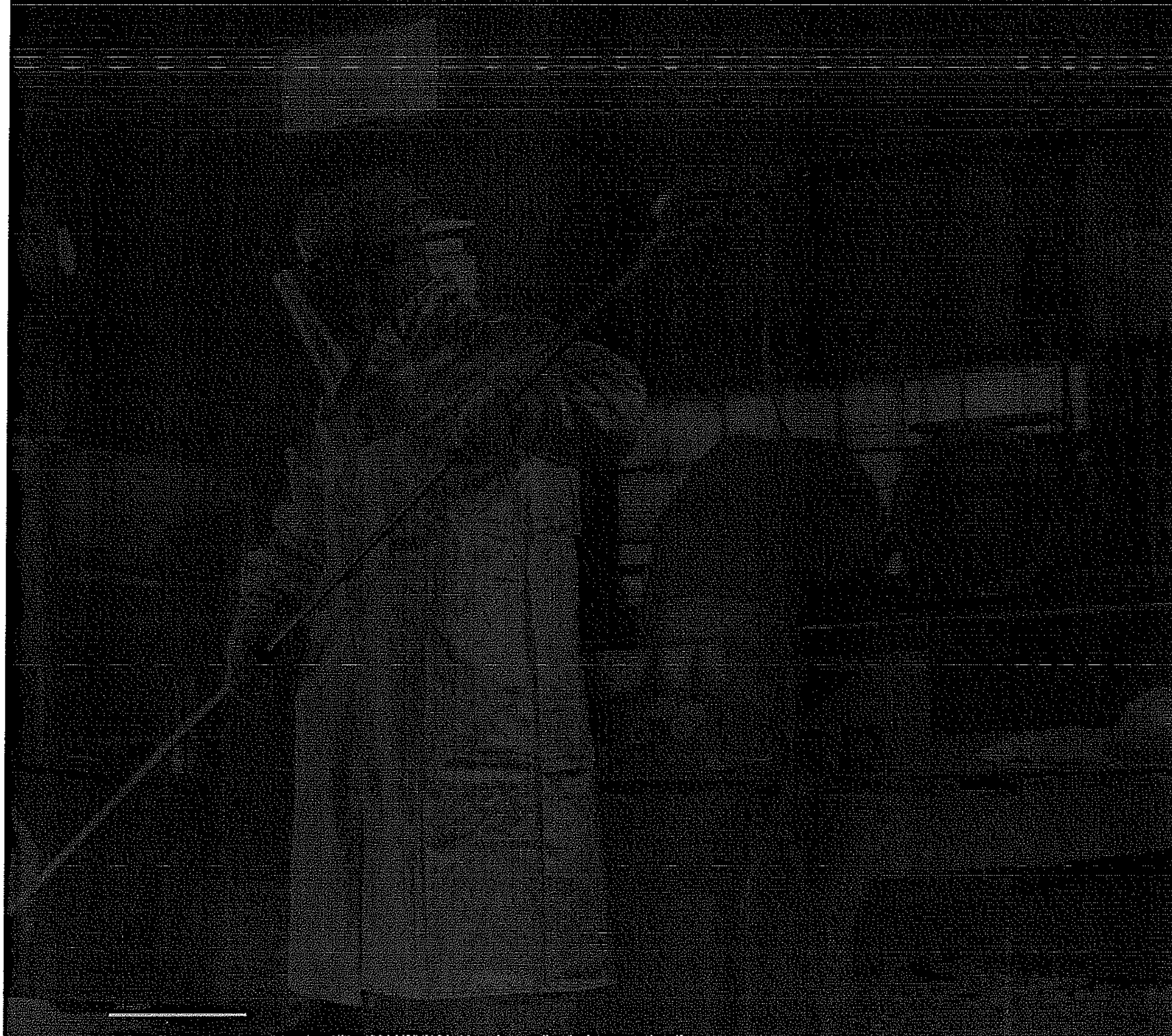
Mid-South Metallurgical is a niche commercial heat-treating company in Murfreesboro, Tennessee. The Mid-South Metallurgical facility operates 24 hours a day and it must accommodate furnace temperatures ranging from 120°F to 2375°F. To address efficiency challenges, the Industrial Assessment Center sponsored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

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

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

recommendations, Mid-South Metallurgical lowered its energy use by 22 percent and decreased its energy costs by 18 percent, helping the company remain competitive through the recession and earning DOE's Energy Champion Award.[3]

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



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

2.2.2.2 Energy Management System Certification

Establishing and certifying an energy management system that systematically tracks, measures, and continually improves energy performance can serve as the foundation for increasing the energy productivity of industrial businesses. For example, manufacturers may focus on the energy used in their processes, as 18 percent of the manufacturing sector's total electricity use is due to direct non-process uses such as facility lighting and space conditioning.[106] Participation in DOE's Superior Energy Performance program, which includes achieving certification under the International Organization for Standardization (ISO) 50001 standard and the American National Standards Institute (ANSI)/MS Standard 50021, yielded average energy savings of $500,000 per year, which is equivalent to a two-year payback period.[107] Additionally, program participants have noted that certification provided more awareness of and confidence in energy performance improvements, unlocking additional resources to fund further improvements.

2.2.2.3 Advanced Manufacturing

Advanced manufacturing is composed of "efficient, productive, highly integrated, tightly controlled processes across a spectrum of globally competitive U.S. manufacturers and suppliers."[108] Reinvigorating the U.S. industrial sector by fostering the growth of advanced manufacturing capabilities will also provide high-quality jobs, which can further improve the U.S. economy. However, in order to bring about the changes necessary for advanced manufacturing, private investment needs to be complemented by public investment.[109]

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

106 "2010 MECS Survey Data," U.S. Energy Information Administration, accessed July 2015, http://www.eia.gov/consumption/manufacturing/data/2010/.

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

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

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

for building automation technologies by 2018[110] to over $120 billion for manufacturing automation sales by 2020.[111] While acknowledging cyber security concerns, attendees at the *Roadmap* regional dialogues noted the value of a standard protocol for new ICT products to allow interoperability between new entrants in this market. This QER also identified this.[112] The next section discusses strategies to develop new business models around enabling customers' energy productivity.

2.2.2.4 Innovative Products to Enable Energy Savings

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

Providing products (e.g., lighter weight materials) that reduce this energy use not only provide value to the customer, but also reduce overall energy use and potentially create new markets. Continued advances in solid state lighting technology (SSL), such as fully controllable color tuning, have resulted in new and growing applications for highly efficient lighting that are geared specifically for productivity improvements. A sampling of these applications include spectrally controlled lighting to make people more alert or to facilitate sleep; spectrally optimized lighting for crop growth and livestock rearing; and spectrally tuned lighting for visual inspection processes or other enhanced visibility functions.[113]

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

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

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

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

MANUFACTURING SUCCESS STORY

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

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

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

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

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

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

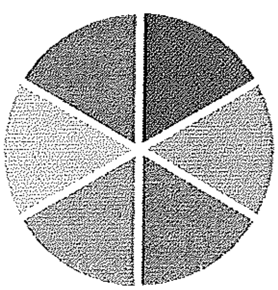
A step-by-step guide to conducting your own Energy Marathon as well as other tools to help others save energy can be found at: http://www.legrand.us/aboutus/sustainability/high-performance-buildings/tools-and-downloads.

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

2.3 Electric Utilities

Utilities—including investor-owned utilities, municipalities, and cooperatives—have significant potential to impact energy productivity through increased investments and reduced Btu consumption. In 2013, ratepayer-funded energy efficiency programs saved an estimated 23.16 billion kWh of electricity or 0.6 percent of U.S. retail electricity sales in 2013.[114] Such programs show the potential to increase energy productivity through reducing energy consumption. Although these energy efficiency impacts are important for increasing energy productivity, potentially even larger impacts could result from cost-effective investments. Investing in upgraded infrastructure and technologies, along with potential revenue increases from new product and services would induce economic growth. Through market transformation programs and other innovations, the electricity sector serves as a leader and test bed for enabling new technologies with products, services, and markets that contribute to energy productivity improvements. This section of the *Roadmap* takes a holistic look at the energy system and focuses on enhancing U.S. energy productivity through accelerated efforts to implement a smarter, modernized electric energy system.

Together with utilities, public utility commissions and public service commissions[115] can be drivers of electricity rate designs, distributed generation deployment, energy efficiency programs, and other strategies that increase energy productivity. For example, moving from traditional block electricity pricing to time-variant rates can be critical for the functioning of a smarter grid, integration of distributed energy resources (DER) like wind and solar, and adjusting to slower growth in electricity use. Actions by electric utilities contribute to all six energy productivity wedges:



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

2.3.1 GRID INFRASTRUCTURE ENERGY PRODUCTIVITY

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

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

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

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

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

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

Multiple regional dialogue participants at Accelerate Energy Productivity 2030 dialogues emphasized the transformative potential of a standard protocol for data to be communicated between smart grid devices. In the QER, the Administration recommended that DOE work with industry, the Institute of Electrical and Electronics Engineers, state officials, and other interested parties to identify additional efforts the Federal Government can take to better promote open standards that enhance connectivity and interoperability on the electric grid.[116] DOE efforts to support the development of voluntary standards in a number of areas continue.[117] These standards will allow devices created and operated by different companies to communicate, contributing to interoperability between grid technologies and increasing the value of smart grid technologies for all consumers. Standards are also important for the adoption of smart manufacturing, as described previously in the section on advanced manufacturing.

2.3.1.1 Reducing Economic Losses from Power Outages

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

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

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

U.S. economy ranges between $119 and $188 billion per year.[118] The societal cost of a massive blackout is estimated to be in the order of approximately $10 billion per event.[119]

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

2.3.1.2 Effects of a Flexible Smart Grid on Energy Productivity

Transitioning the country's electric energy system to a smarter, modern system could result in direct energy productivity benefits through enhanced infrastructure investments, and more significantly, indirect benefits through enabling two-way flow of electricity and information. Managing the flow of information and electricity in two directions (traditionally electricity flows in one direction from large power generation stations through transmission and distribution grids to consumers) will enable the effective integration of electric vehicles, smart buildings and houses, distributed generation systems (such as rooftop solar systems), and energy storage devices with the electric grid and open opportunities for new markets where participants are rewarded for providing enhancements in efficiency and resiliency. The total economic value generated from a fully deployed smart grid is estimated as high as $130 billion annually.[120]

2.3.1.3 Improving Electric Generating Unit Heat Rates to Gain Energy Productivity

Results of a recent analysis indicate that approximately 4.6 percent of electricity is consumed in the production of electricity itself, making the electric sector the second largest electricity consuming industry in the United States.[121] The performance of a thermoelectric power plant can be measured by its heat rate—the efficiency of conversion from fuel energy input to electrical energy output. A generating unit with a lower heat rate can generate the same quantity of electricity than a unit with a higher heat rate while consuming less fuel to generate electricity. Lower fuel use per unit of electricity generated also reduces the corresponding emissions of pollutants.

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

119 119 U.S.-Canada Power System Outage Task Force, *Final Report on the August 14, 2003 Blackout in the United States and Canada: Causes and Recommendations* (Washington, D.C.: U.S. Department of Energy, 2004), accessed July 2015, http://energy.gov/oe/downloads/blackout-2003-blackout-final-implementation-report.

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

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

Modern coal-fueled power plants now achieve net conversion efficiencies of over 39 percent.[122] A variety of technologies show potential to increase efficiency of power plants. Examples include: the incorporation of adjustable-speed-drive mechanisms for plant motors; turbine upgrades for higher temperatures and pressures; advanced materials for expanded operational temperature ranges; condenser upgrades; replacement seals and firing system upgrades and diagnostics; and sensors and controls for optimizing performance.[123]

Over 80 percent of the U.S. electric power generation capacity comes from thermal turbines.[124] Consequently, improving heat rates at existing generators can lower fuel costs and help achieve compliance with environmental regulations. A heat rate improvement of 1 percent on a single 500-megawatt (MW) base-loaded coal-fired unit can save $700,000 per year in fuel costs alone, and it can reduce carbon dioxide (CO_2) emissions by approximately 40,000 tons per year.[125]

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

Utilities started delivering energy efficiency services in the 1980s, many of which are now standard, with regulators adopting policies to encourage and mandate them. Demand side energy efficiency driven by the 2015 Clean Power Plan is expected result in a 7 percent reduction in electricity demand by 2030.[126] A utility faces the following financial concerns adopting an energy efficiency program:

- Failure to recover program costs in a timely way has a direct impact on utility earnings.
- Reductions in sales due to energy efficiency can reduce utility financial margins.
- As a substitute for new supply-side resources, energy efficiency reduces the earnings that a utility would otherwise earn on the supply resource.[127]

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

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

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

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

126 "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.

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

These financial concerns can be effectively addressed through mechanisms such as decoupling and lost revenue adjustment mechanisms. These concerns are part of the broader discussion of evolving utility business models. The QER noted the impact and implications of new technologies, including those that facilitate increased energy productivity, including end-use efficiency on particularly the distribution part of utilities: "At high penetrations, many of these new technologies could challenge current distribution systems and the functional integrity of the current electricity system. New investments and changes to existing regulatory, policy, financial, and business structures may be necessary to fully realize the benefits of these technologies. Regulators and policymakers will need to address the operational issues associated with new technologies, as well as longer-term concerns, such as how the loss of revenue (and a utility's ability to cover fixed costs) and load resulting from increasing numbers of installations could challenge utilities' financial health under current business models."[128]

2.3.2 PROMOTING ENERGY PRODUCTIVITY IN RATE DESIGN

Since the year 2000, as noted in the QER, "many states have adopted policies to support utility investments in energy efficiency."[129] There are at least three different regulatory approaches being used: decoupling, lost revenue adjustment mechanism, and a broad set of methods to allow performance incentives. These efforts create a regulatory model that rewards utility shareholders for effective energy efficiency efforts that lower ratepayer bills in the long term. These three general categories of regulatory policy and rate-setting changes serve to address negative financial effects on utilities. Thus, they do modify the distribution utility's business model by making it at least neutral and in some cases, providing a financial return, for delivering energy efficiency to their customers, which represents a prime method of improving energy productivity.

The last decade and a half shows substantial growth in utility-delivered energy efficiency, whether through state's adopting mandates known as energy efficiency portfolio standards or allowing changes to distribution utility business models through the three regulatory policy and rate-setting categories noted earlier. Utility-delivered energy efficiency is projected to grow aggressively over the next decade through a combination of all these measures. The QER found that, "Appropriate valuation of new services and technologies and energy efficiency can provide options for the utility business model," but that "Different business models and utility structures rule out 'one-size-fits-all' solutions to challenges."[130]

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

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

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

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

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

The federal government can use its convening power to gather information from a broad range of stakeholders, and it can provide tools and resources for understanding the value of services provided by new and innovative technologies. Such resources would allow policymakers to make informed decisions about how best to leverage new technologies in their communities to support growing energy productivity.[131] For example, Michigan passed the Clean, Renewable, and Efficient Energy Act in 2008. This act allowed certain utilities to decouple their rates thus making the utilities financially neutral to negative financials resulting from increased ratepayer energy efficiency; the act also required electric and natural gas utilities to help consumers increase the energy efficiency of their homes and businesses. These programs are expected to result in over $700 million in value to customers, and in 2011, the program achieved enough savings to power 1.5 million homes and heat 40,000 homes for a year.[132]

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

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

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

UTILITY SUCCESS STORY

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

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

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

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

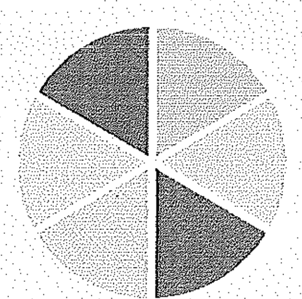
On average, the program helps over 15,000 customers save up to 15 percent annually on electricity purchases. The benefits of Energy Select have also translated to a boost in overall customer satisfaction with the electric utility service itself, resulting in customer satisfaction rates as high as 95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

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

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

2.4 Water Utilities

In a 2002 report, EPRI estimated that 4 percent of the nation's electricity use goes towards moving and treating water and wastewater.[133] Providing the same water services while consuming significantly less energy offers a significant contribution to meeting the productivity goal. Actions taken by public and private water utilities contribute to two energy productivity wedges:



Smart Energy Systems

Water Infrastructure

Energy consumption by public drinking water and wastewater utilities represents a substantial cost for both public and private water systems. The cost of energy for municipal water systems can be extraordinarily burdensome for localities, accounting for as much as 25-40 percent of their energy bills.[134] Local governments can reduce energy use at water and wastewater facilities through energy efficiency programs, waste to energy technologies, measures that promote water conservation, investments that prevent water loss and reduce storm water.[135] For example, the Missouri Water Utilities Partnership, a public-private partnership, identified and implemented strategies projected to reduce water-related electricity use by more than 8 million kWh per year, which is enough energy to power over 730 homes for a year.[136]

Infrastructure is also pivotal to ensuring water and energy savings. Nationwide, aging, leaking infrastructure results in significant energy waste, with national estimates of leaks and other losses as high as 20-25 percent.[137] This indirectly translates to energy waste from additional required treatment and pumping. The situation can be addressed through advanced leak monitoring, advanced pressure management, and accelerated replacement of buried infrastructure.

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

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

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

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

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

At drinking water plants, the largest energy use (about 80 percent) is to operate motors for pumping.[138] There is a recognized potential to improve the efficiency of water utility pumping processes by as much as 30 percent.[139] Water utilities like American Water are implementing pump efficiency programs. Improving the efficiency of motors used in water pumps from the current average of 55 percent to 80 percent would save 10 million MWh per year, the equivalent of lighting a city the size of Chicago for over two years.[140]

There is also significant opportunity for improving the wastewater aeration process, which consumes 30-50 percent of all energy in wastewater treatment plants. This can be accomplished through the use of more efficient aeration or the use of anaerobic processes that do not require aeration. Nutrient removal is also energy-intensive. Thus, more efficient microbial processes to remove nitrogen and phosphorus from wastewater, can also significantly reduce energy consumption.[141]

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

Beyond improving the efficiency with which utilities move and treat water, energy savings can be realized by more efficient end-use of water. Indeed, "water-related energy consumption was 12.6 percent of national primary energy consumption in 2010."[142] Reducing this end user water consumption can thus have an indirect and significant impact on energy consumption. Outdoor watering practices can also indirectly waste energy. Technologies such as drip irrigation and low-flow plumbing fixtures can improve water use efficiency, which indirectly translates into energy savings.

2.4.1 RATE REFORM

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

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

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

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

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

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

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

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

WATER UTILITY PUMP EFFICIENCY ENERGY SAVINGS SUCCESS STORY

American Water

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

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

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

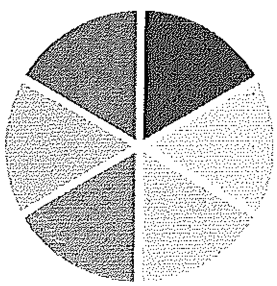
American Water pump refurbishment programs maintain, repair and replace pumps, motors and variable frequency drive (VFD) equipment. The cost of pump replacement/ refurbishment to recover capacity and improve efficiency is weighed against the typical decline in efficiency/capacity over time. American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

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

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

2.5 Higher Education Institutions

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



Smart Energy Systems
Technologies for Buildings Energy Productivity
Smart Manufacturing
Transportation

2.5.1 WORKFORCE TRAINING

Additional energy productivity gains can come from efficiently operating and maintaining buildings. Building operators can realize annual energy bill savings of 5-20 percent by implementing operations and maintenance (O&M) best practices, including operating equipment only when needed, performing preventative O&M, and tracking performance.[143]

The Building Operator Certification (BOC®) is a training and certification program that provides building operators with the skills and knowledge to implement the types of O&M best practices that can help maximize the efficiency of existing and future buildings. BOC certification is offered by several Regional Energy Efficiency Organizations as well as community and technical colleges in the Northeast, Mid-Atlantic, Southeast, and the West.[144] Annual energy and utility bill savings specific to companies with BOC-certified operators are estimated to be 170,000 kWh per year and $12,000 per year, respectively, which is enough electricity to power nearly 100 refrigerators for a year.[145]

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

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

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

While higher education can lead to certain careers that will help accelerate energy productivity, many job opportunities exist in the energy and advanced manufacturing fields that do not require four-year degrees. Technical and community colleges can provide the skills and knowledge for the next generation of energy and manufacturing industry employees. Mississippi's Get on the Grid[146] and Ohio's Advanced Manufacturing Industry Partnership[147] are examples of the types of workforce training programs that can be leveraged to increase energy productivity.

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

2.5.2 ACCELERATING ENERGY PRODUCTIVITY FROM THE LAB TO THE REAL WORLD

Colleges and universities are instrumental partners for carrying out federally funded R&D. While the growth of federal R&D funding has largely stagnated since 2004, universities are contributing a larger share of funding and they were responsible for over $12 billion (FY 2014 dollars) of the $64 billion (FY 2014 dollars) total university science and engineering R&D funding in 2012.[148]

Universities can play an important role in transferring innovative technologies to businesses. Universities offer unique opportunities to act as real world testbeds for technologies and practices that increase energy productivity. For instance, the Future Renewable Electric Energy Delivery and Management (FREEDM) System Center, directed by North Carolina State University, supports fundamental research for breakthrough energy storage and power semiconductor technologies as well as partnerships with businesses to facilitate the transition of research into commercially viable products.[149] Several technologies developed by FREEDM have received commercial licenses.[150]

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

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

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

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

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

HIGHER EDUCATION INSTITUTIONS SUCCESS STORY

North Carolina State University Creates Electricity at Renovated Utility Plant

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

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

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

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

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

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

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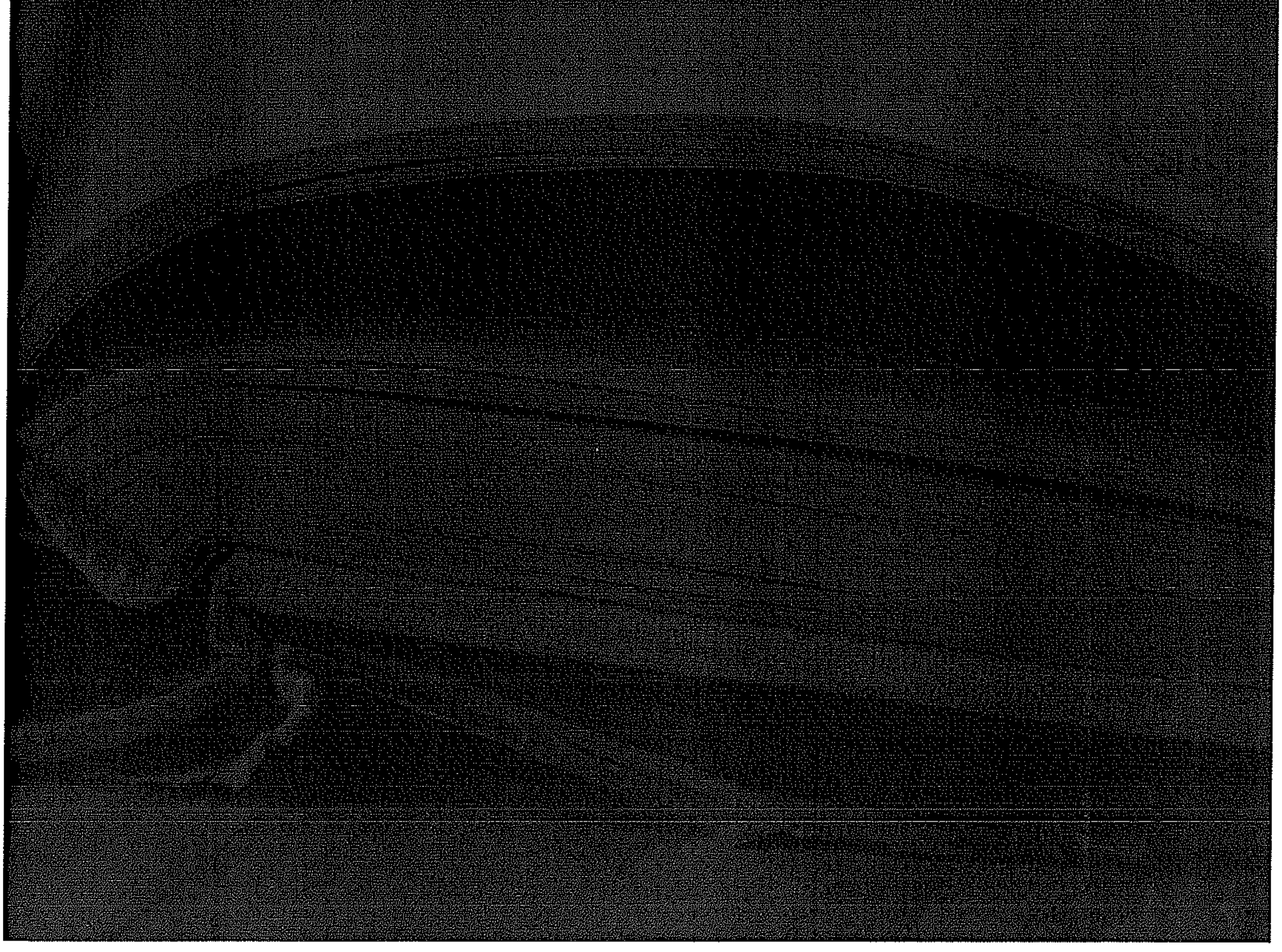
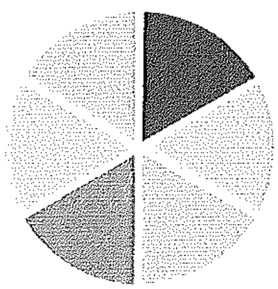


2.6 Households

Households account for a large portion of U.S. energy use, and household purchases of goods and services drive much of the U.S. economy. Residential buildings and personal transportation together represented roughly 40 percent of primary energy use in 2014.[151] Household energy use is even more significant when the energy required to produce consumer goods and services, so called "embodied energy," is considered. Also, household expenditures constitute a large portion of overall economic activity.

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



Technologies for Buildings Energy Productivity
Transportation

2.6.1 ENERGY PRODUCTIVITY AT HOME

Households can reap energy productivity benefits by participating in the *Roadmap* strategies identified for government and businesses. The goal of many of these strategies is to enable households to choose the most energy-efficient products, which translates into savings on energy bills. Purchasing more energy-efficient appliances, in addition to taking other energy efficiency measures such as installing insulation, could reduce household electricity and natural gas use by 34 percent and 35 percent respectively and could result in utility bill savings of $83 billion (in 2007 dollars) by 2030.[152]

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

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

Many strategies aim to improve the amount and quality of energy information available to households in order to allow consumers to make better-informed decisions on the use of energy in their home and to encourage early adoption of more energy-efficient products. Information-based strategies have been found to reduce electricity use by 7 percent.[153] The federal government provides a suite of websites that address the many facets of household energy efficiency, including homes (http://www.energysaver/.gov) and transportation (www.fueleconomy.gov). Utilities and companies are offering households greater visibility into home energy use. For example, they are providing homeowners and others the option to compare energy use with that of that their neighbors and similar houses.[154] A collaboration of the University of Florida and the International Carbon Bank and Exchange took energy data visibility a step further and created an online platform where anyone can view electricity use and building characteristics of homes in Gainesville, Florida.[155] Initiatives like DOE's Green Button initiative allow households to access their electricity meter data in a standardized format.[156] Green Button also allows users to automatically connect their data to services that will evaluate opportunities to reduce their electric bills.

As many as 37 states and the District of Columbia incentivize the use of EVs.[157] The Federal government and certain states, including California, Colorado, Connecticut, Louisiana, and Maryland, offer rebates or tax credits for purchases of EVs.

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

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

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

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

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

HOUSEHOLDS SUCCESS STORY

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

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

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

EXAMPLE: OPOWER'S CUSTOMER ENGAGEMENT PLATFORM

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

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

EXAMPLE: OPOWER'S HOME ENERGY REPORT

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

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

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

Doubling energy productivity by 2030 is possible only if multiple sectors and initiatives work together.

ANALYSIS & RESULTS

The previous section of the *Roadmap* describes a number of strategies to achieve significant improvements to U.S. energy productivity. In this section of the *Roadmap*, DOE models the impacts of six combinations of productivity improvement strategies, referred to as wedges, to identify the most effective pathway forward. Fully analyzing the effect of those wedges on energy productivity requires a model of interaction between the U.S. economy's use of energy and its GDP. Based on a review of the existing literature on energy productivity and GDP, DOE developed a modeling framework that dynamically relates changes in energy use and investment to changes in GDP.

The model improves upon previous analyses conducted by DOE because it combines robust estimates of the relationships between various sectors of the economy using historical data and because it dynamically estimates the future effects of changes to the economy using those historical relationships. More broadly, the model estimates the net effects of changes to energy use and investments on GDP, capturing any GDP feedback effects caused by energy efficiency investments. Consequently, the model is capable of directly estimating how future changes in both energy use and investments may affect energy productivity. For instance, the model can predict what level of national effort, in terms of investment and energy reduction, is required to meet the energy productivity goal.

3.1 Synthesis of Strategies into Energy Productivity Wedges

The energy productivity strategies presented in the *Roadmap* often involve multiple economic sectors and levels of government. To capture the collective potential impacts of those strategies, DOE has developed six productivity wedges. A summary description of each wedge, including associated investment and energy savings used in the analysis, is provided below. Model inputs for each wedge were developed using assumptions and results from published studies, as summarized in Table 2. The results of these studies were generated using models and assumptions that are separate from the model and analysis developed for the *Roadmap*, and do not represent impacts of specific strategies and actions identified in the *Roadmap*. The results from these studies, however, are assumed to be illustrative of the types of energy and economic changes that would be expected to result from following the *Roadmap* and are appropriate to use as inputs to the energy productivity model. The published studies are best described as prospective analyses that estimate potential energy savings (in Btu and dollars) for a particular economic sector, given a certain level of investment. However, not all sources included estimates of associated investment levels or energy savings in dollars. Where sources did not include dollar energy savings, estimates of these savings were generated using AEO 2014 fuel price projections and estimated energy savings. Note that successful implementation of energy productivity wedges are likely to affect future energy commodity prices. Where a source report did not include energy savings estimates, such as for the Smart Manufacturing wedge, assumptions from the report were used to develop energy savings estimates from AEO 2014 data.

Table 2 presents the productivity wedges and summarizes their connections to the strategies discussed earlier in the *Roadmap*. Note that there are overlaps and interactions between wedges and individual strategies that may be part of several wedges. Energy productivity wedges are entered into the model as changes in overall investment and total energy use. The model does not differentiate between the types of investments and energy savings by sector. More specifically, the model assumes that an increase in investment of $1.00 has the same effect regardless of what sector of the economy the investment occurs. Likewise, the model assumes that a 1 Btu change in energy use has the same effect regardless of the economic sector and the energy carrier. The model does report GDP impacts by three separate sectors: goods, services, and natural resources and utilities. The model does account for energy used to produce the additional goods and services that result from increased investments. This results in a net energy impact that is less than the sum of energy savings of each individual wedge.

Table 2. Summary of Model Analysis Sources and Inputs by Energy Productivity Wedge[158]

Wedge	Summary of Representative Energy Productivity Actions	Sources of Inputs	Inputs
Smart Energy Systems	Implementation of smart grid technologies in transmission and distribution systems and for consumers.	EPRI (Electric Power Research Institute). 2011. *Estimating the Costs and Benefits of the Smart Grid.* Palo Alto, CA: Electric Power Research Institute. EPRI. 2009. *The Potential to Reduce CO2 Emissions by Expanding End-Use Applications of Electricity.* Palo Alto, CA: Electric Power Research Institute.	$738 billion cumulative net cost savings to utilities and consumers; 70 Quadrillion Btu cumulative energy savings by 2030.
Technologies for Buildings Energy Productivity	High achievable potential for adoption of energy-efficient equipment.	EPRI. 2014. *U.S. Energy Efficiency Potential Through 2035,* Palo Alto, CA: Electric Power Research Institute.	5.4 Quadrillion Btu/year energy reduction by 2030; $331 billion cumulative investment costs by 2030; $409 billion cumulative cost savings by 2030.
Buildings Energy Productivity Financing	Building energy efficiency retrofits enabled by energy service agreements, property assessed clean energy, on-bill financing.	Rockefeller Foundation and DB Climate Change Advisors (2012). *United States Building Energy Efficiency Retrofits: Market Sizing and Financing Models.* Frankfurt: Deutsche Bank AG.	Cumulative investment of $279 billion with cumulative cost savings of $717 billion by 2030. 39 Quadrillion Btu cumulative energy savings by 2030.
Smart Manufacturing	ICT that enables energy efficiency in electrical equipment used in manufacturing processes and buildings. Recommendations for government (lead by example, R&D), public utilities, and ICT suppliers.	Rogers, Ethan A., R. Neal Elliott, Sameer Kwatra, Dan Trombley, and Vasanth Nadadur. 2013. *Intelligent Efficiency: Opportunities, Barriers, and Solutions.* Washington, DC: American Council for an Energy-Efficient Economy.	15 Quadrillion Btu cumulative reduction in energy use and $15 billion cost savings by 2030.
Transportation	Technical potential of energy efficiency improvements for light-duty vehicles; adoption of alternative fuel vehicles; reduction of vehicle miles traveled through trip reduction, land use change (e.g., higher densities, walkable neighborhoods), efficient driving, mode switching; and efficient technologies for freight modes.	DOE Office of Energy Efficiency and Renewable Energy, National Renewable Energy Laboratory, and Argonne National Laboratory. 2013. *Transportation Energy Futures* series. http://www.nrel.gov/analysis/transportation_futures/.	Cumulative energy reduction of 152 Quadrillion Btu and cost savings of $4,051 billion by 2030.
Water Infrastructure	Efficiency potential for pumps and other equipment in water supply and wastewater treatment utilities.	WRF (Water Research Foundation) and EPRI. 2013. *Electricity Use and Management in the Municipal Water Supply and Wastewater Utilities.* Denver, CO: Water Research Foundation, Palo Alto, CA: Electric Power Research Institute.	Cumulative energy reduction of 1 Quadrillion Btu and cost savings of $6 billion through 2030.

158 Care was taken to select a set of model inputs that would avoid double-counting investments and energy savings for each energy productivity wedge. However, it was not possible to quantify potential double-counting given the varying level of detail contained in the source reports. The buildings energy productivity technology and buildings finance wedges are the most likely to have some overlap, although this likely does not affect the conclusions drawn from results of the energy productivity analysis. The inputs for the buildings energy productivity-technology wedge were identified in the source report as part of a "high achievable" scenario, which includes barriers that limit adoption of energy efficiency measures. It is assumed that novel funding mechanisms represented by the buildings energy productivity-financing scenario overcome these barriers. As a result, the investments and energy savings are additional and not double-counted.

The published studies can be described as prospective analyses that estimate potential energy savings (in Btu and dollars) for a particular economic sector, given a certain level of investment. However, not all sources included estimates of associated investment levels or energy savings in dollars. Where sources did not include dollar energy savings, estimates of these savings were generated using AEO 2014 fuel price projections and estimated energy savings. Note that successful implementation of energy productivity wedges is likely to affect future prices of energy commodities. Where a source report did not include energy savings estimates, such as for the Smart Manufacturing wedge, assumptions from the report were used to develop energy savings estimates from AEO 2014 data.

Energy productivity wedges are entered into the model as changes in overall investment and total energy use. The model does not differentiate between the types of investments and energy savings by sector. In other words, the model assumes that an increase in investment of $1.00 has the same effect regardless of the economic sector in which the investment occurs. Likewise, the model assumes that a one-Btu change in energy use has the same effect regardless of the economic sector or the energy carrier. The model does report GDP impacts by three separate sectors: goods, services, and natural resources and utilities. The model does account for energy used to produce the additional goods and services that result from increased investments. This results in a net energy impact that is less than the sum of energy savings of each individual wedge.

- **Smart Energy Systems:** Energy systems, including those that participate in the generation and delivery of electricity, are sources and enables the backbone of improvements to U.S. energy productivity. Broad and deep transformations involving the effective integration of information and communications technologies are required to enable transitions to distributed energy resources, real-time energy pricing, smart appliances, and increased energy efficiency. The Smart Grid is estimated to produce cumulative benefits of $23.7 billion–$46.8 billion and 42 billion kWh–134 billion kWh of electricity savings by 2030.[159]
- **Technologies for Building Energy Productivity:** Improving R&D and increased focus on deployment is required to bring the next generation of energy productivity. Enabling technology and equipment for commercial and residential buildings requires both the widespread use of currently available energy-efficient technologies and practices, and the development of next generation technologies. Annual investment in the residential, commercial, and industrial sectors of $7 billion, $12 billion, and $74 million respectively are estimated to yield combined energy savings of 5.4 quads.[160]
- **Financing for Building Energy Productivity:** Significant changes to financing mechanisms are required to ensure that energy productivity-enabling technology is purchased by businesses and households. Strategies include

159 C. Gellings, *Estimating the Costs and Benefits of the Smart Grid: A Preliminary Estimate of the Investment Requirements and the Resultant Benefits of a Fully Functioning Smart Grid* (Palo Alto, CA: Electric Power Research Institute, 2011), accessed July 2015, http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001022519.

160 S. Mullen-Trento, *U.S. Energy Efficiency Potential Through 2035* (Palo Alto, CA: Electric Power Research Institute, 2014), accessed July 2015, http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001025477.

on-bill financing, creating secondary markets for energy efficiency loans, and tailoring financing for the unique needs of small and medium enterprises. Building retrofits enabled by new financing mechanisms are assumed to result in a 10-year cumulative investment of $279 billion and 3.0 quads of annual energy savings in 10 years.

- **Smart Manufacturing:** Sensors and other ICT will allow industries better control over their processes, as well as improved energy management of their buildings. Based on analysis by the American Council for an Energy-Efficient Economy, annual energy savings are estimated to reach 2.1 quadrillion Btu by 2030.[161]
- **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. Model inputs for this wedge are net annual energy reduction of 16 quads/year by 2030 and investments of $531B/year by 2030.
- **Water Infrastructure:** The linkages between energy and water systems provide opportunities to increase energy productivity. Specifically, water and waste water treatment plants can improve energy efficiency and demand response, implement emerging technologies and processes, and deploy energy recovery and generation technologies. Improvements made in this wedge are assumed to result in an energy reduction of 0.14 quads/year by 2030 and investments of $800M/year by 2030.

Table 3. Energy Productivity Strategies Organized by Productivity Wedge

	Smart Energy Systems	Technologies for Buildings Energy Productivity	Buildings Energy Productivity Financing	Smart Manufacturing	Transportation	Water Infrastructure
FEDERAL GOVERNMENT						
Research and Development	X	X		X	X	X
Performance Information and Product Standards	X	X			X	X
Tax Policy	X	X	X		X	X
Workforce Training	X	X			X	
Demonstration and Leading by Example	X	X	X		X	X

161 Ethan A. Rogers, R. Neal Elliott, Sameer Kwatra, Daniel Trombley, and Vasanth Nadadur, *Intelligent Efficiency: Opportunities, Barriers, and Solutions, Research Report E13J* (Washington, D.C.: American Council for an Energy-Efficient Economy, 2013), accessed July 2015, http://aceee.org/research-report/e13j.

	Smart Energy Systems	Technologies for Buildings Energy Productivity	Buildings Energy Productivity Financing	Smart Manufacturing	Transportation	Water Infrastructure
STATE GOVERNMENT						
Energy Efficiency Portfolio Standards		X	X			
Energy Productivity Financing		X	X			
Combined Heat and Power		X	X			
Smart Regional Transportation Solutions						X
Building Codes		X				
LOCAL GOVERNMENT						
Local Ordinances to Facilitate Distributed Resources, where appropriate	X	X				X
Building Energy Disclosure Ordinances	X	X	X			
Creating Advanced Manufacturing Ecosystems		X	X		X	X
Built Environment-Transportation Nexus	X	X				X
COMMERCIAL BUSINESSES						
New Financing Models		X	X	X		
Workforce Training	X	X		X	X	
INDUSTRIAL BUSINESSES						
Public-Private Partnerships	X				X	X
Energy Management Certification		X			X	
Advanced Manufacturing					X	X
Innovative Products to Enable Energy Savings	X	X		X	X	X

	Smart Energy Systems	Technologies for Buildings Energy Productivity	Buildings Energy Productivity Financing	Smart Manufacturing	Transportation	Water Infrastructure
ELECTRIC UTILITIES						
Grid Infrastructure Productivity	X					
New Business Models	X		X		X	X
Rate Design	X	X			X	X
WATER UTILITIES						
	X			X		
HIGHER EDUCATION INSTITUTIONS						
Workforce Training	X	X			X	X
Accelerating Energy Productivity from the Lab to the Real World	X	X			X	X
HOUSEHOLDS						
Energy Productivity at Home		X				X

3.2 Overview of Energy Productivity Analysis Framework

As described in the previous section, the strategies identified in the *Roadmap* are aggregated into six illustrative energy productivity wedges. These wedges are representative of the *Roadmap* strategies and illustrate the types of economic and energy changes that could be expected following implementation of the *Roadmap*. The investments and corresponding reductions in energy use for each wedge are described in Table 2 and serve as inputs to the modeling efforts.

In the abstract, diverting spending from one use (such as consumption) to another use (such as investments in energy-efficient technology) has ambiguous effects on GDP that depends on the relative GDP multipliers of the specific type of consumption and investment. (The GDP multiplier captures the direct and indirect effects of a change in direct spending patterns on GDP.) Thus DOE built a model to better understand how changes in direct spending, such as increases in energy efficiency investment as described by the wedges, would produce indirect effects on GDP. The combination of those direct and indirect effects represent the net effects of changes to energy use and investments on GDP, capturing any GDP feedback effects caused by energy efficiency investments.

Specifically, DOE employed a vector error correction model (VECM) to estimate the effect of the wedges on U.S. GDP. This approach is commonly used by economists as a forecasting tool because of its ability to robustly estimate historical relationships between various sectors of the economy and then use those historical relationships to dynamically predict economic growth in a way that incorporates interactions and feedback effects between economic sectors. The model improves upon previous analyses conducted by DOE. The model has three component parts, each with two periods: the estimation period when historical relationships between sectors are statistically estimated (1970 to 2013), and the forecast period (2014 to 2030).

The objective of the first set of VECM equations is to dynamically estimate GDP and energy use with feedback effects. The equations capture how energy expenditures interact with consumption and investment, two major components of GDP. The primary actors in all wedges are investors, privately held businesses, and households; this set of equations models the economic relationships between those actors and energy expenditures.

The objective of the second set of VECM equations is to estimate energy prices such that energy expenditures can be converted to the quantity of energy used. Energy expenditures were estimated in the first set of equations, which consist of prices for various energy commodities multiplied by the quantities of those energy commodities consumed. The second set of VECM equations captures feedback effects between prices, quantities and other macroeconomic variables including consumption, investment, and total energy expenditures.

The objective of the third set of VECM equations is to estimate the changes in activity for each modeled sector of the economy. The model decomposes GDP into three component sectors: goods, services, and natural resources combined with utilities. These sectors were chosen because they correspond well with the structure of the model, which focuses on GDP and energy. The goods sector contains agriculture, manufacturing, and construction. The natural resources and utilities sector contains mining and other extractive industries as well as utilities. The services sector contains all other industries, including sales, warehousing, transportation, information business services, leisure services, and other services. These equations rely on the variables estimated in the first two sets of equations, as well as other variables such as the size of the labor force, net exports, and industrial production.

Data for the model is drawn primarily from the Energy Information Administration (EIA) with sector-specific data pulled from the Bureau of Economic Analysis (BEA) and the World KLEMS Initiative.[162] Specifically, the VECM model relies on historical data between 1970 and 2013 and forecasts from 2014 to 2030, which is developed in EIA's AEO 2014. The model's baseline does not precisely match that of AEO 2014 because of different model structure and assumptions, although the two baselines are similar. Data that relate economic growth to the use of economic inputs are provided by the Bureau of Economic Analysis (BEA) and the World KLEMS Initiative. These data are widely used in productivity analysis to estimate how changes in the use of economic inputs affect changes in economic output.

Energy productivity wedges are entered into the model as increases in overall investment and reductions in total energy use. The model does not differentiate by sector between the types of investments and energy savings by sector. More specifically, an increase in investment of $1.00 is the same regardless of what sector of the economy the investment occurs. Likewise, the model assumes that a 1 Btu change in energy use is the same regardless of the economic sector and the energy consumer.

This modeling technique is not without limitations. Perhaps the most significant hurdle to successful implementation of the model is the large amount of historical detail required for each sector modeled. As the number of sectors increases, longer time series are necessary to find statistically significant relationships between industries. Other techniques that are often used for similar forecasting exercises, such as input-output (I-O) and computable general equilibrium (CGE) models, often have even more sector-level detail, yet rely on theoretical interactions between sectors rather than observed historical relationships. In addition, I-O models are described as static because they assume that prices, technology, and productivity remain unchanged over time. And although relative prices can change in a CGE model, CGE model results are dependent on what the modeler specifies, instead of historical relationships, with respect to the sensitivity of changes in energy consumption by each industry or households are to prices. Thus, the VECM model was attractive because it is a dynamic model that relies on historical data to identify relationships between sectors.

3.3 Energy Productivity Potential

Given the scenario outlined above for all six productivity wedges, the model shows that doubling energy productivity by 2030 is possible but only if multiple sectors and initiatives concurrently work together. By 2030, model results show that

162 KLEMS is an acronym for the five components of intermediate inputs used by industries: capital (K), labor (L), energy (E), materials (M), and services (S). These data are widely used in productivity analysis to estimate how changes in the use of economic inputs affect changes in economic output. See, for example: Douglas Koszerek, Karel Havik, Kieran McMorrow, Werner Röger, and FrankSchönborn, *An Overview of the EU KLEMS Growth and Productivity Accounts* (Brussels: European Commission Economic and Financial Affairs, 2007), accessed July 2015, http://ec.europa.eu/economy_finance/publications/publication9467_en.pdf and Era Dabla-Norris, Si Guo, Vikram Haksar, Minsuk Kim, Kalpana Kochhar, Kevin Wiseman, and Aleksandra Zdzienicka, *The New Normal: A Sector-Level Perspective on Productivity Trends in Advanced Economies* (Washington, D.C.: International Monetary Fund, 2015), accessed July 2015, http://www.imf.org/external/pubs/ft/sdn/2015/sdn1503.pdf.

GDP (2005$) increases to $22.5 trillion and primary energy use falls to 78 quads. In comparison, the Energy Information Administration's (EIA) *Annual Energy Outlook* (AEO) 2015 projections are $21.7 trillion and 103 quads Btu in 2030. Thus, in 2030, the Roadmap scenario achieves 3.6 percent higher GDP and 24 percent lower primary energy use than AEO 2015 projections. These results are equivalent to increasing energy productivity in 2030 to $287/MMBtu, which is more than double the modeled 2010 baseline of $134/MMBtu, as shown in Figure 7. From 2014 to 2030, energy productivity increases at an annual average rate of approximately 4.2 percent. This rate of improvement is slightly greater than the rate experienced from 1981 to 1983, the period of the largest multi-year energy productivity growth experienced between 1970 and 2010. The buildings- and transportation-related productivity wedges offer the greatest potential to drive energy productivity improvements. Although these wedges alone may result in significant progress, achieving the doubling goal requires many actors working together across all sectors of the economy.

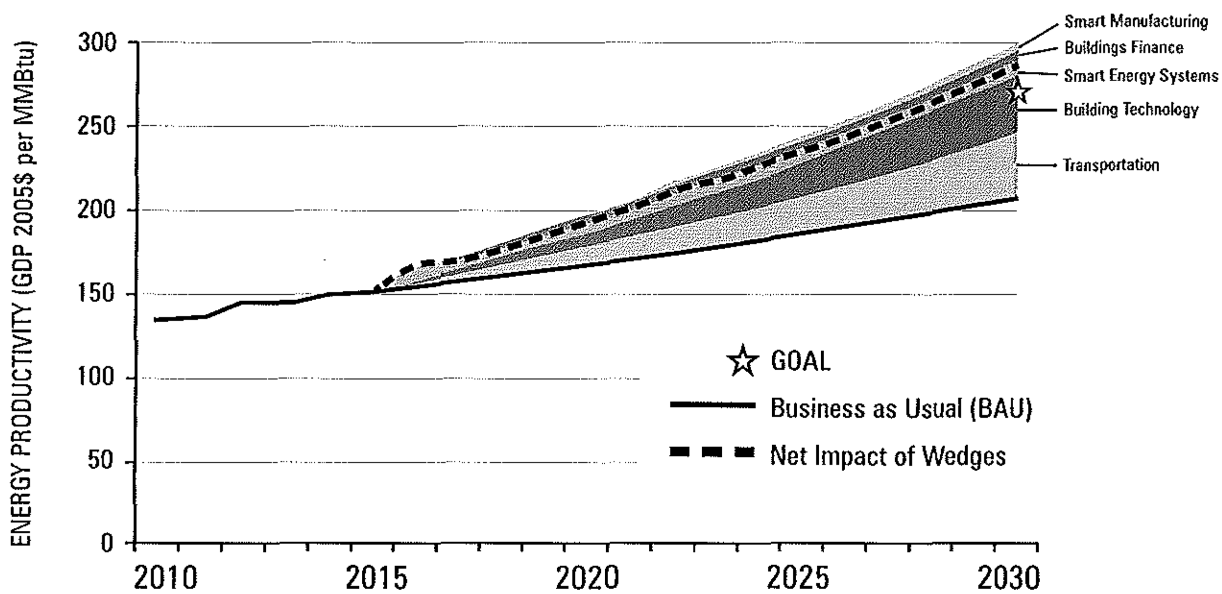


Figure 7. Projected Energy Productivity Benefits to 2030

The wedges in aggregate contribute 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, although it is also driven by a $169 billion increase in investment.

Consumption and investment represent allocations of expenditures in an economy. These are not modeled as two different groups of consumers. One household, for example, could invest while also making personal consumption expenditures. The wedges analyzed involve changing these allocations and subsequently receiving returns on these investments in the form of savings from reduced energy expenditures. Investors are also the owners of businesses, so business investments also directly affect households. These capital expenditures must come from the population,

and subsequent returns then accrue back to these investors. Put more simply, households are able to increase their purchases of other goods and services by making energy productivity investments that reduce their energy bills.
By 2030, there is a 26-quad gross reduction in energy consumption compared to the baseline. Over the period of the analysis, the net total reduction is 23.7 quads. The model does account for energy used to produce the additional goods and services purchased by households. This results in net energy savings values that are approximately 14 percent smaller than the 26-quad gross reduction specified in the model inputs for each productivity wedge. The effect is shown in Figure 7 as the dashed line.

Producers of goods and services are also shown to benefit from increased economic activity spurred by energy productivity investments. As shown in Figure 8, the service industry exhibits the most significant growth, with a nearly $1.08 trillion increase in baseline by 2030. By 2030, goods-providing industries increase by approximately $51 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. By 2030, this decrease is $248 billion, or -1.6 percent of GDP, below baseline. Because the analysis focuses on investment and energy spending, these results do not capture other benefits that are likely to accrue to the natural resources and utilities sector, such as reduced economic losses from power outages (discussed in Section 2.3.1.)

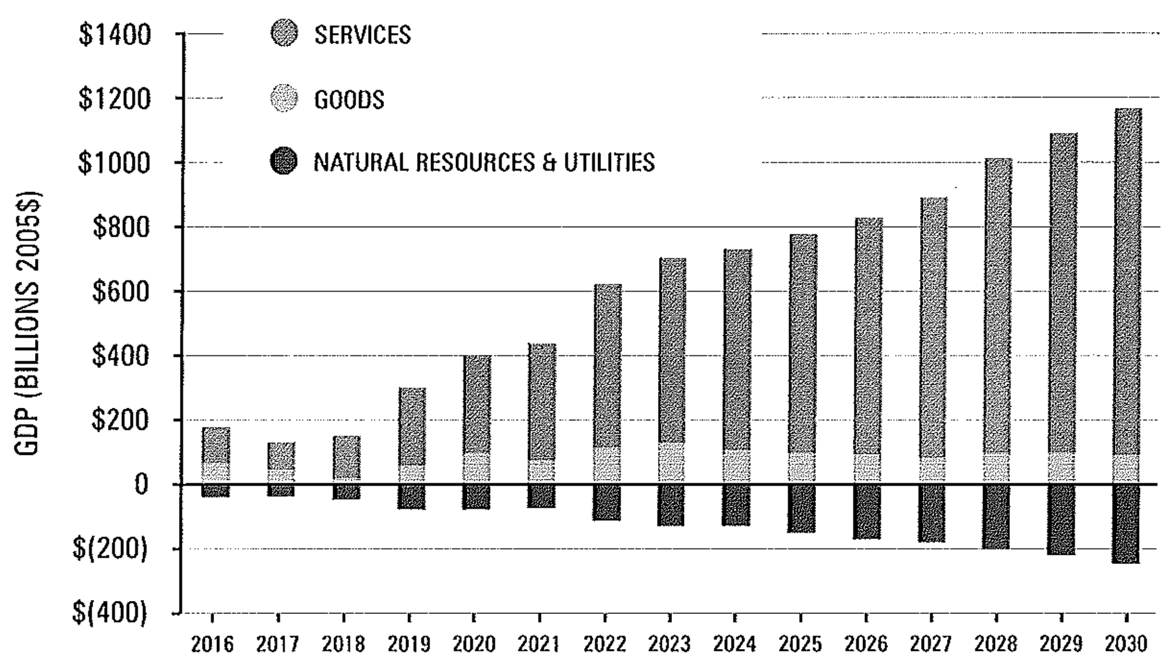


Figure 8. Projected Changes to GDP by Sector (Billions 2005$)


Implementation
will require changes in
behavior, investment, and
deployment of technologies.

NEXT STEPS & CONCLUSION

The federal government has taken significant actions that will improve energy productivity, but these steps require private-sector participation and they will only get the United States roughly halfway to the goal. To achieve the other half of the national goal, decision makers across the United States also need to take action. Participants at the regional dialogues discussed a wide range of opportunities for diverse stakeholders to improve their own energy productivity and contribute to meeting the national goal. The *Roadmap* provides an overview of the types of strategies and actions that need to be taken by businesses, the government, and other actors in the U.S. economy to increase energy productivity and fully meet the 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 good practices for building energy information; support the development of advanced manufacturing ecosystems; and reduce personal vehicle miles traveled 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 as 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.

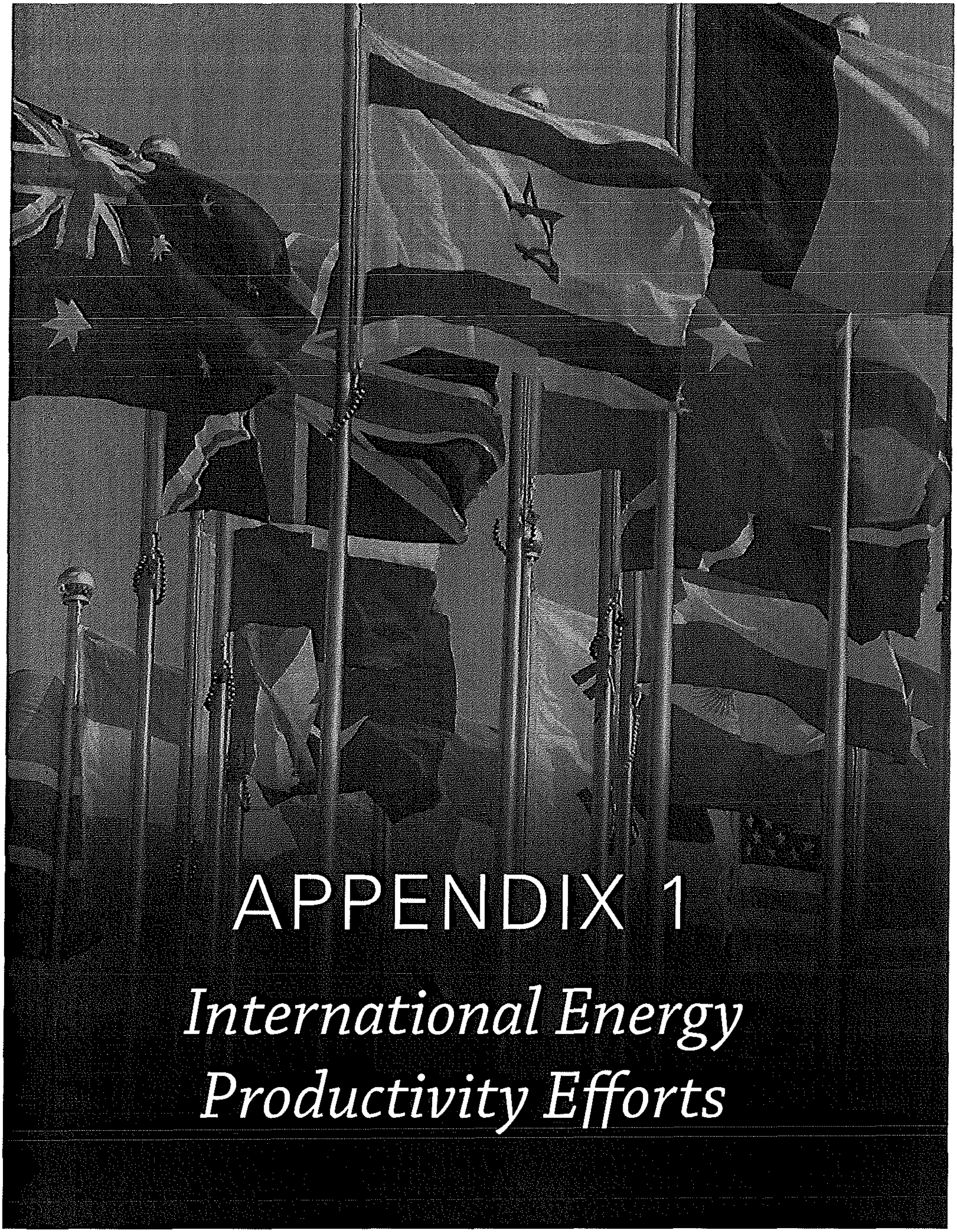
UTILITIES AND LARGE CONSUMERS

- **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 legal) for careers in the clean 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.

According to both the regional dialogues and the technical analyses conducted as part of the Accelerate Energy Productivity 2030 initiative, a wide range of activities can be taken that will yield significant productivity benefits. Implementing these activities will require changes in behavior, investment, and deployment of technologies. Collectively, they can improve U.S. economic output, reduce U.S. energy consumption, and reduce the impact of energy on the environment. The fact that the government and private sector, including endorsers of the goal, are undertaking many of these activities suggests the significant challenge of doubling energy productivity can be—and is on the way to being—met. The *Roadmap* provides a foundation for scaling up these efforts nationwide while allowing for flexible and tailored solutions. Through the roundtables, three regional dialogues, innovative analysis, and this *Roadmap*, the Accelerate Energy Productivity 2030 Initiative catalyzed action to meet this important national goal.



APPENDIX 1

International Energy Productivity Efforts

Overview and Background

Note: This summary is derived from a forthcoming roundtable report from the sixth Clean Energy Ministerial.

The United States is not alone in its interest in increasing energy productivity. Energy productivity, the ratio of economic output per unit of energy use, focuses attention on how scarce energy resources can be put to their best use and how energy efficiency can lift economic growth. The last decade displayed growth in the energy productivity of both Organization for Economic Co-operation and Development (OECD) member country groups and non-member economies. According to the International Energy Agency's Energy Efficiency Market Report, 2014, energy productivity in OECD Americas grew by 22 percent between 2003 and 2013 (see Figure 9).

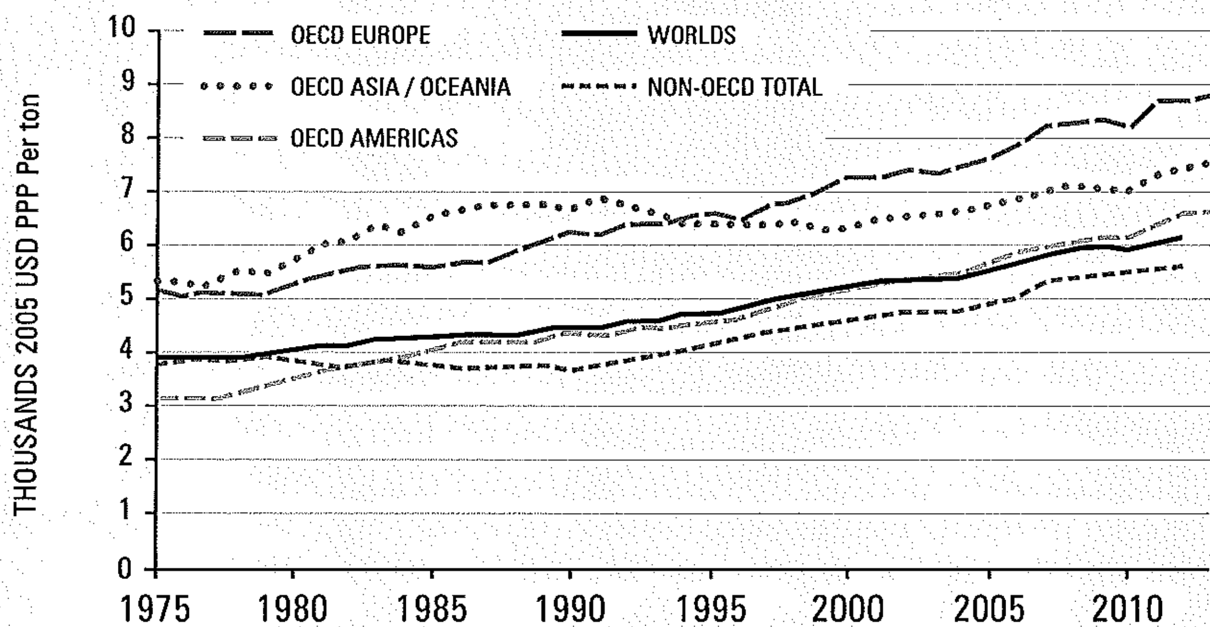


Figure 9. Increase in Energy Productivity by Region

While energy productivity is a relatively new concept compared to its inverse, energy intensity, a number of governments and international actors are embracing this framework to set or support the achievement of national and regional goals.

Australia is notable for a call in its 2015 Energy White Paper to focus on boosting the productive use of energy, which includes the development of a national energy productivity plan.[163] The Energy White Paper identifies that an achievable target for national energy productivity could be an increase of 40 percent by 2030, but even this level of improvement will require regulatory and voluntary actions across the economy. Analysis from ClimateWorks Australia supports the possibility of nearly doubling energy productivity by 2030 through a combination of improved energy supply, energy efficiency, electrification, and structural change.[164]

In addition to individual actions, countries have begun sharing best practices and discussing common barriers. The sixth meeting of the Clean Energy Ministerial (CEM), a global forum for advancing clean energy policy and technology, included a roundtable discussion on accelerating energy productivity where topics included opportunities for partnerships and the challenges of retrofitting existing energy generation and end use infrastructure.[165] According to the *2015 Energy Productivity and Economic Prosperity Index* study commissioned by Royal Philips, Europe's efforts to double energy productivity by 2030 could cut energy expenditures by one-third, improve energy security, and create 1.2 million jobs by 2020.

Achieving these benefits requires identifying and implementing policies and measures that lower energy use while growing the economy, as well as making available financing instruments to translate future savings into liquidity for investments today.

Articulating the Case for Energy Productivity

Businesses that have already adopted energy productivity practices find the business case is overwhelmingly compelling. Nonetheless, a barrier to scale is lack of awareness, necessitating the engagement and education of all stakeholders on the benefits of energy productivity.

CEM Roundtable participants highlighted examples of government and private-sector approaches that have delivered energy savings and economic benefits. In Denmark, the Central Bank concluded that a focus on energy efficiency and savings resulted in approximately 9 percent gains in wage competitiveness over the last decade. This success

163 Commonwealth of Australia, 2015 Energy White Paper (Canberra: Commonwealth of Australia, 2015), accessed July 2015, http://ewp.industry.gov.au/files/EnergyWhitePaper.pdf.

164 ClimateWorks Australia, *Australia's Energy Productivity Potential: Energy's Growing Role in Australia's Productivity and Competitiveness* (Melbourne: ClimateWorks Australia, 2015), accessed July 2015, http://climateworks.com.au/sites/default/files/documents/publications/climateworks_energy_productivity_report_20150310.pdf.

165 Clean Energy Ministerial, "A Summary of the Clean Energy Ministerial 6 (CEM6)" *CEM Bulletin* 181:12 (2015), accessed July 2015, http://www.iisd.ca/download/pdf/sd/crsvol181num12e.pdf.

is attributed to establishing predictable, long-term efficiency policies such as the National Energy Efficiency Action Plan; targeting both residential and commercial sectors simultaneously; setting standards; and sharing information on best practices. India's energy productivity is increasing by 1.6 percent annually and is being boosted through policies to align energy pricing, promote new business models and new markets, and enhance regulations for efficiency.

> *"Economic productivity is a major priority for governments across the world, especially as labor productivity slows. Energy productivity offers one of the most promising productivity solutions, with resultant benefits for competitiveness, wages, living standards and profit margins."*
>
> Dan Hamza-Goodacre
> Program Director
> ClimateWorks Foundation

Benchmarking, setting goals, and monitoring progress toward those goals were identified as best practices by businesses that have achieved significant productivity gains and energy savings. The practice of continuous improvement was also highlighted, as was working with supply chains to encourage efficiency along the value chain. The international standard for energy management, ISO 50001, provides a flexible and robust framework for businesses to "Plan–Do–Check–Act" their way to continual improvement in energy savings. In Germany, incentives such as tax rebates or exemptions from surcharges have been effective in fostering the uptake of energy management systems (more than 3,000 ISO 50001 certified systems).

Finally, the discussion highlighted the importance of setting and publicizing goals. According to a study conducted by the Johnson Controls Institute for Building Efficiency,[166] organizations that made their goals public were almost twice as likely to have made investments in energy efficiency and renewable energy in the previous year, implemented 50 percent more measures, and were roughly three times more likely to increase investments the following year.

Scaling Up Energy Productivity

A common theme that emerged around energy productivity from the CEM roundtable was the importance of partnerships between the public and private sectors—most importantly, the need to agree on common goals and a vision to motivate actions. Coordinated platforms and forums, such as the CEM, International Partnership for Energy Efficiency Cooperation,

166 Institute for Building Efficiency, *2013 Energy Efficiency Indicator Survey* (Washington, D.C.: Johnson Controls, Inc., 2013), accessed July 2015, http://www.institutebe.com/InstituteBE/media/Library/Resources/Energy%20Efficiency%20Indicator/061213-IBE-Global-Forum-Booklet_I-FINAL.pdf.

United Nations Sustainable Energy for All Energy Efficiency Accelerator Platform, and the International Energy Agency's Low-Carbon Energy Technology Platform, offer mechanisms for governments and the private sector to work together and avoid duplicating efforts.

Several specific policy areas were discussed, including regional alignment of energy efficiency test procedures, standards, and codes, as well as providing support for the development of regional testing laboratories. Participants agreed that key ingredients for effective codes and standards are awareness-raising and investment in implementation and compliance support. Participants further identified the challenge of extending successful policies to system-level solutions, recognizing the desire to avoid unintended consequences that can arise, for example, from focusing solely on component-level standards.

Participants also distinguished between policies for new versus existing facilities and products. While developing policies and standards for new facilities and products is often easier than retrofitting existing facilities, policies focused on the efficiency of industrial processes, especially new processes must be carefully designed and tested before implementation. This is especially true in the power sector, where robustness and resilience are critical. Significant opportunities exist to improve power system efficiency and resilience through system optimization and controls that enable situational awareness and integration of distributed generation and microgrids, but realizing this potential requires developing robust interoperability standards.

Unlocking finance for efficiency investments is also essential to overcoming first cost barriers. KfW, the government-owned development bank, served as a "neutral contractor," successfully accelerating energy-efficient renovations. In France, the use of fee-and-rebate programs, or "feebates," is encouraging the purchase of clean energy products, helping make France's vehicle fleet among the most efficient in the world. In the power sector, there is a need to bridge traditional finance mechanisms for conventional generation that have long-term contracts with newer technologies and business models that attract risk investors.

One outcome of the Clean Energy Ministerial roundtable discussion on accelerating energy productivity is recognition of all participants' importance in the dialogue to promulgate the "Energy Productivity Imperative" across many different policy and business platforms—regionally, in the participants' respective nations, and in partnership with other global and non-governmental organization (NGO) initiatives. The roundtable included a formal commitment to include the "Energy Productivity Imperative" as one of the 2015 "Principles of Competitiveness Strategy" that the Global Federation of Competitiveness Councils (GFCC) will present at its 6th Annual Meeting in Saudi Arabia, November 1–3, 2015. The pivotal role of CEM6 in elevating energy productivity as a core driver of economic growth and industrial competitiveness was also be highlighted at the GFCC's Innovation Summit on 21st Century Infrastructure in 2015.

Industrial energy use accounts for roughly one-third of global energy demand. While there is significant potential to decrease energy consumption in this sector, opportunities to improve energy efficiency are still underexploited.[167]

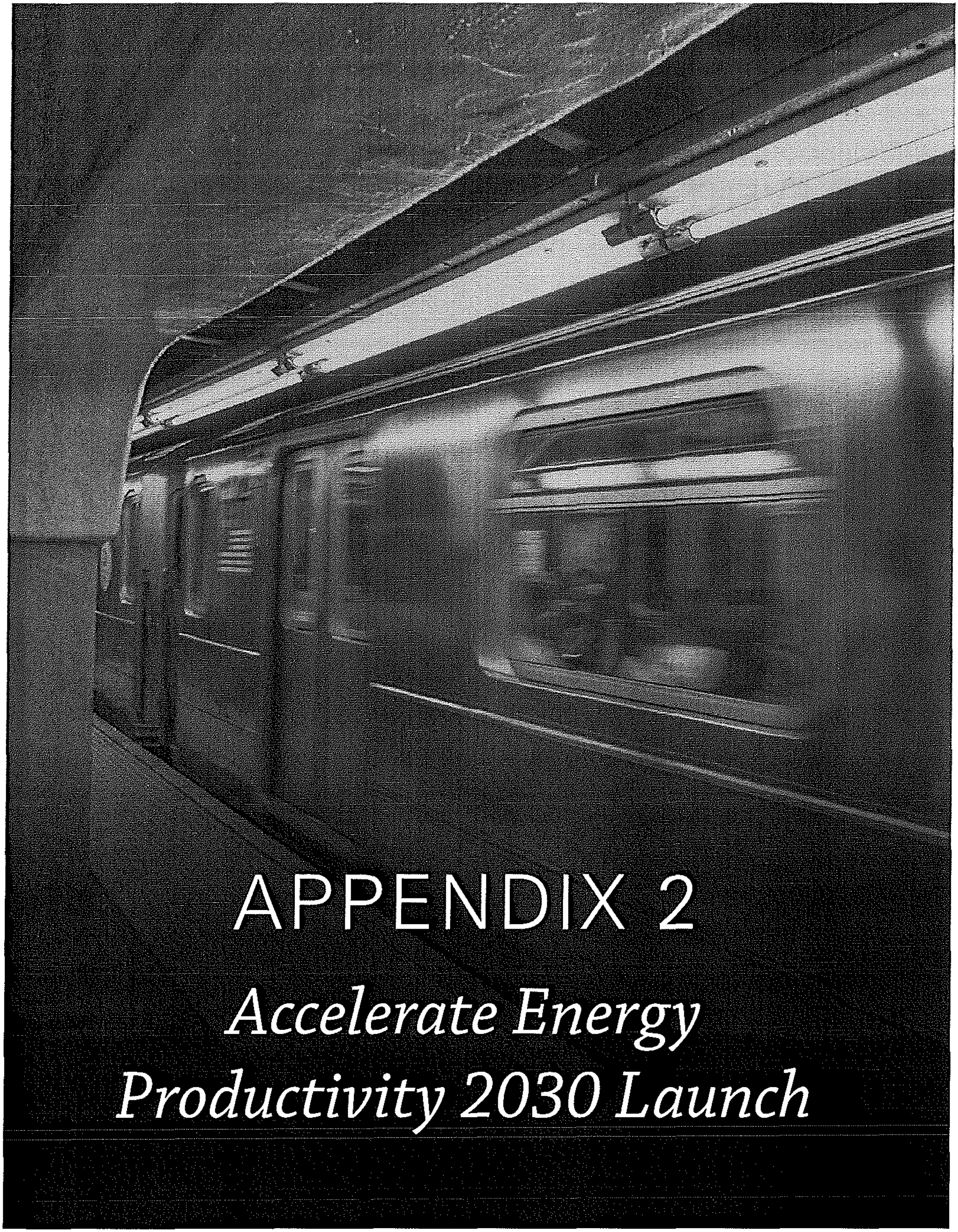
Although energy efficiency measures have frequently been demonstrated to contribute to the competitiveness of companies and to raise their productivity, energy efficiency actions and improvements are still not typically or widely viewed as a strategic investment in future profitability. A number of barriers to industrial energy efficiency exist including limited access to technical know-how and to capital, risk aversion and transaction costs.[168]

Improving energy efficiency in industrial companies provides benefits for the companies themselves as well as for the economy as a whole. Company-level benefits include improved productivity, optimized processes, and new business opportunities. In addition, energy efficiency in industry contributes to improved energy security and emission reductions.[169]

167 Institute for Industrial Productivity, Energy Management Programmes for Industry: Gaining through Saving (Paris and Washington, D.C.: International Energy Agency and Institute for Industrial Productivity, 2012), accessed July 2015, http://www.iipnetwork.org/PolicyPathway_IEAIIP.pdf.

168 Ibid

169 Ibid.



APPENDIX 2

Accelerate Energy Productivity 2030 Launch

EVENT SCHEDULE

DATE	November 6th, 2014
LOCATION	DEPARTMENT OF ENERGY 1000 Independence Ave. SW Rm. 7E - 069 Washington DC 20585
9:00 AM	**SECURITY CHECK-IN AND REGISTRATION**
9:30 AM	**OPENING REMARKS** **The Honorable Ernest J. Moniz,** Secretary of Energy, U.S. Department of Energy **Ms. Carla Frisch,** Director of End-Use Analysis, U.S. Department of Energy **The Honorable Deborah L. Wince-Smith,** President and CEO, Council on Competitiveness **Ms. Kateri Callahan,** President, Alliance to Save Energy
9:45 AM	**IMPACT: Driving Energy Productivity in the Private Sector**
MODERATOR	**The Honorable Ernest J. Moniz,** Secretary of Energy, U.S. Department of Energy

Productivity—and the prosperity that comes from innovation—is the engine for national competitiveness. This opening conversation aims to identify, from the perspective of the private sector, real success stories in improving energy productivity—output produced (measured in $ real GDP) relative to energy used (measured in million British thermal units (MMBtu) primary energy). This roundtable discussion will explore concrete competitive opportunities the United States can gain, leverage and scale by meeting President Obama's goal to double U.S. energy productivity through an examination of best practices, including specific technologies, processes, and organizational structures "ripe" for increasing energy productivity.

- Can you point to a significant success story your organization has had in improving energy productivity, either in your own operations or for clients?

- How is your organization more competitive because of a focus on energy productivity? How do you quantify this competitive advantage?
- What roles do supply chain efficiencies play in achieving greater productivity gains, and how are you working with supply chain partners to meet your energy productivity goals?
- Looking across your organization's global business base, which nations are focused on the energy productivity challenge—and opportunity? What energy productivity strengthening lessons are you learning abroad that could be emulated in the United States?

10:30 AM **BREAK**

10:35 AM **PATHS FORWARD: Routes to Doubling U.S. Energy Productivity**

MODERATOR **The Honorable Ernest J. Moniz,** Secretary of Energy, U.S. Department of Energy

Deploying energy-efficient technologies and practices, streamlining business processes, and innovating technologies for optimized output all increase energy productivity. Building on the lessons learned in the previous session, this discussion will focus on specific strategies to meet President Obama's goal and to scale for national competitive advantage—identifying how best to propagate industry best practices across the broader economy and examining opportunities for public-private engagement.

- What would a set of industry best practices around energy productivity look like? What would be the most effective ways to share and scale these practices across the broader economy? Which stakeholders need to be involved in these efforts and what would be their roles?
- From the perspective of your organization and your own experiences, how can we articulate the best business case for the investments necessary to drive greater energy productivity?
- Does the United States need new initiatives or specific policies (federal, state, or local) to reach—and surpass—the president's energy productivity goals? If so, what would be some examples?
- Can you define, from the perspective of your organization and industry, the most promising opportunities for the private sector to partner with the Department of Energy to meet the goal to double energy productivity by 2030?

11:25 AM **REFLECTIONS AND CLOSING REMARKS**

The Honorable Ernest J. Moniz, Secretary of Energy, U.S. Department of Energy

11:30 AM

ACCELERATE ENERGY PRODUCTIVITY 2030: Where Do We Go from Here?

Ms. Kateri Callahan, President, Alliance to Save Energy

The Honorable Deborah L. Wince-Smith, President and CEO, Council on Competitiveness

PARTICIPANTS

Dr. Tilak Agerwala
Vice President, Systems, IBM

Mr. Marty Bates
President, Global Primary Products (GPP) Strategy and Transformation, Alcoa

Ms. Kateri Callahan
President, Alliance to Save Energy

Mr. Paul Camuti
SVP, Innovation and CTO, Ingersoll Rand

Mr. Richard Caperton
Director, National Policy and Partnerships, Opower

Mr. Jorge Carrasco
General Manager and CEO , Seattle City Light

Mr. Jeff Eckel
President, CEO and Chairman of the Board, Hannon Armstrong

Ms. Amy Ericson
U.S. Country President, Alstom

Mr. John Galyen
President, Danfoss North America

Mr. Christian Gianni
SVP, Product Development, Whirlpool

Ms. Judi Greenwald
Deputy Director for Climate, Environment and Energy Efficiency
Office of Energy Policy and Systems Analysis,
U.S. Department of Energy

Mr. Al Halvorsen
Senior Director, Environmental Sustainability, PepsiCo

Dr. Kathleen Hogan
Deputy Assistant Secretary for Energy Efficiency, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy

Ms. Melanie Kenderdine
Director, Office of Energy Policy and Systems Analysis,
U.S. Department of Energy

Mr. Jim Madej
SVP, Customer Energy Solutions, National Grid

Dr. Ernest Moniz
Secretary, U.S. Department of Energy

Mr. Blake Moret
SVP, Control Products and Solutions, Rockwell Automation

Ms. Jane Palmieri
Business President, Dow Building & Construction,
The Dow Chemical Company

Dr. John Palmour
CTO, Power & RF, Cree Inc.

Mr. Gil Quiniones
President and CEO, New York Power Authority

Mr. Ram Ramakrishnan
EVP and CTO, Eaton

Ms. Aurelie Richard
SVP, Strategy and Business Development, Schneider Electric

Dr. Gayle Schueller
SVP, Sustainability, 3M

Mr. Kevin Self
Vice President, Strategy & Corporate Development, Johnson Controls Inc.

Dr. William Sisson
Director, Sustainability, United Technologies Corporation

The Honorable Deborah L. Wince-Smith
President and CEO, Council on Competitiveness

APPENDIX 2

APPENDIX 3

Accelerate Energy Productivity 2030 Regional Dialogue

RALEIGH, NORTH CAROLINA

EVENT SCHEDULE

Day 1 - Executive Roundtable Dialogue Overview

On the first day, 30 key private and public sector leaders convened for a private roundtable discussion aimed at gleaning information regarding approaches and challenges associated with advancing energy productivity in the transportation and buildings sectors, and the nexus between the two.

NC State Chancellor and Council on Competitiveness Executive Committee Member Randy Woodson hosted the Day 1 leadership dialogue. Council on Competitiveness President & CEO Deborah L. Wince-Smith, Alliance to Save Energy President Kateri Callahan, and Jonathan Pershing, Principal Deputy Director for EPSA at DOE, led the discussion.

ACCELERATE ENERGY PRODUCTIVITY 2030:
Emerging Opportunities in the Transportation Sector and Built Environment

DATE	February 4th, 2015
LOCATION	NORTH CAROLINA STATE UNIVERSITY James B. Hunt Jr. Library 1070 Partners Way Raleigh, NC 27606
12:00 PM	**CHECK-IN AND REGISTRATION**
12:30 PM	**OPENING REMARKS** **Dr. Randy Woodson,** Chancellor, NC State **The Honorable Deborah L. Wince-Smith,** President and CEO, Council on Competitiveness **Ms. Kateri Callahan,** President, Alliance to Save Energy

12:45 PM **ROUNDTABLE INTRODUCTIONS (two-three minutes per participant)**

1:30 PM **ACCELERATE ENERGY PRODUCTIVITY 2030: Overview**

Dr. Jonathan Pershing, Principal Deputy Director, Office of Energy Policy and Systems Analysis, Deputy Assistant Secretary for Climate Change Policy and Technology, Office of International Affairs, U.S. Department of Energy

The dialogues in Raleigh focused Accelerate Energy Productivity 2030 initiative—a partnership between the U.S. Department of Energy, the Council on Competitiveness and the Alliance to Save Energy. It supports the president's goal of doubling energy productivity from 2010 levels by 2030. This dialogue will focus on the intersection of transportation and the built environment, and its relationship to energy productivity and U.S. competitiveness. Examples of forward-thinking strategies include the future of urban planning and commerce, electric vehicle infrastructure and the emergence of IT and sensors.

1:45 PM **SESSION I – TODAY'S OPPORTUNITIES: Driving energy productivity at the intersection of transportation and buildings**

MODERATOR **Dr. Randy Woodson,** Chancellor, NC State

Transportation and the built environment—our ability to transport goods, provide services and conduct our daily business in a safe and efficient manner—play a critical role in U.S. commerce and competitiveness. The roles of these two economic pillars—buildings and transportation use roughly 70 percent of the nation's energy—represent both a challenge and an opportunity in achieving exponential gains in energy productivity.

This opening conversation explored current investments that can be made across and connecting the transportation and building sectors to capture near-term energy productivity gains, including what strategies and investments have or have not worked and how various public and private-sector players can support a broader effort around energy productivity. Framing topics included:

- How energy productivity functions as a core driver of growth, an enabler of new innovation and technologies, and market opportunities for new products and processes
- How organizations manage and measure energy use similar to other aspects of their business operations, including adopting energy management systems that integrate buildings and transportation considerations
- Barriers to investments that can improve energy productivity in both sectors, and how to communicate best practices and success stories to peer firms and institutions
- Current RD&D strategies underway to develop the next generation of energy-efficient

technologies, from new modes of transportation and building materials to a "systems" approach to transportation and the built environment

- Technologies, innovations, and strategies that leaders in the transportation and building sectors can offer the broader economy.

2:45 PM

NETWORKING AND COFFEE BREAK

3:00 PM

SESSION II – THE FUTURE: Emerging opportunities and key challenges at the intersection of transportation and buildings

MODERATOR

The Honorable Deborah L. Wince-Smith, President and CEO, Council on Competitiveness

This session focused on the future of the intersection between the transportation sector and the built environment—in particular the technologies and the investments that will enable game-changing opportunities around energy productivity. Each participant gave their perspective on anticipated barriers and opportunities both within their organization and facing their organization in supporting productivity across economic sectors. In particular, emerging issues at the intersection of transportation and the built environment were explored. Framing topics included:

- RD&D investments and strategies that will enable the game-changing opportunities around energy productivity on a 5-, 10-, and 15-year horizon.
- Sunk costs and current capital investments that are barriers to the adoption of more energy productivity technologies and processes, and how to address them
- Workforce, education and training issues related to emerging technologies, systems and processes that drive energy productivity in both sectors
- The role of the public and private sectors in shaping the future of the transportation-building nexus.

4:00 PM

SESSION III – The role of public policy in facilitating energy productivity at the transportation-building nexus

MODERATOR

Dr. Jonathan Pershing, Principal Deputy Director, Office of Energy Policy and Systems Analysis, Deputy Assistant Secretary for Climate Change Policy and Technology, Office of International Affairs, U.S. Department of Energy

Smart public policy can act as an enabler and driver of productivity, innovation, and growth. Sending clear market signals, facilitating effective public-private relationships, and creating competitiveness opportunities are all possible through robust, forward-thinking policy. This session explored the various policy approaches—from building codes and fuel economy standards to urban development and IT-enabled smart buildings—to facilitate energy productivity across the broader economy. Framing topics included:

- Local, state, and federal policies that either enable or present challenges to meeting each participant's vision of energy productivity in the future
- Structuring policies around incentives and regulations in ways that facilitate and compliment private-sector strategies and investment
- How public organizations can help communicate industry best practices and the energy productivity roadmap to peer organizations and institutions, and across the broader economy
- Success stories from participating organizations that would be transferable to government agencies—as owners of vehicle fleets and building portfolios—to drive energy productivity in the public sector.

5:00 PM **CLOSING REMARKS**

Ms. Kateri Callahan, President, Alliance to Save Energy
The Honorable Deborah L. Wince-Smith, President and CEO, Council on Competitiveness
Dr. Randy Woodson, Chancellor, NC State

PARTICIPANTS

Ms. Kateri Callahan
President, Alliance to Save Energy

Ms. Judith Cone
Interim Vice Chancellor for Commercialization and Economic, Development, University of North Carolina, Chapel Hill

Mr. Chad Evans
EVP, Council on Competitiveness

Ms. Carla Frisch
Director of End-Use Analysis, U.S. Department of Energy

Mr. Justin Gore
North America Energy Manager, Saint-Gobain

Dr. John Hardin
Executive Director, Board of Science, Technology and Innovation, North Carolina Department of Commerce

Mr. Chris Hess
Director of Public Affairs, Eaton Corporation

Ms. Julie Hughes
Director of Policy, Institute for Market Transformation, Deputy Director for Strategy and Development, City Energy Project

Maj. Gen. Nick Justice
Executive Director, PowerAmerica

Mr. Steve Kalland
Executive Director, North Carolina Clean Energy Technology Center

Mr. Brian Kerkhoven
Senior Energy Policy Advisor, North America's Building Trades Unions

Mr. Chris King
Senior Advisor, Energy Policy and Systems Analysis,
U.S., Department of Energy

Mr. Mark Lantrip
President and CEO, Southern Company Services Inc.

Dr. Louis Martin-Vega
Dean, College of Engineering, NC State University

Dr. John Palmour
CTO, Power and RF, Cree Inc.

Dr. Jonathan Pershing
Principal Deputy Director, Office of Energy Policy and Systems Analysis,
Deputy Assistant Secretary for Climate Change Policy,
Technology, Office of International Affairs, U.S. Department of Energy

Dr. Andreas A. Polycarpou
Department Head & Meinhard H. Kotzebue '14 Professor,
Texas A&M University

Mr. Adam Procell
President and CEO, Lime Energy

Dr. Richard Newell
Director, Duke University Energy Initiative

Mr. Curt Rich
President and CEO, NAIMA

Ms. Aurelie Richard
SVP of Strategy and Business Development, Schneider Electric

Mr. Keith Trent
EVP, Grid Solutions and President, Midwest and Florida Regions,
Duke Energy

Dr. Mladen Vouk
Interim Vice Chancellor of Research, Innovation and Economic
Development, NC State University

Mr. Tom Wenning
Program Manager, Institute for Advanced Composite
Manufacturing Innovation

The Honorable Deborah L. Wince-Smith
President and CEO, Council on Competitiveness

Dr. Randy Woodson
Chancellor, NC State University

Mr. Paul Woolverton
Vice President, Government and Institutional Business Development,
Mohawk Industrie

Day 2 - A State and Local Dialogue Overview

ACCELERATE ENERGY PRODUCTIVITY 2030:
Emerging Opportunities in the Transportation Sector and Built Environment

DATE	February 5th, 2015
LOCATION	NORTH CAROLINA STATE UNIVERSITY James B. Hunt Jr. Library 1070 Partners Way Raleigh, NC 27606
8:30 AM	**REGISTRATION & BREAKFAST**
9:00 AM	**WELCOME & OPENING REMARKS** **Kateri Callahan**, President, Alliance to Save Energy **Deborah L. Wince-Smith**, President and CEO, Council on Competitiveness **Kathleen Hogan**, Deputy Assistant Secretary for Energy Efficiency, U.S. Department of Energy
9:20 AM	**KEYNOTE REMARKS** **Keith Trent**, EVP, Grid Solutions and President, Midwest and Florida Regions, Duke Energy
9:35 AM	**KEYNOTE REMARKS** **Dr. John Hardin**, Executive Director, Board of Science, Technology and Innovation, North Carolina Department of Commerce
9:50 AM	**DRIVING ENERGY PRODUCTIVITY: An Integrated Approach to Buildings and Transportation**
MODERATOR	**Brian Coble**, SVP, Advanced Energy Corp.
PANELISTS	**Matt Cox**, Buildings Energy Efficiency Project Manager, Office of Sustainability, City of Atlanta **Sean Flaherty**, Program Director, Envision Charlotte **Paul Camuti**, SVP of Innovation and CTO, Ingersoll Rand **Steve Kalland**, Executive Director, North Carolina Clean Energy Technology Center at North Carolina State University

10:50 AM	**NETWORKING AND REFRESHMENT BREAK**
11:20 AM	**DRIVING ENERGY PRODUCTIVITY: In Buildings across Communities and on Campus**
MODERATOR	**Kathleen Hogan**, Deputy Assistant Secretary for Energy Efficiency, U.S. Department of Energy
PANELISTS	**Billy Jackson**, Facility Manager, City of Raleigh **Claudia Powell**, PEM, Energy Program Coordinator, North Carolina State University **Adam Procell**, President and CEO, Lime Energy **Ed White**, Chairman, Research Triangle Cleantech Cluster
12:20 PM	**DRIVING ENERGY PRODUCTIVITY: Best Practices and Policies in the Public and Private Sectors**
MODERATOR	**Julian Prosser**, Assistant City Manager, City of Raleigh (Retired)
PANELISTS	**John Palmour**, CTO, Power and RF, Cree Inc. **ToNola D. Brown-Bland**, Commissioner, North Carolina Utilities Commission **David Doctor**, President and CEO, E4 Carolinas **Bryan Cordell**, Executive Director, The Sustainability Institute
1:20 PM	**KEYNOTE REMARKS**
	Chancellor Randy Woodson, North Carolina State University
1:40 PM	**WRAP UP & NEXT STEPS**
	Deborah L. Wince-Smith, President and CEO, Council on Competitiveness **Kateri Callahan**, President, Alliance to Save Energy

Summary

On February 5, 2015, the Department of Energy (DOE), and Council on Competitiveness (Council) joined the Alliance to Save Energy (Alliance) in co-hosting the first of three State and Local Dialogues in Raleigh, North Carolina as part of the Accelerate Energy Productivity 2030 initiative. The initiative, officially launched by Secretary of Energy Ernest Moniz in September, seeks to build momentum and support for energy productivity by catalyzing action in the public and private sectors through a series of dialogues aimed at co-creating a road map for doubling U.S. energy productivity by 2030. The half-day event—sponsored by Alliance Associate Members Ingersoll Rand, Lime Energy, and Cree—convened leading public and private-sector energy experts, and approximately 90 attendees in the impressive James B. Hunt Library at North Carolina State University for a discussion on emerging challenges and opportunities associated with improving energy productivity in the buildings and transportation sectors, as well as the intersection between the two. The event enjoyed robust discussion and provocative dialogue thanks in large part to an active and engaged group of participants.

The agenda for the dialogue was populated with regional and local stakeholders well positioned to discuss energy productivity in the buildings and transportation sectors from the various vantage points of the diverse group of organizations they represent. Speakers included representatives from the Department of Energy, North Carolina Utilities Commission, Duke Energy, North Carolina Department of Commerce, City of Atlanta, City of Raleigh, North Carolina State University, Lime Energy, Advanced Energy, Envision Charlotte, Ingersoll Rand, North Carolina Clean Energy Technology Center, Research Triangle Cleantech Cluster, Cree, E4 Carolinas, Council on Competitiveness, and The Sustainability Institute.

Ahead of the day's panel discussions, participants took in keynote remarks from Dr. John Hardin, Executive Director of the North Carolina Board of Science, Technology and Innovation and Keith Trent, EVP of Grid Solutions and President for the Midwest and Florida Regions for Duke Energy, learning more about how the state of North Carolina and the region's largest utility are working to make North Carolina a leader in the Southeast region on energy productivity.

The panelists' discussions honed in on the important themes of driving energy productivity in the built environment and transportation sectors, with a focus on the work speakers representing state and local government, academic institutions, businesses, utilities, advocacy organizations, and manufacturers are doing to drive energy productivity within their respective organizations, and the areas they serve.

Of note, participants heard stakeholders from the cities of Raleigh, Charlotte, Charleston, and Atlanta discuss various programs they have undertaken to influence consumer behavior and energy consumption; increase electric vehicle penetration, help finance energy efficiency retrofits for residential homeowners, and enhance efficiency in large buildings across the region. Additionally, the location of the discussion at NC State University, one of the top research universities in the region and an integral component of the Research Triangle, afforded the opportunity to hear from various stakeholders about the cutting-edge research taking place in the triangle to bolster energy productivity in the United States. In particular, a representative from Cree Inc., a LED lighting manufacturer that grew out of the NC State materials science and engineering lab, was able to highlight their groundbreaking work with the city of Raleigh to deploy LEDs across the city, as well as their recent triumph lighting this year's Super Bowl in Phoenix, AZ, making it the most efficient Super Bowl to date.

The Accelerate Energy Productivity 2030 goal of doubling U.S. energy productivity by 2030 resonated with the panelists and audience alike as both engaged in a dialogue regarding the specific approaches taken and challenges encountered in advancing energy productivity at the local, state, and regional levels. While in Raleigh, the productivity initiative was able to secure endorsements from several key companies and institutions, most notably Duke Energy, the largest utility in the United States and NC State University. The initiative partners look forward to fostering lasting relationships with these and many of the participants who joined us in Raleigh to ensure they remain engaged and proactive in their efforts to drive energy productivity within their spheres of influence.

ATTENDEE BREAKDOWN

There was a strong showing from all target stakeholder groups in the Raleigh, North Carolina region. One hundred five people were registered for the event with 88 in attendance at the Hunt Library. Registrants included 17 representatives from academic institutions; 32 advocacy group representatives; 20 business representatives; 23 government officials or staff members; and 13 energy utility representatives. In addition to the partners listed above, organizations represented include: The City of Raleigh, NC Clean Energy Tech Center, Eastman Chemical Company, Research Triangle Cleantech Cluster, Duke Energy, NC Utilities Commission, University of North Carolina, NC State University, Duke University, Envision Charlotte, Sierra Club, E4 Carolinas, Ingersoll Rand, Advanced Energy, City of Atlanta, Schneider Electric, Climate Mobilization Fund, North Carolina Electric Cooperatives, Brasfield and Gorrie LLC, Fleishman Hillard, Cree, Office of Congressman Ellmers, North Carolina Rural Electrification Authority, Department of Energy, Brady Trane Services, and the North Carolina Department of Environment and Natural Resources. The Accelerate Energy Productivity Initiative will work with representatives from these organizations to ensure that the goal of doubling energy productivity by 2030 remains a priority in the region moving forward.

Overview of Energy Efficiency Policy in the Southeast

The Southeast region of the United States represents 36 percent of the nation's population and 44 percent of its energy consumption. These numbers mean there is great potential for increasing energy efficiency in the Southeast, and many states are taking innovative and proactive measures to increase the region's energy productivity.

On February 5, 2015, the Department of Energy, the Alliance to Save Energy, and the Council on Competitiveness hosted an event, "Accelerate Energy Productivity 2030 Raleigh: A State and Local Dialogue," as part of the Accelerate Energy Productivity 2030 initiative in Raleigh, North Carolina. The event brought together stakeholders from the region to initiate dialogues and garner endorsements for the goal to double our nation's energy productivity by the year 2030.

At this one-day forum, we examined the possibilities for increasing energy productivity in buildings and transportation, and the nexus between the two. Below is an examination of the efforts already underway in the southeast to advance energy productivity in buildings and transportation, including a description of the energy efficiency work done by the city of Raleigh to highlight the efforts of our host city.

BUILDINGS

North Carolina

With the passing of Senate Bill 668 and Senate Bill 1946, all state-owned buildings must surpass the energy efficiency requirements of ASHRAE 90.1-2004 by 30 percent for new construction and 20 percent for buildings undergoing major renovations. The state also set up a goal of reducing the amount of energy consumed per gross square foot for all state buildings, in total, by 30 percent of 2004 levels, by 2015. Additionally, North Carolina is a participant in the U.S. Department of Energy's (DOE) Better Buildings Challenge, and it has committed to reducing energy consumption in all state agency and UNC buildings by 20 percent.

Georgia

A 2008 executive order from Governor Sonny Perdue (R) created the Governor's Energy Challenge 2020 as part of the larger "Conserve Georgia" campaign. As part of the challenge, state agencies and departments must reduce energy consumption to 15 percent below 2007 levels, through energy efficiency or renewables integration by 2020. Reductions in energy use must come either from energy efficiency measures or from renewable energy development.

Funding from the American Recovery and Reinvestment Act of 2009 (ARRA) is being used by the Georgia Environmental Finance Authority (GEFA) to pay for state-agency retrofit projects. These projects will help state government entities meet the goal set by the Governor's Energy Challenge. GEFA is in charge of implementing this program. The challenge is mandatory for state entities, but local governments, schools, businesses, and individuals are encouraged to participate.

South Carolina

South Carolina has also implemented strong policies for state buildings and public schools. The State Energy Office has collected benchmarking data for over a decade from public agencies, K-12 schools, colleges, and universities, which allows the state government to implement energy conservation strategies and monitor progress. This led to H.B. 4766, which requires state agencies and public schools to reduce energy use by 20 percent from 2000 levels.

Tennessee

While Tennessee does not have any formal energy savings targets in place, it has made serious strides in gathering the background information necessary to implement these targets. The State Building Energy Management Program was created in 2009 to coordinate and implement energy efficiency efforts for the state government. This program began its efforts by gathering reliable consumption data from all state agencies, and it is working with other agencies to increase the amount of available data so that it will be available to the state government in the future.

Virginia

Virginia does not currently have an energy savings target for state buildings. Unlike other states that have implemented longer-term targets, Virginia has traditionally focused on short-term goals. For instance, an executive order signed in 2007 required state agencies to reduce annual non-renewable energy purchases by at least 20 percent below 2006 levels by 2010. A subsequent executive order from 2010 directed all state agencies to reduce annual energy consumption by at least 5 percent below 2010 levels for FY 2012.

TRANSPORTATION

North Carolina

In an effort to reduce congestion on roads in the state, in 2009 North Carolina passed House Bill 148 that established a fund to help finance projects that would alleviate congestion and incorporate multi-use capabilities. Efforts to accommodate other modes of transportation were further supported by the adoption of a Complete Streets policy by the State Department of Transportation in 2009. The state also examined current methods used for freight transportation so as to make the entire process more efficient.

Georgia

Georgia has implemented several separate plans relating to transportation in recent years. The Transportation Investment Act allows municipalities to pass sales taxes for the express purpose of generating funds to finance transit development and expansion. The state also decided to adopt a complete streets policy that incorporates bicycle, pedestrian and transit needs into all transportation infrastructure projects in 2012. Lastly, Georgia completed a freight and logistics plan in 2012 that aims to prioritize and coordinate key projects statewide through 2050.

South Carolina

South Carolina adopted Complete Streets legislation in 2003 to ensure that bicycle and pedestrian accommodations were sufficiently included within future State Department of Transportation planning activities. The state has also developed a freight plan to better coordinate and improve the efficiency of the statewide freight system.

Tennessee

In 1998, Tennessee enacted Public Charter 1101 Growth Policy Act that mandates coordination between local governments when it comes to municipal growth. The charter includes recommendations and guidelines on how to create efficient growth plans, but does so without implementing a statewide policy. To ensure coordination, the Charter also allows the state to withhold key economic development subsidies from city, county, and state offices if an agreement cannot be reached. Tennessee has also instated a policy that mandates the inclusion and integration of provisions for bicycles and pedestrians into any new construction or reconstruction of roads and highways. Lastly, Senate Bill 1471 created a Regional Transportation Authority in major municipalities that allows these authorities to design new funding streams for mass transit projects by law or through voter referendum.

Virginia

Virginia has required that every locality complete a comprehensive plan that coordinates land-use planning and future actions to effectively implement zoning requirements through its "Planning, Subdivision of Land and Zoning Code." In addition, the Commonwealth's Mass Transit Fund was created in 2013, and it receives 15 percent of all revenues generated from a 1.5 percent sales and use tax for transportation expenditures.

NOTABLE EFFORTS IN RALEIGH, NORTH CAROLINA

Energy Efficiency

The city of Raleigh has made great strides to improve the city's energy efficiency. One recently launched pilot project is examining the energy savings potential and feasibility of transitioning city-owned streetlights from traditional bulbs to more efficient LED bulbs. The city expects these bulbs to last between 15 and 20 years, which is significantly longer than the two-year average lifespan of a traditional bulb. Furthermore, if the pilot project proves to be successful, it is believed that replacing the roughly 35,000 streetlights in Raleigh could save the city millions of dollars over time.

The city of Raleigh has developed a partnership with Cree, Inc. of Research Triangle Park to test this new technology in municipal settings. In 2006, Raleigh agreed to become the first LED City, a program that Cree has expanded to municipalities across the world. The purpose of LED City is to encourage municipal governments to test this emerging technology in real world settings and share their experience with others.

Since 2006, Raleigh has installed over 40 separate LED projects across the city, including outdoor lighting for city parks, interior lighting, solar LED lighting, streetlights, and lighting in parking decks. These projects are estimated to be generating approximately $215,000 per year in energy and maintenance savings for the residents of Raleigh.

Raleigh has also worked to improve its efficiency in the transportation sector. In 2002, the city began to convert its fleet of vehicles to those powered by alternative fuels. Currently, the city fleet is comprised of approximately 461 alternatively fueled vehicles, which includes those powered by propane, compressed natural gas (CNG), electricity, and biofuels. More recently, Raleigh was chosen as one of three cities in the country to serve as a pioneer for the Rocky Mountain Institute's Project Get Ready. This project is designed as a test for the adoption of plug-in and electric vehicles (PEVs) and new PEV technology. As part of this project, Raleigh has added electric vehicles to its fleet, installed electric vehicle charging stations and removed or reduced barriers hindering the adoption of PEVs.

Furthermore, Raleigh has implemented policies to improve the efficiency of the city's buildings. The city now requires that all new municipal buildings over 10,000 square feet must meet the LEED Silver standards. Additionally, Raleigh has prioritized the completion of energy efficiency improvements to existing city-owned buildings. An example of a city-owned building that shows Raleigh's commitment to this effort is the Raleigh Convention Center that was built in 2008 and is LEED Silver certified.

Raleigh is also a fundamental component of the Research Triangle, which is composed of the cities of Raleigh, Durham, Cary and Chapel Hill as well as the substantial academic presence of North Carolina State University, Duke University, and the University of North Carolina at Chapel Hill. This area is well known for its work in the development of smart grid technologies that will create the electric grid of the future.

OTHER NOTABLE INFORMATION

Raleigh ranks first this year, moving up from third in 2013, on Forbes "Best Places for Business and Careers." The North Carolina capital previously ranked first in 2011 and had a three-year run in the top spot from 2007 to 2009. It is the only East Coast city that made the top 10. It is worth noting that Durham, NC often makes the list as well.

Fueling Raleigh's consistent results are business costs that are 18 percent below the national average, and an adult population where 42 percent have a college degree, the 12th best rate in the United States (30 percent is the national average). Raleigh is home to North Carolina State University, and nearby schools include Duke University and the University of North Carolina at Chapel Hill. The area's appeal has led to a strong inflow of new residents to the city, which boasts the sixth fastest net migration rate over the past five years.

Research Triangle Park (RTP) continues to fuel significant development in the area. The park is located at the core of the Raleigh-Durham-Cary Combined Statistical Area, and it is the largest research park in the country. It features roughly 170 companies that employ 39,000 full-time, mostly high-tech workers. There have been 1,800 start-up companies created at RTP since 1970.

Business Insider named Raleigh one of the "20 Cities Having an Awesome Recovery" in 2011, and Money magazine says Wake county (Raleigh/Cary) is one of the top 20 counties "Where the Jobs Are" this year. Clearly, the Triangle area is one of the best regions to work in thoughout the country.

For years, Raleigh, Durham, and Cary have been showered with placement in the top 10 lists of business-related accolades, and the reason is obvious. A number of different industries have a strong presence in the Triangle, including IT, telecom, pharmaceuticals, biotech, agrochemical, healthcare, and banking/financial services. This diversity makes for a healthy local economy.

RPT is a 7,000-acre campus that is home to more than 170 companies and organizations that employ about 50,000 Triangle residents. RTP has been around—and growing—for more than 40 years, and RTP employees have an average salary of $56,000.

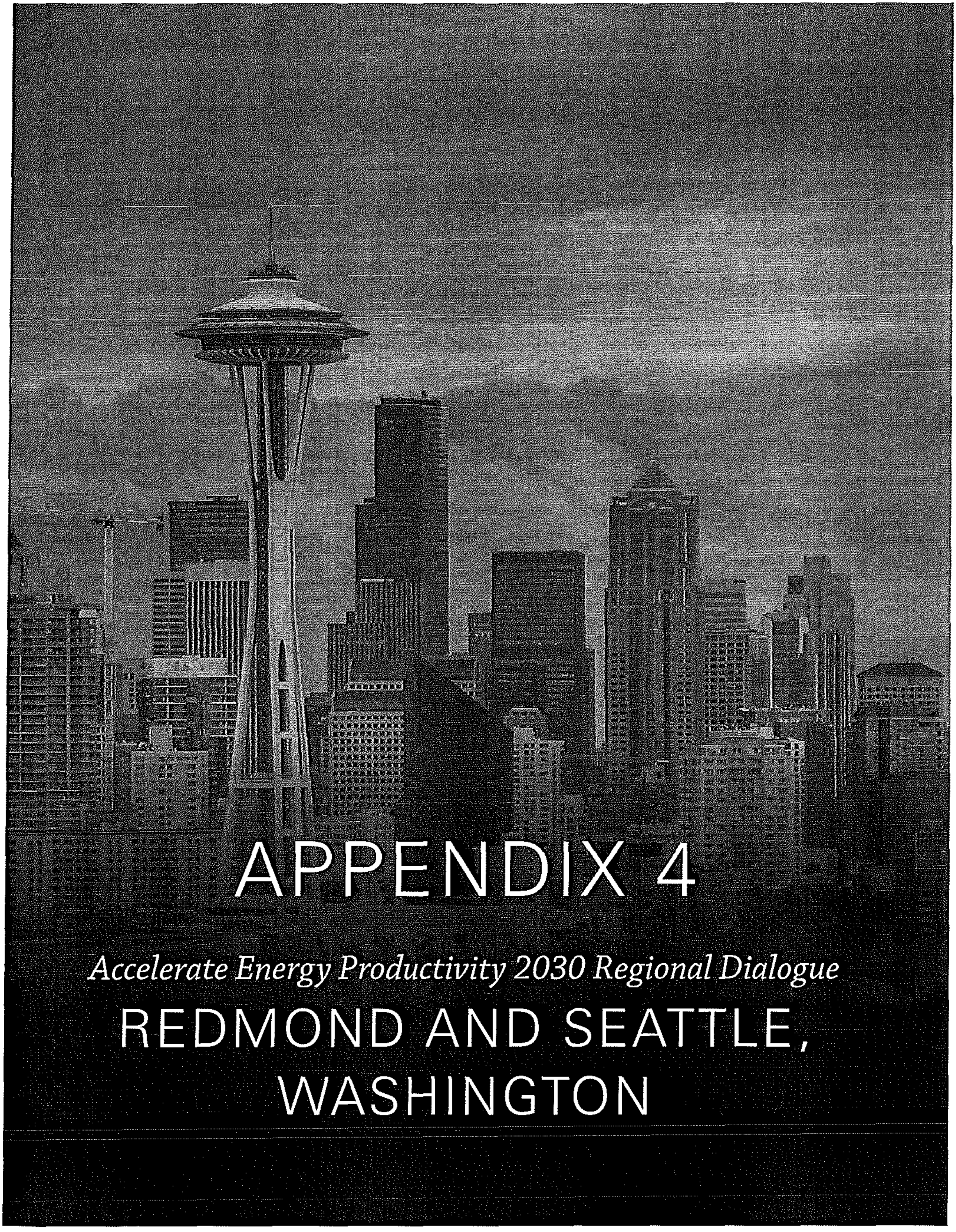
The Triangle area is experiencing a solid job market and even new business growth, despite the recent recession's impact on the economy.

According to NerdWallet, out of 75 of the largest metro areas in the United States the Raleigh-Cary metro is the eighth best place for STEM graduates. With companies like SAS and North Carolina State University's STEM resources, the region is a "major center for technology and research," the financial website says.

NOTABLE EFFORTS IN CHAPEL HILL, NC

In 2006, the town of Chapel Hill became the first U.S. municipality to commit to a 60 percent reduction in carbon dioxide emissions by 2050 through the Carbon Reduction Program. The Council authorized the pledge to reduce carbon dioxide emissions from town municipal operations on a per capita basis, beginning with an initial goal of a 5 percent reduction by 2010.

The Council established a Green Fleets Policy in 2005 that requires the city to obtain energy-efficient vehicles and to operate its fleets in a manner that is energy-efficient and minimizes emissions. The town endeavors to decrease energy expenditures for its fleets by 3percent at the end of 2007–2008. The policy expresses the Council's commitment to reducing energy consumption and dependence on foreign oil, and to improving air quality.



APPENDIX 4

Accelerate Energy Productivity 2030 Regional Dialogue

REDMOND AND SEATTLE, WASHINGTON

EVENT SCHEDULE

Day 1 - Executive Roundtable Dialogue Overview

The focus of the events in Redmond and Seattle were smart power systems and the changing power grid. On the first day, 30 key private and public sector leaders convened for a private, moderated roundtable discussion on smart power systems. The sessions focused on exploring what participants view as the fundamental pillars needed to build a future smart power system, the game-changing opportunities on the horizon with the potential to achieve dramatic gains in energy productivity, opportunities to drive energy productivity through public-private partnerships, and what specific policy recommendations participants have that would foster accelerated development of a smart power system.

Alstom President Amy Ericson and PNNL Director Steve Ashby hosted the Day 1 Dialogue, with Council on Competitiveness President and CEO Deborah L. Wince-Smith, Alliance to Save Energy COO Gail Hendrickson, and Judith Greenwald, Deputy Director for Climate, Environment, and Energy Efficiency, U.S. Department of Energy, leading the discussion.

ACCELERATE ENERGY PRODUCTIVITY 2030:
Energy Productivity and Smart Power Systems

DATE	April 13th, 2015
LOCATION	ALSTOM FACILITY 10735 Willows Road NE Building C Redmond, WA 98052
8:00 AM	**CHECK-IN AND REGISTRATION**
8:30 AM	**OPENING REMARKS** **The Honorable Deborah L. Wince-Smith,** President and CEO, Council on Competitiveness

Ms. Gail Hendrickson, COO, Alliance to Save Energy
Ms. Amy Ericson, U.S. Country President, Alstom
Dr. Steven Ashby, Director, Pacific Northwest National Laboratory

8:50 AM

ACCELERATE ENERGY PRODUCTIVITY 2030: OVERVIEW

Ms. Judith Greenwald, Deputy Director for Climate, Environment, and Energy Efficiency, Office of Energy Policy and Systems Analysis, U.S. Department of Energy

This introduction to the Accelerate Energy Productivity 2030 initiative will lay out the vision of the partnership, how the initiative supports the president's goal of doubling energy productivity, and how today's dialogue will feed into the U.S. Department of Energy's roadmap of strategies that will be released at a national summit on September 15th–16th in Washington D.C.

In addition to reviewing the work to date and the path toward the national summit, this introductory session gave a concise definition of energy productivity in the context of smart power systems and how a robust system acts as an enabler of a wide variety of energy productivity strategies.

9:00 AM

SESSION I – Energy Productivity and Smart Power Systems: Defining the Challenge

MODERATOR

Ms. Gail Hendrickson, COO, Alliance to Save Energy

This session began with participants introducing themselves and describing why energy productivity is important to them and their organizations. This was followed by an exploration of the fundamental pillars needed to build a future smart power system, what is needed to achieve this vision. Framing topics included:

- The "big" pieces needed for a robust and resilient smart power transmission and distribution system
- The role of the grid as enabler of efficiency—from generation to the end user
- The role of consumer decision-making and encouraging consumer participation ("prosumers") in maximizing system response
- The impact of two-way information flows, big data analytics and the overlay of IT infrastructure on the power system
- Gaps and bottlenecks that will inhibit development and deployment of smart grid technology.

10:00 AM

NETWORKING AND COFFEE BREAK

10:15 AM

SESSION II – Game-Changing Innovations and Pathways to an Energy-Productive Future

MODERATOR

The Honorable Deborah L. Wince-Smith, President and CEO, Council on Competitiveness

This session explored the game-changing opportunities on the horizon with the potential to achieve dramatic gains in energy productivity if developed and deployed effectively in the right policy environment. Examples include technologies that anticipate system shocks, "self-healing" components, real-time information flows, integration of advanced distributed sources into the grid, and IT infrastructure that optimize efficiency across the entire network. In the context of the goal to double energy productivity by 2030, the discussion explores what levels of adoption of these new strategies might be possible in the next 15 years, and the potential energy and economic impact that can have.

Participants discussed the most important technological or systematic challenges that, if addressed, would dramatically push the realization of a robust and dynamic smart power system. Framing topics included:

- Specific technologies—on the horizon but not yet commercially viable—that will enable dramatic shifts in energy productivity
- Shaping technologies and systems to inform consumer decision-making and enhance awareness around energy productivity and its benefits
- Projections of possible load reductions over the next 15 years, the cost, and what technologies and investments are needed to achieve this
- Policy frameworks, public-private partnerships and enabling pathways to develop and deploy these technologies over a 15-year time frame.

11:15 AM

OPPORTUNITIES TO DRIVE ENERGY PRODUCTIVITY THROUGH PUBLIC - PRIVATE PARTNERSHIPS

DISCUSSION LED BY

Ms. Amy Ericson, U.S. Country President, Alstom
Dr. Steven Ashby, Director, Pacific Northwest National Laboratory

The United States saw a tremendous investment in grid technologies over the past 5 years, most notably through significant American Recovery and Reinvestment Act of 2009 (ARRA) investment that funded a number of demonstration projects. As we enter the next phase—where market dynamics begin to drive technology choices—we must find ways to harness the nation's innovation infrastructure to develop next generation technologies. Framing topics include:

- The role of demonstration projects in pushing new technologies to market and linking research investments with high-priority, industry-defined problem sets.
- Challenges and barriers to effective public-private partnerships—what makes a successful partnership and leads to concrete technology outcomes.
- Policies to stimulate commercialization of power system innovations from national labs and help move them to market.

11:45 AM

LUNCH

12:30 PM

SESSION III – Policy Recap: Opportunities and Challenges, and Building a Strategic Roadmap

MODERATOR

Ms. Judith Greenwald, Deputy Director for Climate, Environment, and Energy Efficiency, Office of Energy Policy and Systems Analysis, U.S. Department of Energy

This session reviewed and synthesized previous discussion, analyzing the major themes through a policy lens in order to draw out specific recommendations for the Roadmap. Policy gaps that, if addressed, would foster accelerated development of a smart power system- or policy hurdles that hinder such development— discussed in greater detail in order to close the dialogue with concrete ideas for an enabling policy framework. Framing topics included:

- Industrial strategies and best practices to accelerate smart grid development and deployment over a 15 year time horizon
- Policy actions at the state, local, and federal level that can catalyze change and support smart grid technologies and investments
- How federal policy can inform consumer decision-making
- Next steps in turning recommendations into policy action.

1:30 PM

CLOSING REMARKS

Ms. Amy Ericson, U.S. Country President, Alstom
Dr. Steven Ashby, Director, Pacific Northwest National Laboratory
Ms. Gail Hendrickson, COO, Alliance to Save Energy
The Honorable Deborah L. Wince-Smith, President and CEO, Council on Competitiveness

PARTICIPANTS

Mr. David Allen
EVP, McKinstry

Dr. Steven Ashby
Director, Pacific Northwest National Laboratory (Battelle)

Mr. Michael Atkinson
Vice President, Alstom Grid North America, Alstom

Mr. Jesse Berst
Chairman, Smart Cities Council

Dr. Anjan Bose
Regents Professor, Washington State University

Dr. Michael Bragg
Dean of the College of Engineering, University of Washington

Mr. Jeffrey Burleson
Vice President, System Planning, Southern Company

Mr. Jorge Carrasco
General Manager and Local Dialogue: CEO, Seattle, WA City Light

Mr. John Di Stasio
President, Large Public Power Council

Dr. Sid England
Assistant Vice Chancellor, Environmental Stewardship and Sustainability, UC-Davis

Ms. Amy Ericson
President and CEO, U.S., Alstom Inc.

Mr. Chad Evans
EVP, Council on Competitiveness

Mr. Bill Gaines
Director and CEO, Tacoma Park Utilities

Ms. Judith Greenwald
Deputy Director for Climate, Environment, and Energy Efficiency, U.S. Department of Energy

Dr. Bryan Hannegan
Associate Laboratory Director for Energy Systems Integration, National Renewable Energy Laboratory

Ms. Gail Hendrickson
COO, Alliance to Save Energy

Mr. David Kaplan
CEO and Founder, 1 Energy

Mr. Steve Klein
CEO and General Manager, Snohomish County PUD

Mr. Doug Macdonald
Vice President North America, Grid Network Management Solutions, Alstom Grid Inc.

Mr. Robert "Rob" MacLean
President, California and Hawaii, American Water

Mr. Mark McCullough
EVP, Generation, American Electric Power

Mr. Matt O'Keefe
Director of Market Development Regulatory Affairs, West, Opower

Mr. John Plaza
President, CEO and Founder, Imperium Renewables

Mr. Mark Reddemann
CEO, Energy Northwest

Ms. Ann Rendahl
Commissioner, Washington Utilities and Transportation Commission

Mr. Eric Schmitt
Vice President, Operations, California ISO

Mr. Bob Stolarski
Director, Customer Energy Management, Puget Sound Energy

Dr. Jud Virden
EED ALD, Pacific Northwest National Laboratory

Dr. Chandu Visweswariah
IBM Fellow and Director, Smarter Energy Research Institute

The Honorable Deborah L. Wince-Smith
President and CEO, Council on Competitiveness

Mr. Gary Yang
President and CEO, UniEnergy Technologies, LLC

Mr. Brian Young
Governor's Clean Technology Industry Sector Lead,
Washington Department of Commerce

Day 2 - A State and Local Dialogue Overview

ACCELERATE ENERGY PRODUCTIVITY 2030:
Energy Productivity and Smart Power Systems

DATE	April 14th, 2015
LOCATION	PERKINS COIE 1201 THIRD AVENUE, SUITE 4900 SEATTLE, WASHINGTON 98101
8:30 AM	**REGISTRATION & CONTINENTAL BREAKFAST**
9:00 AM	**WELCOME & OPENING REMARKS** **Jorge Carrasco,** General Manager & CEO, Seattle City Light
9:15 AM	**KEYNOTE REMARKS** **Ms. Judith Greenwald,** Deputy Director for Climate, Environment, and Energy Efficiency, Office of Energy Policy and Systems Analysis, U.S. Department of Energy

9:15 AM	**KEYNOTE REMARKS**
	Dow Constantine, King County Executive, King County
9:40 AM	**PANEL 1: Energy Productivity's Role in the Changing Power Grid**
MODERATOR	**Ms. Judith Greenwald,** Deputy Director for Climate, Environment, and Energy Efficiency, Office of Energy Policy and Systems Analysis, U.S. Department of Energy
PARTICIPANTS	**Michael Atkinson,** Vice President of Alstom Grid North America Alstom
	Kimberly J. Harris, President and CEO, Puget Sound Energy
	Jeffrey Burleson, Vice President, Systems Planning, Southern Company
10:30 AM	**NETWORKING BREAK (snacks and drinks)**
10:50 AM	**PANEL 2: Driving Energy Productivity through Technological Innovation and Consumer Decision-making**
MODERATOR	**Susan Betcher**, Partner and Co-Chair, Clean Technology Practice, Perkins Coie
PARTICIPANTS	**Matt O'Keefe,** Director of Regulatory Affairs for Western North America, Opower
	Brian Young, Director of Economic Development for the Clean Technology Sector
	Dr. Liesel Hans, Economist, Electricity Markets and Policy Group at LBNL
11:40 AM	**KEYNOTE REMARKS**
	David Danner, Chairman, Washington Utilities and Transportation Commission
12:00 PM	**LUNCH & NETWORKING BREAK**
12:30 PM	**PANEL 3: Public Perspectives on Doubling Energy Productivity in the Northwest**
MODERATOR	**Susan Stratton,** Executive Director, Northwest Energy Efficiency Alliance
PARTICIPANTS	**Michael O'Brian,** Councilmember, Seattle City Council
	Tony Usibelli, Director of the Washington State Energy Office, Washington State Department of Commerce
	Daryl Williams, Tulalip Tribes of Washington

1:20 PM	**BOTTOM LINE DIALOGUE: Technology Pathways to an Energy Productive Power Portfolio**
MODERATOR	**Deborah Wince-Smith,** President & CEO, Council on Competitiveness
PARTICIPANTS	**Dr. Jud Virden,** Associate Lab Director for the Energy and Environment Directorate, PNNL **Jim West,** Assistant General Manager, Snohomish County Public Utility District
1:50 PM	**CLOSING REMARKS**
	Deborah Wince-Smith, President & CEO, Council on Competitiveness

Summary

On April 14, 2015, the Department of Energy (DOE), and Council on Competitiveness (Council) joined the Alliance to Save Energy (Alliance) in co-hosting our latest roundtable in Seattle, Washington focused on smart power systems as part of the Accelerate Energy Productivity 2030 initiative.

More than 75 attendees gathered at Perkins Coie law firm in downtown Seattle for the half-day event sponsored by Alliance Associate Members Puget Sound Energy and Snohomish County PUD, and co-hosted by Seattle City Light and the Northeast Energy Efficiency Alliance (NEEA). The agenda for the dialogue was primarily populated with public and private-sector energy experts from the region with the goal of discussing challenges and opportunities associated with advancing energy efficiency and energy productivity in power generation, distribution, and transmission.

Speakers included representatives from the U.S. Department of Energy, Seattle City Light, King County, Alstom, Puget Sound Energy, Southern Company, Perkins Coie, Opower, Washington Department of Commerce, Lawrence Berkeley National Lab, the Washington Utilities and Transportation Commission, the Northwest Energy Efficiency Alliance, the Seattle City Council, the Council on Competitiveness, Pacific Northwest National Laboratory, and Snohomish County Public Utility District.

The event enjoyed audience participation from an especially strong showing of high-level experts in the energy space, a true testament to the importance of the subject of smart power systems for the region and the timeliness of the event in that regard.

To start things off, participants heard from Jorge Carrasco, the outgoing General Manager and CEO of Seattle City Light;

Judi Greenwald, the Deputy Director for Climate, Environment, and Energy Efficiency at the Department of Energy; and Dow Constantine, County Executive for King County about the changing power grid and the leadership role Seattle and the region are taking in advancing smart power systems of the future.

Speakers from all stakeholder groups including representatives from state and local government, academic institutions, businesses, utilities, advocacy organizations, and manufacturers all touched on what they are doing to drive energy productivity within their respective organization, and the areas they serve. Equally as important, the dialogue benefitted from a robust and engaged audience of an equally diverse background.

The panelists' discussions centered on several important themes as they relate to smart power systems including energy productivity's role in changing the power grid, driving energy productivity through technological innovation and consumer decision-making, public perspectives on doubling energy productivity in the Northwest, and technology pathways to an energy-productive power portfolio. With respect to the changing power grid, panelists discussed the importance of connecting distributed energy resources to the grid, the need for evolving grid technologies and software, and the need for more interoperability and interactivity between the grid and the end user. Additionally, participants heard from all levels of government about what they are doing to drive investment and collaboration on energy efficiency implementation and the adoption of new technologies.

The Accelerate Energy Productivity 2030 goal of doubling U.S. energy productivity by 2030 resonated with the panelists and audience alike as both engaged in a dialogue regarding the specific approaches taken and challenges encountered in advancing energy productivity at the local, state, and regional levels. The initiative partners look forward to fostering lasting relationships with the diverse set of participants in the Seattle meeting to ensure they remain engaged and proactive in their efforts to drive energy productivity within their spheres of influence.

ATTENDEE BREAKDOWN: SEATTLE

The stop in Seattle brought together a diverse audience from Washington State and the greater Pacific Northwest region. A total of 91 people registered for the State & Local Dialogue and 80 attended. Registrants included 12 advocacy group representatives, 24 business representatives, 28 government officials or staff members, 16 utility representatives, and 13 representatives of research and academic institutions. Organizations represented included the Pacific Northwest National Laboratory, Alstom Grid, City of Mercer Island, City of Seattle, Alaska Airlines, Smart Cities Council, CleanTech Alliance Washington, Washington State University, University of Washington, King County Wastewater Treatment Division, City of Port Angeles, Seattle City Light, Southern Company, Seattle Pacific University, Large Public Power Council, University of California–Davis, Office of Congressman Adam Smith, Alstom Inc., Distributed Energy Management, Snohomish PUD, City of Redmond, Emerald Cities Seattle, Seattle University, Chelan PUD, King County, Gussin Climate Action Fund, National Renewable Energy Lab, Western Washington University, 1energy Systems, Oregon BEST, Bonneville Power Administration, Tacoma Power, California American Water, Cisco Systems, American Electric Power, International Living Future Institute, Opower, Imperium Renewables Inc., Northwest Energy Efficiency Alliance, Boeing, Puget Sound Energy, and the Washington Department of Commerce. Representatives from the Accelerate Energy Productivity 2030 partnership will continue to engage these organizations in the goal of doubling energy productivity by 2030.

Overview of Energy Efficiency Policy in the Pacific Northwest

The Pacific Northwest region has long been a leader in energy efficiency, with state and local governments, utilities, and businesses alike implementing programs and incentivizing investment in energy-efficient technologies in order to meet the region's growing demand for electricity. As part of the Accelerate Energy Productivity 2030 initiative, the initiative partners are hosting a State and Local Dialogue in Seattle, Washington, bringing together leaders from state and local government, utilities, business, academia, and nonprofit organizations to discuss smart power systems and ways to enhance energy productivity in the region and across the nation. Given the focus of the event on the power grid and smart power systems, the following information primarily focuses on the efforts made in the Pacific Northwest region that relate to these topics. While there is still more to be done, the information below provides a quick overview of some of the efforts that have been made to promote energy efficiency and energy productivity in the Pacific Northwest and Seattle.

NOTABLE EFFORTS IN SEATTLE, WASHINGTON

Seattle's local government has established several policies to improve energy management and use, which are coordinated by the Office of Sustainability and the Environment. This office also controls a resource conservation fund for energy efficiency projects, including building audits and maintenance improvements. Policies and codes designed to improve buildings efficiency are among the strongest in the country, and include requirements for LEED Gold certification for city-funded buildings and benchmarking of public, multi-family and commercial buildings of specific sizes. Seattle is also a partner with the U.S. Department of Energy's (DOE) Better Buildings Challenge and has committed to reduce energy use in municipal buildings by 20 percent by 2020. Additionally, the Office of Sustainability and Environment offers a Community Power Works program, which was once funded through DOE, to help consumers make energy-efficient upgrades to their homes.

Aside from its strong buildings policies, Seattle has committed to using its own purchasing power to choose energy-efficient products. Municipal vehicles must be alternative-fuel vehicles or hybrid-electric vehicles with at least a 25 percent higher fuel economy rating than a comparable vehicle. In 2013, all 41,000 residential street lights in Seattle were replaced with LEDs that are activated with photo sensors. Currently, the city is undergoing the replacement of 31,000 arterial lighting fixtures with LEDs, to be completed by 2018.

At the moment, Seattle is pursuing a district energy project in three neighborhoods where waste heat from sewer lines, hospitals, and data centers can be harnessed to power energy systems, specifically for the heating and cooling of multiple buildings. An agreement has been made with a private district energy utility, Corix Utilities, to conduct a feasibility analysis of the project. The city and Seattle Housing Authority have also agreed to provide district energy for one housing development, provided a positive feasibility analysis.

To encourage greater energy efficiency in its transportation system, Seattle has incorporated an Urban Village Strategy into its Comprehensive Plan, which guides zoning by encouraging development in neighborhoods most capable of supporting growth and reducing greenhouse gas emissions. Neighborhood planning also considers walkability and accessibility to public transportation. The city has implemented policies to achieve a goal of reducing passenger vehicle miles traveled 14 percent by 2020, and 20 percent by 2030, from a 2008 baseline. Similarly, Seattle has a Commute Trip Reduction plan and provides Transportation Demand Management programs for employers in the city.

KING COUNTY INITIATIVES

King County, which includes Seattle and is the most populous county in Washington, has been proactive in issuing policies that accelerate energy efficiency projects throughout the county. King County Executive Dow Constantine, a keynote speaker at the Accelerate Energy Productivity 2030: A State and Local Dialogue in Seattle, issued his biennial budget proposal that will speed up county energy efficiency projects while reducing overall costs. "By investing in projects that pay for themselves over time through lower utility bills, we can meet our climate targets faster and save money at the same time," said Executive Constantine, who released his proposed 2015–2016 budget last September.

As part of operating King County as a best-run government, the Executive's budget proposes a Fund to Reduce Energy Demand that would provide county agencies with a new tool to meet long-term goals for both energy reduction and climate change. Under the program, the county could issue bonds to provide loans to departments for equipment upgrades that reduce the use of energy or other resources. The savings on utility bills would be used to pay back the bonds. Additional bonds could be issued to fund future energy-, water-, or waste-reduction projects and initiatives—creating even more savings.

The Executive's proposed budget will include loans totaling $2.2 million for eight energy and water efficiency projects across five county agencies. About 20 percent of the total project costs are expected to be repaid through utility rebates. The combined projects would reduce the county's output of carbon dioxide emissions by nearly 1,000 metric tons every year.

WASHINGTON STATE POLICIES

The Washington State government is strongly committed to leading by example by requiring energy-efficient public buildings and fleets, benchmarking energy consumption, and encouraging the use of energy savings performance contracts (ESPCs). In fact, Washington's programs are so impressive that the state was ranked eighth on the American Council for an Energy-Efficient Economy's State Energy Efficiency Scorecard, which assesses energy efficiency policies and programs for every state.

Washington State offers several financial incentives for energy efficiency projects, including grants, rebates, loans, tax credits, and reductions. Among these is the Community Energy Efficiency Program, which identifies and funds projects for community-wide residential and commercial energy efficiency retrofits. It is estimated that these retrofits produce $1.7 million in savings on energy costs each year. Another financial incentive is the Energy Efficiency Grants for Higher Education and Local Governments, which provides $38 million in funding for energy efficiency upgrades to facilities of institutions of higher education and local governments.

Washington has extensively used ESPCs as a means of financing retrofits for state and municipal facilities. The ESPC Program, in the Department of General Administration, assists entities seeking to use an ESPC, by offering no-cost preliminary audits, a list of pre-qualified energy service companies, model documents, and low-interest financing options. Washington also has an energy performance contracting program provided by the Washington Department of Enterprise Services, and available for state agencies, colleges, towns, counties, school districts, hospitals, libraries, and ports. Since the program's inception in 1986, it has supplied more than $350 million in public facility efficiency projects, including $288 million in public building energy efficiency upgrades in the last five years alone, and has saved $22 million in energy costs annually.

Like Seattle, the state of Washington is also characterized by having strong policies on buildings efficiency. Of note, Washington is one of the few states to require commercial buildings to disclose their energy use, using an Energy Star rating system. State buildings have required energy savings targets, as mandated by a Washington executive order. State agencies must achieve a 20 percent reduction in building energy use by 2020, compared to a 2009 baseline. The same executive order also requires that state agency buildings be benchmarked, and if found to consume more energy than average for that building type, undergo an audit and implement efficiency improvements. A previous executive order and state statute mandate that major state construction projects and major facility projects receiving any funding from the state budget must be designed in accordance with LEED Silver standards. The current building energy code in Washington was developed in 2012, is compliant with the 2012 IECC, and contains codes applying to both residential and commercial buildings.

In terms of transportation efficiency policy, Washington, like Seattle, requires that state agencies phase in fuel economy standards for motor pools and conventional vehicles by 2015. State agencies must also purchase ultra-low carbon fuel vehicles or achieve an average fuel economy of 40 miles per gallon for light passenger vehicles, and 27 miles per gallon for light-duty vans and sport utility vehicles. The Washington Department of Transportation operates the largest ferry system in the United States, which also consumes the most fuel in the state government. However, the Washington Department of Transportation installed bio-fuel blending systems for its fleet in 2013, and has been honored by Government Fleet magazine as one of the most sustainable and efficient public fleets in the United States. Washington has also committed to reducing vehicle miles traveled per capita 18 percent by 2020, 30 percent by 2025, and 50 percent by 2050, compared to 1990 levels.

UTILITIES LEAD THE WAY

Washington's private and public utilities have a long history of offering customer energy efficiency and conservation programs supported by regional organizations including the Northwest Energy Efficiency Alliance (NEEA), the Large Public Power Council (LPPC), the Northwest Power and Conservation Council (NPCC), and the Bonneville Power Authority (BPA).

In Washington, energy efficiency is considered as a resource for planning and investment decisions by utilities. For example, NPCC designed its Sixth Power Plan, a regional energy blueprint, to guide the largest electricity supplier in the area, BPA. The plan, which aims to save 5,900 megawatts over 20 years, must be updated every five years, in accordance with federal law. NPCC even reports that energy efficiency, as a resource, is the largest power source in the Pacific Northwest behind hydroelectric power, based on a survey of almost 90 percent of the region's retail electricity sales. The report finds that energy efficiency has saved 5,570 MW since 1978 and met almost 62 percent of the Pacific Northwest load growth since 1980. These energy savings directly translate into monetary savings. The NPCC estimates that electricity consumers in the Pacific Northwest saved $3.5 billion in 2013 due to high investment in energy efficiency, which amounts to roughly twice the national average of its share in electricity revenues, totaling $375 million in 2013.

Washington has its own energy efficiency resource standard, established by the Energy Independence Act ballot initiative, which requires that Washington electricity utilities achieve specific gains in energy productivity and conservation each year, roughly 1.4 percent in electricity savings. The act also requires utilities to use methodologies consistent with those of NPCC to assess and plan their ten-year cost-effective conservation potential, which is updated every two years. Utilities also must create biennial acquisition targets, which are also updated every two years. Any utility that fails to meet conservation and productivity goals faces a fine.

Puget Sound Energy, a utility serving the Pacific Northwest region, offers many different types of programs and incentives to encourage energy efficiency, including rebates for homeowners using energy-efficient appliances, engineering consulting for commercial and industrial projects, and grants for retrofits and upgrades to buildings. In 2013 alone, Puget Sound Energy's energy efficiency programs saved enough electricity to power over 25,000 homes and enough natural gas to heat more than 6,000 homes.

Alliance Associate Member Snohomish County Public Utility District also provides a strong energy conservation program that covers weatherization and heating, efficient lighting and appliances, audits, heat pumps, and more, for both commercial and residential applications. Jim West, an assistant general manager for customer and energy services at Snohomish County PUD, has stated that though some utilities "might view energy efficiency offerings as more of a customer service, we very much make the investment as a strategic approach for meeting load growth on the system."

Seattle City Light, the primary utility providing electricity to the Seattle area and an endorser of Accelerate Energy 2030, offers substantial incentives and programs to encourage residential and commercial consumers to use energy more efficiently. These programs have been largely successful and have generated considerable savings. In 2013, Seattle City Light reported net electricity savings of 138,160 megawatt-hours, 1.46 percent of its retail sales, as a result of their energy efficiency programs. To ensure the long-term sustainability of improvements in energy productivity, Seattle has committed to achieving 0.90 percent energy savings, approximately 122,640 megawatt-hours each year.

OTHER NOTABLE EFFORTS IN THE REGION

In addition to these policies, new technology is also being used throughout the Pacific Northwest region as a means of advancing energy efficiency for utilities. Over the past three years, DOE has been testing smart grid technology in five states in the Northwest. In Washington, Seattle City Light and the University of Washington collaborated to create a micro-smart grid to serve the University of Washington campus. Smart grid technology has the potential to produce significant savings; in 2014, a representative of the University of Washington reported that the smart grid had saved the University $130,000 in annual energy costs. While smart grid technology has not yet been adopted citywide, Seattle City

Light has plans to provide 400,000 homes with advanced meters within the next year. These smart meters will be able to show customers and utilities more detailed information regarding energy use, allowing utilities to better identify and resolve any malfunctions while allowing consumers to control and monitor their usage.

Seattle also boasts the greenest commercial building in the world. The Bullitt Center is designed to have a 250-year lifespan. The building is designed to be energy and carbon neutral, with a water and sewage processing system that allows the building to be independent of municipal water and sewage systems. Energy neutrality is achieved with a large solar panel array on the roof of the building along with energy conservation measures that will cut the building's energy consumption to approximately one-third of the consumption of a typical office building of similar size.

The partners learned a great deal about the progress that Seattle, Washington, and the Northwest, have made toward realizing a more energy-productive future at the Accelerate Energy Productivity 2030 event in Seattle on April 14.

APPENDIX 5

Accelerate Energy Productivity 2030 Regional Dialogue

ST. PAUL, MINNESOTA

EVENT SCHEDULE

Day 1 - Executive Roundtable Dialogue Overview

The focus of the events in St. Paul was growing U.S. industrial competitiveness through smart manufacturing processes. On the first day, 20 key private and public sector leaders convened for a private, moderated roundtable discussion on advanced manufacturing. The sessions focused on the role of advanced manufacturing in driving energy productivity, what energy productivity means to the participant's respective organizations, and the challenges, opportunities, and strategies to drive energy productivity through advanced manufacturing processes.

Dr. Gayle Schueller, Vice President of Global Sustainability at 3M, was joined by Kateri Callahan, President of the Alliance to Save Energy, Bill Bates, Chief of Staff and EVP of the Council on Competitiveness, as well as senior Department of Energy leaders—Assistant Secretary Dave Danielson from the Office of Energy Efficiency and Renewable Energy, and Dr. Jonathan Pershing from the Office of Energy Policy and Systems Analysis—in leading the day's discussion.

ACCELERATE ENERGY PRODUCTIVITY 2030:
Growing U.S. Industrial Competitiveness through Smart Manufacturing Processes

DATE	April 15th, 2015
LOCATION	3M INNOVATION CENTER 2350 Minnehaha Ave. East Maplewood, MN 55119
11:00 AM	**CHECK-IN AND LUNCH**
12:00 PM	**OPENING REMARKS** **Mr. Bill Bates,** Chief of Staff and EVP, Council on Competitiveness **Ms. Kateri Callahan,** President, Alliance to Save Energy **Dr. Gayle Schueller,** VP, Global Sustainability, 3M

Dr. Dave Danielson, Assistant Secretary, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy

12:25 PM

THE ROLE OF ADVANCED MANUFACTURING IN DRIVING ENERGY PRODUCTIVITY

Dr. Dave Danielson, Assistant Secretary, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy

Advanced manufacturing—efficient, productive, highly integrated, tightly controlled technologies and processes that can increase competitiveness across the spectrum of U.S. manufacturers and suppliers—is uniquely capable of dramatically improving the energy productivity of the U.S. manufacturing sector. This session provided an overview of the advanced manufacturing activities currently ongoing in the Office of Energy Efficiency and Renewable Energy and their role in meeting the energy productivity goals of the U.S. Department of Energy.

12:40 PM

SESSION I – What does Energy Productivity Mean to Your Organization?

FACILITATOR

Dr. Gayle Schueller, VP, Global Sustainability, 3M

New technologies, systems and processes are increasingly being implemented in the advanced manufacturing sector that can enable superior device and process control, tighten and reduce barriers along supply chains, drive energy productivity, and lend significant competitive advantage to the organizations and nations that embrace them. In particular, the use of information and communications technology to integrate all aspects of manufacturing—Smart Manufacturing—can achieve significant improvements in energy efficiency while delivering added competitive advantage to organizations that leverage it.

In this session participants introduced themselves and spoke briefly on the opportunities and challenges in driving energy productivity from the perspective of their organization. Participants responded to the following questions:

- What successes have your organizations seen, either in achieving gains in energy productivity, or assisting others in doing so?
- Are there success stories that can be quantified (e.g. implementation of a certain system that enabled a new process, reduced costs associated with energy use, or led to a specific competitive advantage)?
- What is the single biggest role DOE can play in facilitating the adoption of smart manufacturing techniques by the U.S. industrial sector?

1:30 PM **NETWORKING AND COFFEE BREAK**

1:45 PM **SESSION II – Challenges and Opportunities to Drive Energy Productivity through Advanced Manufacturing Processes**

FACILITATOR **Ms. Kateri Callahan,** President, Alliance to Save Energy

Due to the maturity of the installed base of many industrial plants and its frequently changing structural composition, there is considerable opportunity to drive energy productivity throughout the U.S. industrial sector. An energy-efficient industrial sector increases productivity, enhances global competitiveness, and creates jobs. Because the industrial sector has a wide variety of large and small energy users and extensive supply chains, dissemination and replication of energy saving technologies, projects, and best practices can yield significant energy savings.

This session explored challenges and opportunities that participants have observed throughout their own experience and within their own organizations.

- What is the biggest obstacle to wider adoption of energy-productive advanced manufacturing approaches? What barriers are specific to large OEMs versus the barriers facing SMEs?
- Are the barriers primarily technological, cultural, or financial?
- What are the respective roles of the public and private sectors in disseminating smart manufacturing techniques across OEMs and through supply chains?

2:45 PM **STRATEGIES TO DRIVE ENERGY PRODUCTIVITY IN THE U.S. MANUFACTURING SECTOR**

PRESENTER **Dr. Jonathan Pershing,** Principal Deputy Director, Office of Energy Policy and Systems Analysis, U.S. Department of Energy

In September, Secretary Moniz will release a strategic roadmap—based on the Accelerate Energy Productivity 2030 dialogues—to achieve the President's vision of doubling energy productivity by 2030. This roadmap will include strategies that private firms, and federal, state and local governments can take to improve energy productivity in the U.S. manufacturing sector. This session featured a set of potential strategies specific to the advanced manufacturing sector that are being considered for the roadmap—that were discussed and vetted by participants in the later sessions.

3:00 PM **SESSION III – Input on Advanced Manufacturing Strategies**

FACILITATOR **Dr. Jonathan Pershing,** Principal Deputy Director, Office of Energy Policy and Systems Analysis, U.S. Department of Energy

In this session participants discussed and vetted the concepts from the preceding presentation—with the goal of developing specific recommendations to inform the sections of the policy roadmap that are relevant to the U.S. industrial sector.

- What are the key features of a strategic policy roadmap that can successfully facilitate improvements in energy productivity in the U.S. industrial sector?
- Does the suggested strategy broadly capture these elements? What gaps exist and what elements could be refined to better facilitate the private and public sectors in meeting its energy productivity goals?
- How can we ensure that this strategy is additive—not duplicative—to existing efforts in driving energy productivity for U.S. manufacturers?

3:45 PM **NETWORKING AND COFFEE BREAK**

4:00 PM **SESSION IV – Policy Recap: Next Steps and Building a Strategic Roadmap**

FACILITATOR **Dr. Dave Danielson,** Assistant Secretary, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy

This session reviewed and synthesized previous discussions, analyzing the major themes through a policy lens in order to draw out specific recommendations for the roadmap. Policy gaps that, if addressed, would foster accelerated uptake of energy-productive manufacturing solutions—or policy hurdles that hinder such development—were discussed in greater detail in order to close the dialogue with concrete ideas for an enabling policy framework.

- Pathways and best practices to accelerate energy-productive manufacturing technologies over a 15 year time horizon
- Policy actions at the state, local, and federal level that can catalyze change and support advanced manufacturing technologies and investments
- How federal policy can enable advanced manufacturing solutions across supply chains
- Next steps in turning recommendations into policy action.

4:45 PM **CLOSING REMARKS**

Mr. Bill Bates, Chief of Staff and EVP, Council on Competitiveness

Ms. Kateri Callahan, President, Alliance to Save Energy

Dr. Gayle Schueller, VP, Global Sustainability, 3M

PARTICIPANTS

Mr. Bill Bates
Chief of Staff and EVP, Council on Competitiveness

Ms. Kateri Callahan
President, Alliance to Save Energy

Dr. Sujeet Chand
CTO and SVP, Advanced Technology, Rockwell Automation

Dr. David Danielson
Assistant Secretary for Energy Efficiency and Renewable Energy, U.S. Department of Energy

Mr. Terry Gallagher
SVP and General Manager, Global Water and Process Services, Heavy Operating Division, Nalco

Mr. John Galyen
President, Danfoss North America

Dr. Bruce Hedman
Technical Director, Institute for Industrial Productivity

Dr. Mark Johnson
Director, Advanced Manufacturing Office, Office of Energy Efficiency & Renewable Energy, U.S. Department of Energy

Dr. Martin Keller
Associate Laboratory Director, Energy and Environment Directorate, Oak Ridge National Laboratory

Ms. Stacey Paradis
Executive Director, Midwest Energy Efficiency Alliance

Dr. Jonathan Pershing
Principal Deputy Director, Office of Energy Policy and Systems Analysis, U.S. Department of Energy

Mr. Jim Phillips
Chairman and CEO, Nanomech

Ms. Susan Rochford
Vice President, Sustainability & Public Policy, Legrand

Mr. Todd Rytting
CTO, Panasonic Corporation of America

Dr. Gayle Schueller
Vice President, Global Sustainability, 3M

Dr. George Wan
Vice President, Engineering and Technology, Ingersoll Rand

Mr. Aldie Warnock
SVP, External Affairs, Communications and Public Policy, American Water

Mr. Geff Wood
Director, GPM IPS Manufacturing & Process Control, and Automation, Alcoa

Day 2 - A State and Local Dialogue Overview

ACCELERATE ENERGY PRODUCTIVITY 2030:
Energy Productivity and Smart Power Systems

DATE	April 16th, 2015
LOCATION	3M INNOVATION CENTER 2350 Minnehaha Ave. East Maplewood, MN 55119
8:30 AM	**REGISTRATION & CONTINENTAL BREAKFAST**
9:00 AM	**WELCOME & OPENING REMARKS**
	Ms. Kateri Callahan, President, Alliance to Save Energy
9:10 AM	**KEYNOTE REMARKS**
	Dr. Gayle Schueller, VP, Global Sustainability, 3M
9:20 AM	**KEYNOTE REMARKS**
	Dr. David Danielson, Assistant Secretary for Energy Efficiency and Renewable Energy, U.S. Department of Energy
9:35 AM	**PANEL 1: Advanced Manufacturing: Creating More Goods, Using Less Energy**
MODERATOR	**Dr. Mark Johnson,** Director, Advanced Manufacturing Office, Office of Energy Efficiency & Renewable Energy, U.S. Department of Energy
PARTICIPANTS	**George Wan,** VP Engineering and Technology at Thermo King, Ingersoll Rand **Bruce Hedman,** Technical Director, Institute for Industrial Productivity **Barri Gurau,** Senior Engineer for Corporate Energy Initiatives, Lockheed Martin

10:35 AM	**BOTTOM LINE DIALOGUE: Exploring the Energy-Water Nexus**
MODERATOR	**Dr. Jonathan Pershing,** Principal Deputy Director, Office of Energy Policy and Systems Analysis, U.S. Department of Energy
PARTICIPANTS	**Terry Gallagher,** SVP and General Manager, Global Water and Process Services, Heavy Operating Division, Nalco **Aldie Warnock,** SVP, External Affairs, Communications and Public Policy, American Water
11:05 AM	**LUNCH AND NETWORKING BREAK**
1:05 AM	**PANEL 3: Public Perspectives on Doubling Energy Productivity in the Midwest**
MODERATOR	**Stacey Paradis,** Executive Director, Midwest Energy Efficiency Alliance
PARTICIPANTS	**Janet Streff,** Manager of State Energy Office, Division of Energy Resources, Minnesota Department of Commerce & Chair of National Association of State Energy Officials Board of Directors **Sheldon Strom,** Founder and President, Center for Energy and Environment **Al Juhnke,** State Agriculture & Energy Advisor, Office of Senator Al Franken and Former Minnesota State Representative **John Hoffman,** Senator and Vice Chair of Environment and Energy Committee, Minnesota Senate

Summary

On July 16, 2015, the U.S. Department of Energy (DOE), and Council on Competitiveness (Council) joined the Alliance to Save Energy (Alliance) in co-hosting their third and final roundtable in St. Paul, Minnesota focused on the manufacturing sector and growing industrial competitiveness through increased energy productivity as part of the Accelerate Energy Productivity 2030 initiative. The initiative, officially launched by Secretary of Energy Ernest Moniz in September 2014, seeks to build momentum and support for energy productivity by catalyzing action in the public and private sectors through a series of dialogues aimed at co-creating a road map for doubling U.S. energy productivity by 2030.

More than 80 attendees gathered at 3M Innovation Center in St. Paul for the event sponsored by Alliance Associate Members Lockheed Martin and Ingersoll Rand, and co-hosted by 3M and the Midwest Energy Efficiency Alliance (MEEA). The agenda for the dialogue was primarily populated with public and private-sector energy experts from the region with the goal of discussing challenges and opportunities associated with advancing energy efficiency and energy productivity in the manufacturing sector.

Speakers included representatives from 3M, the Department of Energy, Ingersoll Rand, and the Institute for Industrial Productivity, Lockheed Martin, Nalco, American Water, Minnesota Department of Commerce, the Office of Senator Al Franken (D-MN), the Minnesota State Senate, the Center for Energy and Environment, the Midwest Energy Efficiency Alliance, the Council on Competitiveness and the Alliance to Save Energy.

Speakers from all stakeholder groups including representatives from state and local government, academic institutions, businesses, utilities, advocacy organizations, and manufacturers all touched on the challenges and opportunities facing their particular sectors and on what they are doing to drive energy productivity within their respective organization, and the areas they serve. Equally as important, the dialogue benefitted from a robust and engaged audience of an equally diverse background.

Dr. Gayle Schueller, VP of Global Sustainability at 3M, kicked things off with some background on 3M's role in the manufacturing space and their history in the region. The first panel followed, moderated by Mark Johnson, Director of the Advanced Manufacturing Office at DOE, who focused on the innovative advanced and additive manufacturing technologies that have allowed private companies to create more goods using less energy. The audience heard from representatives from Ingersoll Rand, the Institute for Industrial Productivity, and Lockheed Martin about the importance of driving continued advancements in advanced manufacturing and increasing energy productivity in manufacturing processes in order to keep our manufacturing sector prosperous and competitive with other nations.

The second panel focused on the ever-increasing importance of the energy-water nexus and the need to look at energy and water as inextricably linked. Dr. Jonathan Pershing, Principal Deputy Director of the Office of Energy Policy and Systems Analysis at DOE, moderated a discussion between a representative from Nalco, a water-heavy manufacturer of chemicals and other products, and an American Water representative, the nation's largest water utility. Both spoke of the importance of water conservation, increasing water efficiency, and the dual benefits for increased energy savings and energy productivity.

The final panel focused on the public perspectives from the region, featuring a current and former member of the state legislature, a representative from the State Energy Office of Minnesota, and the president of a regional energy and environment nonprofit. This panel discussed the state's long history of bipartisan support for energy efficiency and renewable energy and the need to continue to make strides in increasing state and local policies that promote them.

The event featured particularly strong audience participation from a high-level group of energy stakeholders, with a particularly large presence from the public sector in the state and region. The Accelerate Energy Productivity 2030 goal of doubling U.S. energy productivity by 2030 resonated with the panelists and audience alike as both engaged in a dialogue regarding the specific approaches taken and challenges encountered in advancing energy productivity at the local, state, and regional levels.

ATTENDEE BREAKDOWN

As with previous events, the State & Local dialogue in St. Paul brought together a diverse range of stakeholders from around Minnesota and the upper-Midwest. In all, 125 people registered for the event and 90 people attended. Registrants included 24 advocacy group representatives; 45 business representatives; 41 government officials or staff members; 6 utility representatives; and 9 research or academic institution representatives. Organizations represented included Indiana NAACP, Ever-Green Energy, Center for Energy and Environment, Great Plains Institute, Minnesota Department of Commerce, City of Maplewood, Metropolitan Council, Benton County, Neighborhood Energy Connection, Evolve technologies, Ever-Green Energy, Frederick County, NALCO, Minnesota Power, Cook County Minnesota, City of St. Paul, City of Ruchfield, City of Vadnais Heights, Lockheed Martin, 3M Company, Institute for Industrial Productivity, Environmental Quality Board, State of Minnesota, Xcel Energy, Humphrey School of Public Affairs, Process Technology LLC, Oneida County Wisconsin, Franklin Energy, Home Scan, University of Minnesota, Earthtech Energy, Ingersoll Rand, City of Northfield Minnesota, Fresh Energy, Fulton County Board, Minnesota GreenCorps, Minnesota Interfaith Power & Light, Midwest Energy Efficiency Alliance, CenterPoint Energy, American Water, City of White Bear Lake, Minnesota Trade Office, Metropolitan Airports Commission, Office of Senator Al Franken, Office of Senator Klobuchar, Majestic Custom Electric, Smiths Medical, Delano Municipal Utilities, City of Highland Park, and Eaton. The initiative partners look forward to fostering lasting relationships with the diverse set of participants who participated in St. Paul to ensure they remain engaged and proactive in their efforts to drive energy productivity within their spheres of influence.

Overview of Energy Efficiency Policy in the Upper Midwest

As part of the Accelerate Energy Productivity 2030 initiative, a collaborative effort to help achieve the resident's goal of doubling U.S. energy productivity by 2030, the initiative partners hosted the final State and Local Dialogue in St. Paul, Minnesota, on July 16 at 3M's Innovation Center. The half-day event brought together leaders from state and local government, utilities, business, academia and nonprofit organizations to discuss the importance of increasing energy productivity in the region, with a focus on growing industrial competitiveness through advanced manufacturing and smart manufacturing processes.

This event could not have come at a more appropriate time, as strides are being made toward a more energy-efficient community at the local, state, and regional levels of the Upper Midwest area. Government clunkers are being traded in for fuel-efficient hybrids and charging stations, St. Paul citizens are witnessing their city being transformed into the "Most Livable City in America," and private businesses are seeing growing returns on their investments in retrofitted buildings. Learn more below about St. Paul and the ways in which citizens and organizations can improve upon the foundation the Upper Midwest community has built for an efficient future.

INNOVATIVE PROGRESS FOR ST. PAUL

As part of the American Recovery and Reinvestment Act, in 2009 the Department of Energy (DOE) awarded the City of St. Paul $2.7 million in funding from the Energy Efficiency and Conservation Block Grant. The City of St. Paul has since been able to invest millions of dollars in energy efficiency projects. Among these have been improved efficiency of municipally owned facilities, LED retrofitted streetlights and investments in 23 electric vehicle charging stations with plug-in electric fleet vehicles. The city government has been able to provide homeowners with loans to conduct energy audits and make energy management system installations. The city has projected that it will achieve $395,705 of aggregate yearly energy savings solely through replacing lights and installing new energy management systems in local libraries, parking ramps and recreational centers.

The federal stimulus has also enabled a partnership between the St. Paul Port Authority (SPPA), the Center for Energy and Environment (CEE) and Xcel Energy through the Trillion BTU program in which SPPA uses the grant funding through the Minnesota Department of Commerce to create a business loan program. Businesses first voluntarily agree to energy audits paid for by Xcel Energy; engineering studies are then performed on facilities with conservation opportunities—25 percent of the cost paid for by the participating business and 75 percent paid by Xcel. Based on these studies and audits, installation of necessary physical improvements is implemented and covered by a Port Authority loan and an Xcel Energy rebate, making the loan repayment less than estimated energy savings.

St. Paul also has the nation's largest wood-fired Combined Heat and Power plant to serve a district energy system. St. Paul Cogeneration produces approximately 65 megawatts of heat and up to 33 megawatts of electricity, making it more than twice as efficient as a conventional electric power plant. The system is fueled by clean urban wood residue and primarily uses wood from storm events, commercial tree trimmings and removals, and municipal and private tree and brush sites. The plant's reduced impact on the environment includes a 70 percent reduction in the use of coal, a 50 percent reduction in particulates, and a reduction of up to 280,000 tons of greenhouse gases yearly.

To promote further efficiency in an area with projected population growth of 34 percent between 2000 and 2030, the state-of-the-art Energy Innovation Corridor was established in 2010 along the 11-mile light rail transit route between downtown St. Paul and downtown Minneapolis. The Corridor not only features "one of the most sophisticated energy and transportation infrastructure systems ever developed," but also serves residents with smart energy technologies, renewable energy sources, and advanced efficiency programs. Between 2010 and 2014, the Corridor avoided about 3.3 billion pounds of carbon emissions, equating to over $66.2 million in economic savings.

MINNEAPOLIS: A TOP CITY FOR EFFICIENCY

This year, the American Council for an Energy-Efficient Economy ranked Minneapolis seventh in the country for having strong energy efficiency policies. Minneapolis has been rising in the ranks for its progress in energy efficiency, largely due to its strides in promoting energy-efficient buildings and new efforts in reducing carbon emissions. According to data in Minneapolis' Sustainability Indicators, the city reduced it greenhouse gas emissions from local government operations by 18 percent between 2008 and 2012, an average annual reduction of over 4 percent.

Regarding transportation, The Green Fleet Policy requires the city of Minneapolis to obtain highly efficient vehicles that emit the lowest levels of pollutants. The city also has an anti-idling policy to deter city fleets and other automobiles from unnecessarily polluting the air. Public lighting has also undergone updates, particularly in the last months of 2014 when the city purchased 1,000 LED fixtures for replacing HID streetlights. For building standards and energy codes, Minneapolis continues to raise the bar. LEED silver standards must be implemented in every phase of the building or significant renovation process for city municipal complexes. City financed buildings must also be outfitted with ENERGY STAR appliances if applicable under the Environmentally Preferable Purchasing Policy.

Among all of these excellent programs, the city's Climate Action Plan and Clean Energy Partnership are perhaps the most exceptional. The Climate Action Plan aims to reduce greenhouse gas emissions 30 percent by 2025 with 2006 as a baseline. As a part of this goal, Minneapolis intends to use renewable sources for 10 percent of its electricity, raise the bicycle-commute mode share to 15 percent, double regional transit ridership and reduce overall energy use by 17 percent. Additionally, the Climate Action Plan commits the city to recycling half of all waste with an added composting rate of 15 percent.

To work toward achieving the city's Energy 2040 Vision of providing "reliable, affordable, local and clean energy services for Minneapolis homes, businesses and institutions," and "sustaining the city's economy and environment and contributing to a more socially just community," Minneapolis has established the Clean Energy Partnership with natural gas and electric utility companies Xcel Energy and CenterPoint Energy. Through these utility franchise agreements, Xcel and CenterPoint will have access to run distribution lines on the public right of way under an assurance that their services will meet the city's energy efficiency goals.

MINNESOTA LEADS MIDWEST IN SAVINGS PROGRAMS

Minnesota leads the way in energy efficiency by offering technical, contractual, and financial resources to institutions at each level of government as well as by instituting programs that incentivize efficiency, conservation, and innovative technology. Through the Guaranteed Energy Savings Program implemented in 2010, school districts, universities, local governments and state agencies are enabled to engage in Energy Savings Performance Contracts through the state's Division of Energy Resources. These contracts not only create jobs and save on operational costs, but also effectively reduce overall energy consumption with the goal of a 20 percent aggregate reduction in state agencies. All investor-owned utilities in the state operate under a shared savings model in which they are incentivized to reach efficiency targets: utility companies receive an increased percentage of net benefits in direct proportion to their increased energy savings.

Overall, "Minnesota has been very progressive in terms of clean energy policy, promoting efficiency and renewables" said Kyle Aarons, senior fellow at the Center for Climate and Energy Solutions and producer of a study tracking energy savings and energy efficiency gains across the United States.

Minnesota's government agencies have been intentional about creating projects and programs to meet federal goals. In response to the EPA's 1.5 percent recommendation, the Minnesota Department of Commerce, Office of Energy Security and Minnesota Environmental Initiative coordinated to form a stakeholder initiative called "The 1.5 Percent Energy Efficiency Solutions Project". Through the initiative, nonprofit, environmental and public groups came together on a short term basis to connect with contractors, trade groups and utilities companies to brainstorm the policy barriers that were currently blocking the path to reaching 1.5 percent yearly energy efficiency savings. Since issuing a final report in 2011, stakeholders have continued to work with agencies to promote progress in energy efficiency and reach the goal of 1.5 percent annual savings.

Manufacturing is yet another sector in which Minnesota has promoted high standards of efficiency. With the help of grant funding, the Minnesota Technical Assistance Program (MnTAP) now helps two manufacturing facilities each year on a three-year cycle to determine where energy efficiency opportunities exist and which strategies would be best for effective implementation. The impetus for this program came from a report by MnTAP in 2010 that revealed potential gas and electric savings in Minnesota's industrial sector of over 2.5 million MCF (8 percent) and 271.4 million kWh (7 percent). As a result, MnTAP's work with individual manufacturing companies each year could eventually lead to an effective statewide Conservation Improvement Program based on their case studies with individual companies about which strategies and implementation programs are most effective.

Minnesota's most recent initiative issues new state residential and building energy codes, effective last February and this June, respectively. The new state residential energy code alone has been projected to save over 880,000 MMBTU annually compared to the old code, according to the Midwest Energy Efficiency Alliance (MEEA) and DOE. This energy savings translates to about $540 less in utility bills each year for the average homeowner and over $8 million in aggregate savings for homeowners.

UPPER MIDWEST INITIATIVES

In addition to the significant progress Minnesota has made in energy efficiency, surrounding states in the region have also taken measures to implement efficiency programs.

Illinois Energy Now, a program that offers grants for low-income housing and public sector programs as well as recommendations on market transformation and technical assistance programs, has now saved almost $585 million in aggregate energy costs through the Illinois Department of Commerce and Economic Opportunity. Since 2008, the program has created and sustained over 17,800 jobs, saved 7.8 billion kWh in electricity equipment, and conserved over 218 million therms in natural gas equipment. Looking ahead, Energy Now is expected to reach $1 billion in public sector savings in the next 10 years.

Wisconsin's Focus on Energy Program funded by the state's investor-owned energy utilities, has been instrumental in facilitating energy savings of more than $730 million for over 2.8 million residents and businesses. The incentive program focuses on renewable resources and energy efficiency for the state's many utility companies and their consumers. Success stories so far include consumers ranging from school districts and apartment complexes, to breweries and pizza shops; each receiving incentives and expertise based on their own unique business models and industries.

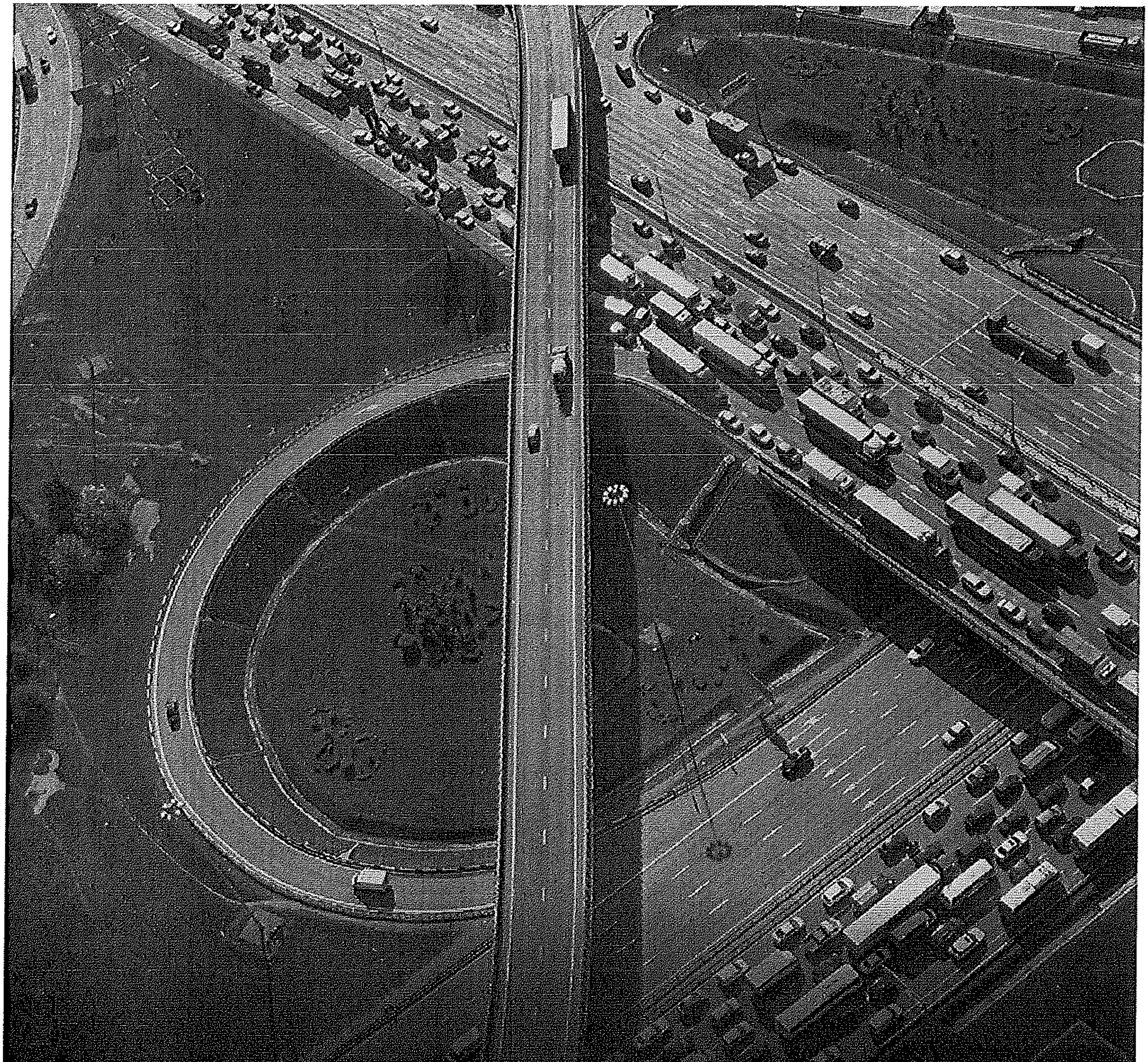
Iowa in particular has had a focus on renewable energy sources with a program established in 2012 for solar tax credits available to residential and commercial consumers through the Iowa Department of Revenue. Just in the first five months of this year, the system has been able to provide over $1.15 million in credits. Additional efforts include Iowa's Alternate Energy Loan Program in which individuals or businesses are able to obtain one, low-interest loan (often zero percent) of half the cost of the project (up to $1 million) to help cut down on the costs of financing the construction of a renewable energy facility featuring solar, wind turbine, small hydro or biomass technologies.

Michigan has made clean energy a top priority as it reaches its goal of generating 10 percent of its total energy uses from renewable sources this year; however, Governor Rick Snyder continues to press for further conservation measures using efficiency methods for waste reduction. As of March, Snyder presented his plan for Michigan to meet up to

40 percent of its energy needs primarily through waste reduction, a shift away from coal, and the continued development of renewables. According to the governor, "The most affordable energy you can ever get is the energy you never use. You didn't need to build the power plant; you didn't need to buy the fuel; you didn't need the transmission system." Because Michigan residents use 38 percent more energy than the national average, there is significant potential for improvement through efficiency techniques.

The Accelerate Energy Productivity 2030 team looks forward to engaging in meaningful conversations regarding the steps that state and local policy officials, business owners, industry, and households have made in St. Paul and in the Upper Midwest.

APPENDIX 5



APPENDIX 6

Organizations Committed to Accelerate Energy Productivity by 2030

A total of 122 organizations have committed to the goal of doubling U.S. energy productivity by 2030, pledging to (1) improve energy productivity within their own organizations, (2) share success stories, (3) encourage other organizations to endorse and (4) participate in Accelerate Energy Productivity 2030 educational outreach activities. Similarly, nine international organizations have endorsed the goal of doubling global energy productivity by 2030.

3M Company

5 Lakes Energy, LLC

Acuity Brands Lighting

Advanced Energy Economy

Advanced Power Control, Inc.

Alliance for Industrial Efficiency

Alliance to Save Energy

American Council for an Energy-Efficient Economy

American Council on Renewable Energy

American Public Transportation Association

Artfox

American Society of Heating, Refrigerating, and Air-Conditioning Engineers

Big Ass Solutions

Bombard Renewable Energy

BSH Home Appliances Corporation

Business Council for Sustainable Energy

Business Efficiency Consulting Services, Inc.

CALMAC Manufacturing Corporation

Center for Energy and Environment

Center for Environmental Innovation in Roofing

Center for the New Energy Economy at Colorado State University

City of Ann Arbor

City of Grand Rapids

Clean Energy Project

Conservation Services Group, Inc.

Copper Development Association

Council on Competitiveness

Cree

Danfoss

Design AVEnues, LLC

The Dow Chemical Company

Downtown DC Business Improvement District

Duke Energy

EcoValuate, LLC

EES Consulting

Efficiency Valuation Organization

Efficient Windows Collaborative

Encap Development

Energetics, Inc.

Energy Future Coalition

Energy Insight, Inc.

Energy Network

Energy Systems & Installation

EnergyFit Nevada

Environmental Defense Fund

EPS Capital Corp.

Exelon Corporation

Field2Base, Inc.

Galligan Energy Consulting, Inc.

Georgetown University Energy Prize

Geos Neighborhood

Green Building Initiative

GreenerU

GreenLaw

Grundfos

Habitat for Humanity International

Hampton/NASA Steam Plant

Hannon Armstrong

Herty Advanced Materials Development Center

ICLEI USA

Illuminating Engineering Society

Ingersoll Rand

Institute for Industrial Productivity

Institute for Market Transformation

International Copper Association, Ltd.

Johns Manville

Johnson Controls, Inc.

Knauf Insulation

Large Public Power Council

Legrand

Light and Energy International, LLC

Lime Energy

Lockheed Martin Corporation

Los Angeles Department of Water and Power

Masco Corporation

Nalco, an Ecolab Company

National Association for State Community Services Programs

National Fenestration Rating Council

National Grid US

National Insulation Association

Nebraskans for Solar

Nevada Energy Star Partners GREEN Alliance

Nevada Governor's Office of Energy

New Jersey PACE

New York Power Authority

North American Insulation Manufacturers Association

Natural Resources Defense Council

NV Energy

Ohio Energy and Advanced Manufacturing Center

Opower

Owens Corning

Panasonic Corporation of North America

Pacific Gas & Electric Corporation (PG&E)

Philips Lighting Company

Pierce Energy Planning

Polyisocyanurate Insulation Manufacturers Association

Potential Difference, Inc.

Rebuilding Together

Schneider Electric

Seattle City Light

Siemens Industry, Inc.

Snohomish County Public Utility District

Solar Habitats, LLC

South-central Partnership for Energy Efficiency as a Resource

Southeast Energy Efficiency Alliance

Southern California Edison

Southface Energy Institute

Southwest Energy Efficiency Project

The Stella Group

UC Davis Policy Institute for Energy, Environment, and the Economy

United Nations Foundation

United Technologies Corporation

Vermont Energy Investment Corporation

Vinyl Siding Institute

Vitandra Business Solutions

Washington Gas

Washington State Energy Office

Wisconsin Energy Conservation Corporation

Western Washington University

Whirlpool Corporation

This list represents endorsements as of Aug. 12, 2015. For more information, see http://www.energy2030.org/.