United States Department of Energy

Office of Energy Efficiency and Renewable Energy

2016–2020 STRATEGIC PLAN

and Implementing Framework

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

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Message from the Assistant Secretary

Today, the United States is faced with a national imperative to address the enormous challenge presented by climate change and to seize upon the multi-trillion dollar economic opportunity that a transition to a global clean energy economy will provide.

In his historic 2013 speech at Georgetown University releasing his Climate Action Plan, the President laid out this national imperative in clear terms: "A low-carbon, clean energy economy can be an engine of growth for decades to come. And I want America to build that engine. I want America to build that future—right here in the United States of America. That's our task."

The U.S. Department of Energy (DOE) is at the forefront of achieving this task. The first strategic objective of the 2014–2018 DOE Strategic Plan is to "advance the goals and objectives in the President's Climate Action Plan by supporting prudent development, deployment, and efficient use of all of the above energy resources that also create new jobs and industries." The Office of Energy Efficiency and Renewable Energy (EERE) leads DOE's efforts to help build a strong clean energy economy as the engine of growth described by President Obama, while also reducing our oil use, saving families and businesses money, and reducing pollution. We support many of America's best innovators and businesses to research, develop, and demonstrate cutting-edge technologies and work to break down market barriers in sustainable transportation, renewable power, and energy efficiency.

Today, a number of technological advancements that EERE has supported through investments in American innovation over the last four decades are, for the first time in our nation's energy history, showing a clear path to direct cost competitiveness with conventional forms of energy. Wind, solar photovoltaics (PV), light emitting diodes (LEDs), and electric vehicles are just four EERE technologies that have experienced spectacular cost reduction and deployment growth in recent years.[1] But even with these successes, EERE's targeted investments in clean energy are needed more now than perhaps ever before.

While the United States has world-class innovation capacity and a unique culture of entrepreneurship, there has historically been significant under-investment in many of clean energy's most promising and important technologies. As these technologies have advanced, market barriers have become a more significant and visible limitation to the speed of deployment. Our sense of urgency is further increased as we see the rest of the world investing billions of dollars in clean tech R&D and deployment while the impacts of climate change are becoming more apparent in our daily lives.

Our national imperative is clear: win the clean energy race. This would ensure that the United States captures a significant and growing share of the multi-trillion dollar global clean energy market and the jobs, energy security and other opportunities that will be created along the way. This Strategic Plan is EERE's blueprint for how we will tackle the challenges and opportunities that lie ahead for the country and the world in clean energy and how we will evaluate our success. EERE's talented team will lead the execution of this plan, working with internal and external partners including other DOE offices, industry, universities, state and local governments, stakeholder groups, and international partners. EERE's strategic relationship with NREL and the other national laboratories—with their world-class R&D capabilities and facilities—will be particularly important to the accomplishment of our mission.

I hope you find this document and its contents informative and useful. At EERE, we are engaged in an undertaking that will not only transform our energy and economic systems, but that also has the potential to leave our nation and our world safer, stronger, and more prosperous for future generations. I know that working together, we can and will be successful.

Sincerely,

Dr. David T. Danielson
Assistant Secretary

[1] *Revolution Now: The Future Arrives for Four Clean Energy Technologies*, DOE, 2013.

Acknowledgements

The 2016–2020 EERE Strategic Plan and Implementing Framework was developed through the tireless efforts of EERE staff, and with the help of EERE's key stakeholders, both those inside of the Federal Government and those representing the National Laboratories, companies, universities, think tanks, and state and local government organizations that are touched by EERE activities. As the first EERE Strategic Plan in over a decade, EERE considers the expertise of both its own staff and its stakeholder community fundamental to this plan being a true reflection of the role that EERE can play in the future of clean energy. This plan is better because of the contributions from dedicated EERE employees and nearly 150 experts from outside of EERE that provided their knowledge and time to its development.

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Introduction

EERE's vision is a strong and prosperous America that is powered by clean, affordable, and secure energy. In the context of this vision, EERE's mission is to create and sustain American leadership in the transition to a global clean energy economy. This mission requires that EERE perform its work at the intersection of national energy, economic, and environmental systems, as well as across industry and other stakeholder organizations.

In order to realize its vision and achieve its mission EERE has created a set of strategic goals that are both sector specific and crosscutting. These goals are:

EERE Vision

A strong and prosperous America powered by clean, affordable, and secure energy

EERE Mission

To create and sustain American leadership in the transition to a global clean energy economy

1. **Accelerate the development and adoption of sustainable transportation technologies**
2. **Increase the generation of electric power from renewable sources**
3. **Improve the energy efficiency of our homes, buildings, and industries**
4. **Stimulate the growth of a thriving domestic clean energy manufacturing industry**
5. **Enable the integration of clean energy into a reliable, resilient, and efficient electricity grid**
6. **Lead efforts to improve federal sustainability and implementation of clean energy solutions**
7. **Enable a high-performing, results-driven culture through effective management approaches and processes.**

This Strategic Plan describes these goals and EERE's metrics for success and our approach toward investment and execution. While the specific programs and initiatives to address these goals may change over time, all EERE activities are guided by the key organizational principles of **economic prosperity, affordability, reduced environmental impact, energy security, and consumer choice**. These principles parallel fundamental areas of national interest and underpin all of EERE's work to ensure lasting value from the work we do.

Planning Foundations

The EERE Strategic Plan provides a keystone reference for execution of critical executive branch policy and goals. It has been designed to support and respond to the **2014–2018 DOE Strategic Plan**, specifically the Department's Science and Energy mission and advancement of clean energy technologies. The EERE Strategic Plan is also aligned with the White House **Quadrennial Energy Review (QER)**, published in April 2015, which serves as a guide to energy policy and programmatic decisions across the Executive Branch. The EERE Strategic Plan was also heavily informed by the **Quadrennial Technology Review (QTR)**, issued in September 2015. The QTR is designed to serve as a detailed blueprint for the Energy Department, its National Laboratories, and the public and private sectors to guide work on future technology breakthroughs that can help to mitigate the risks of climate change, modernize our energy infrastructure, and enhance our energy security. As the leading Federal office for clean energy technology applied research and development, EERE will continue to play a prominent role in addressing the QER and QTR's opportunities and challenges. Finally, the Strategic Plan serves as our implementing framework for the **President's Climate Action Plan (CAP)**, a comprehensive strategy to address the mounting effects of climate change. In particular, the areas of the CAP focusing on clean energy deployment, a modern transportation sector, improving energy productivity, and Federal leadership in clean energy directly align to EERE's strategic investments and correlate to many of the goals in this Strategic Plan.

The EERE Investment Approach

EERE designs its portfolio to make a significant impact in transforming the national energy landscape and maximizing the value it delivers to the taxpayer. Ultimately, EERE's goal for its investments is to make clean energy technologies and services more available and reliable while lowering their direct and indirect costs, both to energy users and society as a whole. EERE performs extensive analyses, based on a detailed understanding of energy costs and market structures, to

project which investments offer the highest impact. The EERE investment approach is designed to address specific gaps in the technology development pathway–areas where the private sector or other non-government stakeholders are unable to make the required investments to the scale or in the timeframe required for clean energy technologies to be commercialized.

Even in this critical role, each EERE investment is closely scrutinized based on our Five Core Questions to ensure the highest return for taxpayer supplied funds.

The EERE investment approach is segmented into three distinct phases, shown in Figure 1:

Phase 1—Applied Research: Applied research is initially focused on a particular application–but often not a specific product. In this phase, high initial cost and uncertainty about the timing of product development and market acceptance impede sufficient private investment. Because of this, EERE's investments in proof of concept, cost and performance improvement, and early prototyping are critical to clean energy technology development.

In this phase, EERE invests heavily through the national laboratories and universities, as well as industry. Detailed analysis is performed to identify if a technology may be able to achieve market competitiveness and fundamentally lower costs to society. EERE often invests in several promising technology pathways guided by well-developed, long-term roadmaps that are created in collaboration with key stakeholders. EERE also promotes and sustains an internal culture that is open and receptive to new ideas and approaches that may be outside of our current long-term roadmaps to ensure the rapid identification and onboarding of promising new technology pathways that emerge over time.

The Five EERE Core Questions

EERE designs its portfolio to make a significant impact in transforming the national energy landscape and maximizing the value it delivers to the taxpayer. We prioritize our work according to five core questions.

Impact
Is this a high-impact problem?

Additionality
Will EERE funding make a large difference relative to existing funding from other sources, including the private sector?

Openness
Are we focusing on the broad problem we are trying to solve and open to new ideas, approaches, and performers?

Enduring Economic Impact
How will EERE funding result in enduring economic impact for the United States?

Proper Role of Government
Why is this investment a necessary, proper, and unique role of government rather than something best left to the private sector?

Phase 2—Development and Demonstration: As a technology nears direct market competitiveness, private capital is typically brought in to validate and scale the technology to manufacturing and deployment. However, because of the nature of energy markets, clean energy technologies–and specific products–often require very large amounts of capital to fully validate, surpassing the capacity or risk tolerance of private sources because of their still unproven nature. This again creates a critical gap in the clean energy development process.

EERE's investments during this phase focus on testing and validating performance, reliability, and costs through full-scale technology demonstration and analyses of the technology's market competitiveness. EERE may also fund small or limited scale demonstrations, with technologies integrated into full systems, to catalyze and leverage additional private sector investment. Aided by these EERE investments, the barriers to private investment are decreased, opening up development of business models and supply chains and further reducing cost.

Phase 3—Focus on Market Barriers: Once a technology achieves initial market adoption, additional cost reduction can take place through high volume process engineering, industry alignment, supply chain development, new business models, and product standardization. However, technologies that are cost effective may still face challenges to high volume adoption due to "Soft" or "Perceived Costs" described in Figure 1. EERE focuses on activities that can help overcome these market barriers. These activities can include providing key information to consumers, regulators, financiers and other market participants or addressing particular market issues such as workforce training. EERE's Congressionally authorized appliance standards program is another example of an activity to address market adoption by establishing minimum levels of product energy efficiency. These market adoption programs can provide an important catalyst in making sure that markets and industries for new clean energy technologies operate as efficiently as possible.

The investment approach described above and shown in Figure 1 reflects a single technology for simplicity though in practice, EERE invests in a portfolio of options in each sector and at multiple points in the process. The investment pathway is intended to be flexible, and the nature of EERE and its partners' roles varies by technology, as does the nature of the activity as a technology moves down the cost curve.

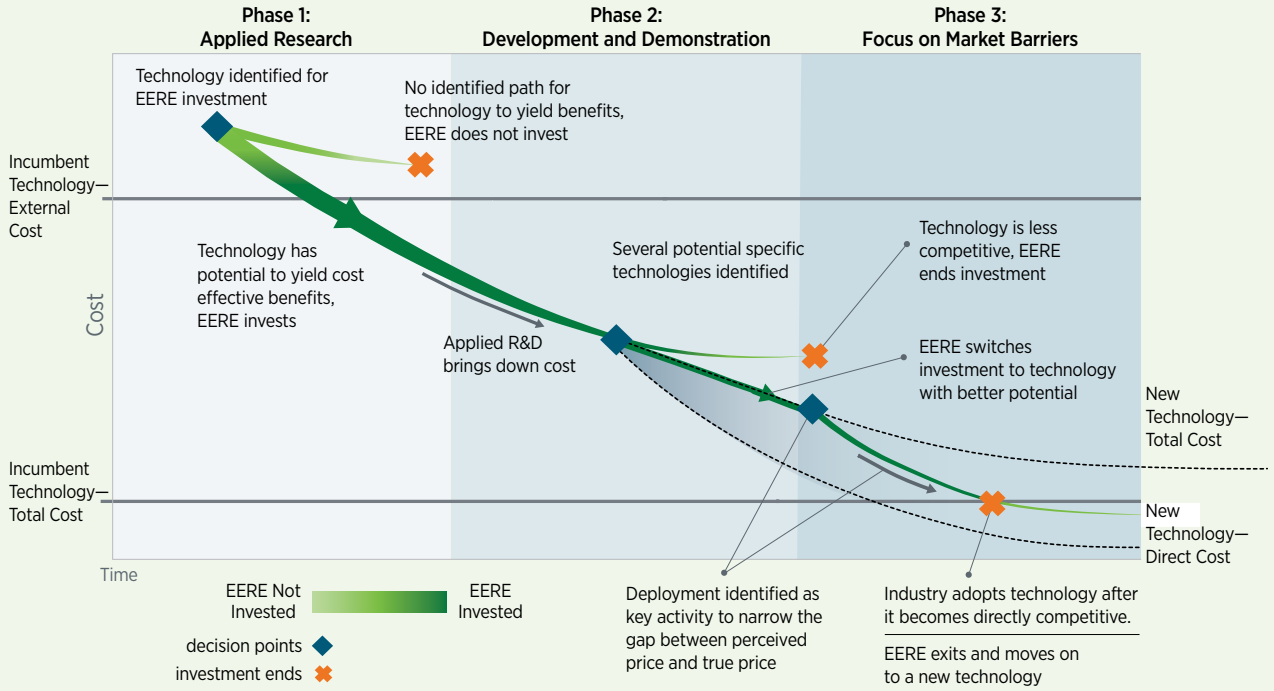

Figure 1: Diagram of the EERE investment pathway

Products incorporating a New Technology must have a Total Cost that is less than the Total Cost of those with the Current or Incumbent Technology to be widely adopted by the market. Total Cost includes the Direct Cost of the product itself plus User Costs, including operations and maintenance, and unique infrastructure or system integration costs. It may also include unique Acquisition or "Soft" Costs such as financing, installation, regulation, training, or certification. Finally, it may include less tangible Perceived Costs resulting from customer concerns about the product's inherently novel or unfamiliar technologies.

Assessing Our Investments

Specific investments are closely monitored with detailed objectives and milestones and are terminated when a technology reaches competitiveness or as sufficient private sector investment takes over. Investments can also be modified or terminated if a pathway to competitiveness cannot be identified or if market barriers prevent a technology from reaching its full potential and an alternative can be identified.

To further ensure effectiveness, EERE evaluates its portfolio on an ongoing basis and seeks to quantify the return on investment (ROI) across all of EERE's investments using a peer-reviewed methodology. To date, third party evaluators have assessed one-third of EERE's R&D portfolio (by amount invested from 1976 to 2012) through multiple evaluations covering R&D investments in photovoltaic

When and Why EERE Stops Investment

EERE may end its investment for any of three distinct reasons:

- When evaluating a new investment opportunity area, if analysis cannot identify a credible pathway to market competitiveness; we retain the option to invest later if breakthroughs change the landscape.
- When barriers are significant and competing alternatives that have a more promising pathway are available in generally the same timeframe.
- When the technology reaches competitiveness and is primed for the market to take over.

(PV) energy systems, wind energy, vehicle combustion engines, geothermal technologies, and advanced battery technologies for electric-drive vehicles. These assessments have found that the total EERE taxpayer investment of $12 billion in these technologies has already yielded an estimated net economic benefit to the United States of more than $230 billion, with an overall annual ROI of more than 30%.[2]

About This Plan

The following sections describe each of the EERE goals and the key strategic thrusts that EERE will undertake to reach these goals. Our first three strategic goals correspond to the three sectors under EERE's purview: sustainable transportation, renewable power, and energy efficiency. The last four strategic goals are crosscutting in nature and represent high-priority integrated activities that are coordinated across technology offices to achieve EERE's mission.

The implementing framework for each strategic goal lays out a set of strategies, corresponding to the three phases of our investment approach, describing the actions that EERE will take to achieve that strategic goal. Where appropriate, our strategies are organized into three areas:

- **Cost Reduction and Performance Improvement** – applied research and development of components or whole technology systems.
- **Technology Validation and Risk Reduction** – confirming the performance of technologies, both in controlled laboratory and real world conditions, and providing benchmarks for performance and durability—all to reduce uncertainty for investors.
- **Reducing Market Barriers** – addressing specific gaps in market development such as a lack of reliable product information, inconsistent regulatory environments, or inadequate skill standards for the clean energy workforce.

The implementing framework for each strategic goal also has a set of associated Success Indicators which describe intermediate or ultimate targets that, if and when achieved, will also affirm that EERE is successfully on track toward that goal. Success Indicators are intended to be data driven and selected to be challenging and meaningful to accomplish. Each Success Indicator is established using a combination of market data and detailed system high volume cost modeling, with market data increasingly used as technologies become commercially available.[3] In the sections that follow, summarized versions of the Success Indicators are presented, including basic information, such as technical target and completion year.[4] Success Indicators are numbered for reference, and are not in priority order.

Breaking Down Broadly Applicable Commercialization Barriers in Clean Energy

In addition to pursuing multiple strategies to achieve EERE's seven goals, EERE also takes a matrixed approach to break down barriers to commercializing clean energy technologies that are common to all EERE technologies through several cross-cutting strategies:

- Programs and activities to address barriers to early-stage company formation in clean energy technology areas, including support for student business plan competitions and regional clean energy business incubators.
- Integrated deployment approaches to market adoption in high-cost or locally motivated markets using comprehensive, replicable methods that prioritize EERE technologies and practices, including working with communities impacted by natural disasters, providing guidance on rebuilding with better energy efficiency, and integrating renewables.
- Collaborative efforts in prime international markets for U.S. products and services, such as promoting adoption of codes and standards consistent with those of the United States, providing technical analysis to support grid integration of renewables, and testing and validating new U.S. innovations—all in collaboration with the U.S. private sector and partner countries and organizations.

[2] Preliminary aggregate net benefits calculation combining cost-benefit impact results from formal evaluation studies conducted for EERE; equivalent to a benefit-cost ratio of approximately 7:1 at a 7% discount rate.

[3] References to "modeled cost" imply that detailed system modeling will be used. Unless otherwise noted, "cost" refers to final cost to end customer (i.e. price).

[4] EERE intends to publish a detailed description of each of the technical Success Indicators including relevant assumptions and calculations as an addendum to this Strategic Plan.

EERE Vision
A strong and prosperous America powered by clean, affordable, and secure energy

EERE Mission
To create and sustain American leadership in the transition to a global clean energy economy

EERE's Activities are Guided by Key Organizational Principles
Economic Prosperity | Affordability | Reduced Environmental Impact | Energy Security | Consumer Choice

	Strategic Goals	Strategies	Success Indicators
SECTOR-SPECIFIC	Goal 1: Accelerate the development and adoption of sustainable transportation technologies	Strategies to achieve the first four Strategic Goals are organized into three areas: • Cost reduction and performance improvement • Technology validation and risk reduction • Market barrier reduction	The plan includes 39 indicators that reflect interim milestones or end goals of strategies. Many of these indicators directly align with larger federal goals and provide what we anticipate EERE's contribution to be. Given different technologies' life cycles, indicator target years range from 2017–2035, with a majority in the 2020 and 2030 timeframes. Some indicators map to single strategies while others map to several strategies.
SECTOR-SPECIFIC	Goal 2: Increase the generation of electric power from renewable sources		
SECTOR-SPECIFIC	Goal 3: Improve the energy efficiency of our homes, buildings and industries		
CROSS-CUTTING	Goal 4: Stimulate the growth of a thriving domestic clean energy manufacturing industry		
CROSS-CUTTING	Goal 5: Enable the integration of clean energy into a reliable, resilient, and efficient electricity grid	Strategies to achieve Goals 5, 6 and 7 are cross-cutting in nature.	
CROSS-CUTTING	Goal 6: Lead efforts to improve federal sustainability and implementation of clean energy solutions		
CROSS-CUTTING	Goal 7: Enable a high-performing, results-driven culture through effective management approaches and processes		

EERE's Work is Prioritized According to The Five EERE Core Questions

Impact	Additionality	Openness	Enduring Economic Impact	Proper Role of Government
Is this a high-impact problem?	*Will EERE funding make a large difference relative to existing funding from other sources, including the private sector?*	*Are we focusing on the broad problem we are trying to solve and open to new ideas, approaches, and performers?*	*How will EERE funding result in enduring economic impact for the United States?*	*Why is this investment a necessary, proper, and unique role of government rather than something best left to the private sector?*

Goal 1: Accelerate the Development and Adoption of Sustainable Transportation Technologies

U.S. petroleum use creates significant economic, security, and environmental challenges. Currently, transportation accounts for more than 70% of U.S. petroleum usage with on-road vehicles currently responsible for 80% of this amount.[5] The U.S. transportation sector accounts for approximately one-third of U.S. energy-related carbon pollution and, despite recent progress in reducing other emissions, remains a significant source of air pollution.[6] The average U.S. household spends nearly one-fifth of its total family expenditures on transportation, making it the most expensive spending category after housing. In addition, over the last 10 years, U.S. regular conventional retail gasoline prices have fluctuated from below $1.50 to over $4, affecting annual household budgets by as much as $1,500 per average passenger car. Finally, the cost of our reliance on foreign sources of oil is also significant. A Rand Corporation study placed the ongoing cost to the U.S. military of mitigating the risk of supply disruptions in the global oil market at $67.5 billion to $83 billion annually.[7]

EERE's sustainable transportation portfolio supports comprehensive and analysis-based strategies to accelerate the development and widespread use of a variety of domestic and cost-effective sustainable transportation technologies. Broadly, EERE pursues two key parallel solution pathways: (1) using less petroleum-derived fuel to move people and freight (vehicle efficiency) and (2) replacing conventional fuels with cost-competitive, domestically produced, sustainable alternatives (alternative fuels) that reduce carbon pollution. Because most petroleum use currently occurs in personal vehicles and trucks, EERE's portfolio emphasizes transportation technologies in these areas.

In alternative fuels, EERE develops solutions that can provide domestically produced, low-emission alternatives for the whole barrel of oil, replacing:

- Gasoline in light-duty vehicles[8]
- Diesel in trucks, rail, and marine applications
- Jet fuel in aircraft
- Other products and uses, such as intermediate bioproducts that displace fossil fuel use, such as those in adhesives, carbon fibers, and polymers for plastics.

EERE's sustainable transportation portfolio has the potential to be transformative for the nation. Two recent studies [9,10] concluded that a portfolio of EERE-supported technologies—including fuel cell electric

Success Indicators

1. By 2020, through improvements in engine efficiency, increase the fuel economy of gasoline and diesel light-duty vehicles by 35% and 50%, respectively, compared to a 2009 gasoline vehicle.
2. By 2022, develop materials that enable a cost-effective 30% weight reduction for light-duty vehicles, compared to a 2012 baseline.
3. By 2022, develop a battery pack demonstrating a modeled cost of $125/kWh and an electric drive system demonstrating a modeled cost of $8/kW and efficiency greater than 94%.
4. By 2017, demonstrate a 50% improvement in long-haul truck freight efficiency, compared to a 2009 baseline.
5. By 2017, verify at pilot scale at least one technology pathway for hydrocarbon biofuel production demonstrating a mature modeled cost of $3/gge with GHG emissions reduction of 50% or more.
6. By 2022, verify at pilot or demonstration scale two additional pathways for hydrocarbon biofuel production at a mature modeled cost of $3/gge with GHG emissions reduction of 50% or more.
7. By 2020, develop and demonstrate a fuel cell system for light-duty vehicles achieving 150,000-mile durability and a modeled cost of $40/kW.
8. By 2020, reduce the modeled cost of hydrogen production from renewable resources to less than $4/gge.

[5] *Annual Energy Outlook 2013*, EIA, 2013.

[6] Transportation sector pollutants account for more than half of all carbon monoxide and nitrogen oxide emissions; almost a quarter of all volatile organic compounds; and 2%–6% of particulate matter emissions. See *Transportation Energy Data Book 32nd Edition*, ORNL, 2012.

[7] *Imported Oil and U.S. National Security*, RAND Corporation, 2009.

[8] Light-duty vehicles are defined as vehicles weighing less than 8,500 lbs (e.g., automobiles and light trucks).

[9] *Transitions to Alternative Vehicles and Fuels*, National Research Council, 2013.

[10] "*Transportation Energy Futures*," EERE, 2013

vehicles (FCEVs), plug-in electric vehicles (PEVs), advanced combustion technologies, vehicle light-weighting and large-scale use of biofuels—could reduce domestic consumption of petroleum by light-duty vehicles by 40% by 2030 and 80% by 2050. The analyses also found that these changes could be achieved through multiple pathways using various combinations of technologies in the EERE portfolio. Many of these technologies are just beginning to be introduced in significant volumes into the commercial marketplace, making this a pivotal time for EERE's Sustainable Transportation portfolio.

Cost Reduction and Performance Improvement

Develop Technologies That Enable the Cost-Effective Production of Electric-Drive Vehicles

Electrification[11] of transportation is a key element of EERE's sustainable transportation portfolio. The fueling cost of electric vehicles (EVs) is significantly lower than that of today's gasoline-powered vehicles—generally comparable to about $1 per gallon of gasoline equivalent[12]—and, using domestically produced electricity, consumers are able to conveniently charge their vehicles at home, in public places such as shopping malls and grocery stores, or at their workplaces. EERE's programs in this area will be focused on enabling electric-drive vehicles that meet consumer requirements for performance, convenience, and safety.

Develop Technologies to Reduce Internal Combustion Engine and Vehicle Energy Use

Even as electric-drive vehicles increasingly enter the U.S. transportation fleet, the internal combustion engine will remain an essential vehicle power system for many years—particularly for heavy-duty transportation. Activities will include multiple areas of R&D, including combustion engines with improved efficiencies, fuels, lightweight and alternative propulsion materials, lubricants and tire technologies, vehicle systems (e.g., vehicle, interior ventilation, and air conditioning), and aerodynamics. Many of the technologies developed in this area will result in significant fuel savings for new combustion vehicles and the nation's existing 250 million combustion vehicle fleet, while lowering cost and improving the performance of electric-drive vehicles.

Reduce the Cost of Producing Advanced Biofuels and Hydrogen from Renewable Resources

The use of domestically produced advanced biofuels[13] and hydrogen from renewable resources that do not compete with food and feed production can play a major role in achieving our aggressive national energy goals. After achieving many of its R&D objectives for cellulosic ethanol, EERE will increasingly pursue promising longer-term cellulosic drop-in biofuels that are compatible with existing internal combustion engines and fuel storage, delivery and dispensing infrastructure. EERE is also pursuing low-greenhouse gas (GHG) centralized hydrogen production approaches including biomass gasification, advanced water electrolysis, highly efficient direct solar conversion pathways, and biological production. These technology pathways have the potential to utilize abundant, diverse resources, which could provide hydrogen to fill the demand for fuel in FCEVs, enabling a key pathway for dramatic reductions in carbon pollution.

Reduce the Cost of Delivering and Dispensing Alternative Transportation Fuels

A wide range of systems are needed to deliver and dispense alternative fuels safely and conveniently. Novel fuels may face infrastructure and materials compatibility issues, requiring R&D and analysis to understand delivery scenarios that will best enable deployment and widespread adoption. Depending on the fuel—liquid biofuel, hydrogen, electricity, or natural gas—the cost of these infrastructure systems need to be reduced substantially to compete with the existing fossil-based systems that have been developed and refined over more than 100 years.

Technology Validation and Risk Reduction

Support Pilot and Demonstration Facilities for Alternative Fuel Production

Successful wide-scale U.S. deployment of alternative transportation fuels will be dependent on giving potential investors confidence in new technologies and resolving scale-up issues for first-of-a-kind alternative fuel production facilities. EERE has supported more than 25 biofuel, hydrogen, and other pilot and demonstration facilities that have allowed industry partners to integrate unit operations, validate techno-economic assessments, and prove a variety of technologies at scales relevant for private investors. EERE will continue to encourage private investment through pilot tests and integrated

[11] Electrification includes all electric drivetrain vehicles, such as battery electric, PEVs, and FCEVs.

[12] See DOE's *e-gallon* tracker to compare the cost of driving with electricity.

[13] An advanced biofuel, as defined by the *Energy Security and Independence Act of 2007*, is a fuel for which the renewable fuel life-cycle GHG emissions performance is greater than or equal to a 50% reduction.

demonstration facilities of innovative technologies to verify performance at a scale sufficient to provide the data and equipment specifications together with reducing the risk necessary to design and garner investment for a commercial pioneer facility.

Demonstrate and Evaluate Integrated Systems for Advanced Vehicles and Alternative Fuels

In addition to developing alternative fuel technologies, EERE will conduct real-world evaluations, data collection, and analyses of a variety of emerging alternative fuel vehicles and infrastructure systems. These efforts will help to identify issues that may arise only when systems are operated at full scale under real-world conditions. Furthermore, real-world demonstrations and data dissemination support commercial acceptance of technologies by providing reliable performance data and greater consumer visibility.

Reducing Market Barriers

Support Pioneering Deployments of Market-Ready Vehicles and Alternative Fuels in Key Early Markets

EERE's early market barrier reduction efforts will match commercial-ready technologies with key early markets, where a modest number of new orders will catalyze the industry, establishing a foundation for wider market opportunities. EERE will provide financial and technical assistance in this area, with the goal of reducing costs through catalyzing economies of scale, supporting the development of a domestic industry, and providing feedback through testing programs to manufacturers and other technology users.

Provide Best Practices, Objective Data, and Informational Materials to Potential End-Users and Investors to Promote Acceptance of Advanced Vehicles and Alternative Fuels

Potential end users can be reluctant to adopt new technologies—no matter how economical or useful—unless they are convinced that the benefits and reduced risks are real based on unbiased, trusted, and relevant information. To help accelerate deployment, EERE will provide technical assistance, develop publicly available predictive models, and compile and disseminate data through publications and websites with interactive tools for different end-user and investor needs.

Address Alternative Fuel Infrastructure Deployment Challenges through Analysis and Coordination with State- and Local-Level Initiatives

Perhaps the greatest challenge to the use of new transportation fuel options is the fuel distribution infrastructure. Even though PEVs, for example, can rely on our extensive national electricity network, work in connection standards, charger compatibility, and network communication protocols are necessary. EERE will place a strong emphasis on working with state and local stakeholders to enable a coordinated, holistic approach to the integration of buildings, distributed fuel infrastructure–including electricity and hydrogen–and vehicles onto the distribution system. This emphasis will result in technology solutions that interact across the system and can be scaled to ultimately allow mass-market adoption.

Support the Development and Harmonization of Codes and Standards

EERE will continue to support the generation of critical data required to develop technically sound codes and standards needed for the commercialization, and safe and responsible deployment of alternative fuels and vehicles. EERE will facilitate and promote collaborative efforts among government, industry, standards development organizations, universities, and national laboratories in an effort to harmonize regulations, codes, and standards both domestically and internationally.

Help Prepare and Certify Sustainable Transportation Professionals

If the United States is to be the global leader in developing and manufacturing the next generation of advanced fuels and vehicles, there must be a highly trained workforce possessing the skills required to be successful in these high-technology fields. EERE will continue to work with university partners and other relevant stakeholders to expand course work and university research to support degrees and skill certifications in these critical technology areas. As part of the government-wide science, technology, engineering, and math education consolidation strategy, EERE will continue to engage in the streamlined science, technology, engineering, and math activities conducted by the National Science Foundation and Department of Education.

Goal 2: Increase the Generation of Electric Power from Renewable Resources

Power plants are the largest source of emissions in the United States, together accounting for roughly one-third of all domestic greenhouse gas emissions.[14] Technologies that harness renewable energy sources to produce electric power, therefore, must be an essential part of a global clean energy economy. These technologies also share a fundamental benefit: the fuel is free. Once the costs of capital equipment, operations, maintenance, and other costs are financed into a renewable power project, the price of power is typically predictable for 20 or more years. As such, a diverse energy mix that includes a greater portion of renewable sources offers a more stable cost profile over the long term in comparison to conventionally fueled power systems.

The United States has an abundant supply of renewable energy resources, more than enough to meet its total energy demand for the foreseeable future if these resources can be competitively harvested. To cite just one example, each day more solar energy falls on the United States than the energy our country uses in an entire year.[15] These large and inexhaustible domestic renewable power resources hold great potential to enhance the nation's energy mix.

While the opportunities and benefits associated with renewable power are clear, significant challenges still remain to unlocking its full potential. For one, the cost of renewable power technologies continues to be a barrier, though wind and solar power costs have been dramatically reduced in recent years. Several renewable resources exhibit variable generation patterns, which presents challenges for their successful integration into the grid at larger scales (geothermal and hydropower are notable exceptions). Many of the highest quality renewable resources, in terms of scale, are also far removed from major population centers, requiring major investments in transmission and distribution infrastructure to fully access them. Financing renewable power systems can also be difficult because of their comparative novelty, relative lack of regulatory clarity, and in some cases higher upfront capital costs compared to conventional fuel technologies. Finally, renewable power systems are subject to a complex system of electric utility and environmental regulations that do not yet account for or readily accommodate these new technologies.

Success Indicators

1. By 2020, reduce the cost of solar power to $0.06/kWh at utility scale, $0.07/kWh at commercial scale, and $0.09/kWh at residential scale, without incentives.
2. By 2020, reduce the cost of land-based wind to $0.06/kWh broadly across the U.S. without Incentives.
3. By 2030, reduce the modeled cost of offshore wind to $0.14/kWh.
4. By 2020, reduce the modeled cost of new hydropower to $0.12/kWh.
5. By 2030, reduce the modeled costs of marine and hydrokinetic systems to $0.27/kWh for wave; and $0.28/kWh for tidal.
6. By 2020, reduce the modeled cost of geothermal power from currently undiscovered hydrothermal resources to $0.10/kWh.
7. By 2030, reduce the modeled LCOE from newly developed geothermal systems, including EGS, to $0.06/kWh.

Through its renewable power portfolio, EERE will seek to address these and other opportunities and challenges to make solar, wind, water, and geothermal power generation technologies directly cost competitive with conventional sources of electricity, and address the wide range of related market issues to facilitate their widespread deployment across the country. This will include approaches to address upfront capital, finance, projected operations and maintenance, and other "soft costs" associated with permitting and siting renewable power projects.

Cost Reduction and Performance Improvement

Develop Innovative Materials and Components to Reduce Hardware Costs

Given that renewable power projects have no fuel cost, the upfront capital or hardware cost and investment timing related to these components is usually the strongest driver of the overall cost of any renewable power project. The primary way to reduce these costs per kilowatt-hour produced is to increase the efficiency-to-cost ratio of renewable technologies through innovations that increase conversion efficiency or decrease the initial costs related to characterization, exploration, materials, manufacturing processes or system assembly. EERE will continue to pursue research and development in a broad range of materials and components that have the potential to reduce renewable power project costs.

[14] *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2013*, U.S. EPA, 2015

[15] *Renewable Energy Technical Potentials: A GIS-Based Analysis*, National Renewable Energy Laboratory, 2012

Improve System Efficiencies and Performance

EERE's renewable power R&D portfolio will have a significant focus on technology advances to increase system capacity factors and energy production, helping to both address the variable nature and increase the cost-competitiveness of renewable power technologies. With wind power, for example, the greatest technical opportunity areas EERE will invest in to increase capacity factor are (1) increased energy capture from access to better wind resources, such as taller towers to reach more powerful winds; (2) increased rotor swept area through longer blades; (3) higher tip speeds; and (4) optimized array design, which seeks to reduce array losses and maximize generation from a better understanding of turbine-to-turbine wake effects and more active controls.[16] These improvements have the potential to increase the overall output of an array by approximately 30% above the baseline design through proper spacing and improved operation of the turbines.

Accelerate Understanding of Reliability Issues and Failure Modes to Reduce Operations and Maintenance Costs

While renewable power systems do not have fuel costs, operations and maintenance costs can represent a significant ongoing expense. To minimize these costs and further enable cost reductions, EERE R&D investment areas will include the following:

- **Extending component lifetimes:** EERE will perform R&D to address a broad range of operations and maintenance and reliability issues to extend the lifetime and reduce the servicing costs of critical components. This includes R&D to improve the reliability of rotating components such as gears, bearings, temperature- and pressure-hardened downhole tools, turbines, and generators, as well as stressed components such as shafts, wellbores, support structures, and foundations. The focus will also include electric components such as photovoltaic modules, power electronics, controllers, and sensors.
- **Proactively identifying and mitigating failures:** EERE will also perform cutting-edge R&D to develop new technologies to actively predict, diagnose, and avoid technology failures. This will require advanced predictive models and devices and communication structures designed to identify and alert operators of potential failures or maintenance issues well in advance of a critical failure.

Improve Resource Characterization and Forecasting to Enable Optimized Siting and Plant Operation

Improving the renewable power industry's ability to characterize and forecast renewable resources is essential for providing investment certainty, and optimizing siting opportunities enables more seamless integration of renewable power sources at high penetration levels onto the grid. First, building on its work in wind and solar, EERE will continue to support national renewable energy resource characterization efforts that make resource datasets—containing critical information on quality and predictability—publicly available to help project developers identify the most promising locations to capture particular resources. Second, EERE will support the development of weather models that provide plant operators and utilities with accurate real-time renewable resource forecasts to enable seamless integration of renewable power into the grid. Third, EERE will focus on those renewable areas—such as new hydropower, marine hydrokinetic (MHK), and geothermal—where resource characterization is comparatively less well understood.

Technology Validation and Risk Reduction

Provide Testing and Simulation Capabilities to Speed Component and Systems Development

EERE will continue its work to speed the development of renewable power systems by providing the U.S. renewable power industry with essential modeling, testing, and simulation capabilities. Supporting the iterative process of design, implementation, and testing of particular modifications or innovations for renewable power technologies is critical to the successful development of these products and technologies. EERE's activities will provide continued access to world-class testing infrastructure, including the National Wind Technology Center at NREL and the Scaled Wind Farm Technology (SWiFT) site—allowing partners to use test results to redesign, reconfigure, and retest technologies to advance technology development and optimize component and system designs.

Support Pilots and First-of-a-Kind Demonstrations to Validate the Performance of New Technologies

Demonstration of new renewable power technologies at commercially relevant scale is a critical step to financing and market adoption. EERE will continue to leverage its partnerships with industry and the national laboratories and other agencies, such as the Department of Defense, to conduct demonstrations of next-generation renewable energy

[16] As an example, wind turbines create downstream wakes similar to a rock in the flow of a river; the wake slows the wind speed and potentially lowers the power output of downstream turbines.

technologies, an essential step for ensuring overall commercial viability and "bankability" for investors. One example of this effort is EERE's Frontier Observatory for Research in Geothermal Energy (FORGE), a government-managed site in partnership with industry, academia, and DOE National Labs, where enhanced geothermal systems (EGS) technologies and techniques will be field tested. System demonstrations will make maximum use of real-world operating conditions, as opposed to simulated environments, so that EERE and its partners can measure and evaluate system robustness and performance over time. Technical and economic performance data are the major outputs of these demonstrations—and these data inform next-generation system development, while also providing project developers with the validation data they need to engage the investment community for private financing.

Reducing Market Barriers

Streamline Financing for Renewable Power Projects

High costs of financing renewable energy projects can be a significant barrier to their large-scale adoption. EERE will explore the use of financial processes successfully demonstrated in other industries to reduce transaction costs and timelines—major contributors to overall financing costs. One example of this effort has been EERE's work through the National Laboratories on the Solar Access to Public Capital initiative, which worked with a wide array of solar power stakeholders to standardize key documents used in the project development process, such as contracts for residential leases and commercial power purchase agreements.

Optimize and Streamline Regulatory and Permitting Processes at the Federal, State, and Local Levels

Renewable power projects can face significant permitting and regulatory barriers that increase overall risk and cost. EERE will continue to expand its work with a wide variety of stakeholders to minimize site-related permitting and regulatory challenges, while continuing to protect environmental, cultural, and economic concerns. Building on its "regulatory roadmapping" work for geothermal projects, EERE's efforts will be engagement at the federal, state, and local levels in order to address the potential multiple layers of requirements for developers to navigate. These activities will help enable more efficient and effective processes by addressing the lengthy, costly, and uncertain permitting and regulatory timelines which renewable power projects face, causing significant delays and increasing the overall risk of a project.

Provide Analysis and Resources to Identify and Mitigate Environmental and Other Key Barriers to the Deployment of Renewable Power at Scale

EERE will continue to work with its partners to identify and mitigate key market barriers to the scaled deployment of renewable power technologies. These market barriers may delay, increase the cost of, or totally block projects and can include environmental and cultural issues, grid integration issues, and/or the physical and economic interactions of renewable power projects with other military and civil infrastructure. EERE will seek to proactively work with stakeholders to identify these barriers, perform independent unbiased analyses related to these barriers, and identify and help implement innovative solutions to address them.

Support the Development and Improvement of Codes and Standards, Test Methods, Certification Programs, and Best Practices

EERE will continue to support the development of robust codes and standards in the renewable power sector to help build consumer and investor confidence. EERE's support will include analytical, technical, and standardization approaches that provide code and permitting officials the assurance they need to permit renewable energy projects. We will also work with partners in testing and certification programs to help ensure products meet safety, performance, and durability standards.

Help Prepare the Renewable Power Workforce

To prepare a U.S. workforce that can prosper from, and enable growth in, the renewable power industry, EERE will continue its partnerships with the Departments of Labor and Education, along with regional training providers, in support of training and certification programs for workers in renewable power sectors where skills gaps exist. These include high-quality jobs in research, construction, and manufacturing. For example, EERE will continue to lead the Solar Instructor Training Network, which promotes high-quality solar projects and jobs by developing programs for accreditation of solar trainers and distributing best practices for training programs. In September 2014, EERE launched the Solar Ready Vets program, which included utilizing instructors from the Solar Instructor Training Network to help train veterans and prepare them for careers in the solar industry.

Goal 3: Improve the Energy Efficiency of Our Homes, Buildings, and Industries

Improving the energy efficiency of U.S. homes, buildings, and industrial[17,18] facilities presents a tremendous opportunity for American families and businesses to lower their energy costs, reduce GHG emissions, enhance competitiveness, and create new jobs. Energy used in homes, buildings, and industries represents more than 70% of U.S. energy consumption, energy bills, and carbon pollution, and accounts for more than $600 billion in energy costs each year, with residential and commercial buildings responsible for about two-thirds, at more than $400 billion annually.[19] Nearly one-third of the energy used in buildings and industry is wasted—energy use that can be reduced through the energy efficiency technologies and solutions that are already cost-effective today. Even greater savings opportunities will accrue from continued R&D to bring cutting-edge, cost-effective technologies and solutions into the marketplace. At a time when the nation faces likely major energy system upgrades, energy efficiency can help reduce the need for additional energy system infrastructure improvements.

Through its energy efficiency portfolio, EERE will build on the considerable progress made over the last 40 years and pursue a comprehensive portfolio of programs to improve the energy efficiency of America's homes, buildings, and industries, with an overall goal of cutting energy waste in half. Businesses and consumers will have compelling new energy efficiency options, including products that perform at higher efficiency and with improved performance, new ways to design homes and buildings, and new approaches to improve the vast stock of existing buildings.

Cost Reduction and Performance Improvement

Develop New Materials, Technologies, and Approaches to Enable Significant Energy Savings for American Homes and Buildings

EERE will develop new cost-effective technologies that will drive down the energy used by our homes and buildings, seeking to catalyze new solutions that will lower the energy used in homes and buildings by 30% in 2030. Of particular focus will be technologies that have the potential to decrease energy use in end-use products; improve the thermal capabilities of windows, skylights, and the entire building envelope; and integrate capabilities into relevant products to self-diagnose, communicate, and schedule services to further reduce costs and improve our energy grid.

Success Indicators

1. By 2020 develop cost effective technologies capable of reducing a building's energy use per square foot by 30%, compared to a 2010 baseline.
2. By 2030, reduce energy use per square foot in all U.S. buildings by 30%, compared to a 2010 baseline.
3. By 2025, reduce the energy used for space conditioning and water heating in single-family homes by 40% from 2010 levels.
4. By 2025, demonstrate approaches with market leaders in the commercial sector achieving 30% energy savings per square foot for existing buildings and 50% energy savings in new buildings relative to typical commercial buildings in 2010.
5. By 2020, demonstrate at scale market-based industrial programs and practices providing energy savings of 25% or more.
6. By 2025, introduce new industrial technologies and/or advanced materials that lower facility-level energy costs 50% or more, and/or provide 50% savings over targeted product lifecycles, compared to a 2010 baseline.
7. From appliance standards enacted from 2009 through 2016, realize energy savings to avoid at least 3 billion metric tons of carbon emissions cumulatively by 2030.

[17] EERE defines energy waste as energy that could be captured and productively utilized in a cost-effective manner, but currently goes uncaptured and is ultimately lost. By this measure, almost one third of all delivered energy used in buildings and industry is wasted today. See *Unlocking Energy Efficiency in the U.S. Economy*, McKinsey & Company, 2009.

[18] Demonstrating at scale means demonstrating a technology, system, integrated whole building, or approach at sufficient scale across climate zones, building types, and/or other market segmentations (such as multi-family and single-family), such that it is easily replicable.

[19] *Annual Energy Outlook*, EIA, 2013

Develop New Materials, Technologies, and Processes to Enable Increased Competitiveness for U.S. Industries

EERE will advance a portfolio of high-impact efforts to reduce energy costs for the nation's most energy-intensive industries, and create American leadership in the development of a platform of advanced and efficient materials and manufacturing technologies. Specific areas of focus will include high efficiency motors and drive systems, reduced energy intensity thermal systems, combined heat and power (CHP) systems, advanced forming and fabrication technology, manufacturing design and sensors and process controls. These efforts will benefit and re-invigorate multiple industries, enabling the rapid manufacture of high-quality products at globally competitive costs and generating large energy, carbon, and economic benefits across the manufacturing sector.

Technology Validation and Risk Reduction

Validate Energy Savings Technologies and Systems at Sufficient Scale to Enable Wide-Scale Adoption

New energy efficiency technologies often face significant uncertainties regarding actual savings that hinder volume adoption. To address this first-cost hurdle, EERE will pursue testing, validation, and demonstration activities that range in scale from prototypes of innovative new technologies to commercially available technologies facing specific challenges to implementation, system integration, interoperability, or other challenges. EERE will also play a critical role in reducing perceived risk by supporting development of standard testing procedures that reflect real-world applications.

Demonstrate that Next-Generation Efficient Homes and Buildings are Affordable, Healthy, and Durable

The 1 million homes and 1.5 billion square feet of commercial buildings typically built each year, along with significant renovations in existing buildings, provide a unique opportunity to build in energy waste-cutting measures. EERE's activities in this area, such as the Building America program and Challenge Home partnership, will engage designers, home builders, and building scientists to demonstrate that high performance buildings incorporating new design options can be built and commercially sold. EERE will develop and leverage energy modeling and integrated design techniques and whole building verification to address the significant number of small and medium-sized buildings across the country.

Enable Demonstrations of Energy-Saving Approaches for Buildings and Industrial Facilities

EERE will work with market leaders to demonstrate, in a broad set of real-world and diverse circumstances, that energy efficiency technologies and solutions are low risk and makes sound business sense. Areas of focus include:

- Operational savings approaches: Efficient operations of technologies and processes in addition to efficient technologies offer significant gains. To demonstrate these approaches at scale, EERE will partner with a broad set of leaders whose buildings and facilities represent 80% or more of energy use across the commercial and industrial sectors.
- Residential, commercial, and industrial energy efficiency service models: Demonstrating energy efficiency service models and other approaches can expand the role of utilities and energy efficiency program administrators in engaging their customers in cutting energy waste. EERE will work with leading organizations to demonstrate these models, with an emphasis on the role of data, financing solutions, need for qualified professionals, and employing credible measurement and evaluation.

Reducing Market Barriers

Implement Minimum Appliance and Equipment Energy Performance Standards

EERE will continue to establish or revise minimum appliance and equipment standards as authorized and directed by statute. Developed through open stakeholder processes, these standards provide the maximum improvement in efficiency that is both technically feasible and economically justified, as well as a level playing field for manufacturers that facilitate a national market for products—as opposed to a patchwork of state markets. Standards currently cover more than 60 products, which represent 90% of residential energy use, 60% of commercial energy use, and 29% of industrial energy use; these standards are providing about $50 billion in annual energy savings.[20,21]

Support Increased Energy Savings from Commercial and Residential Building Energy Codes

Building energy codes cover about 70% of all U.S. building energy use and are used to improve the efficiency of new construction and major renovations in residential and commercial buildings. Over the past 20 years, building codes have been adopted by more than 48 states and territories, and were estimated to save businesses and households about $5 billion in 2012, with more than $40 billion in cumulative savings.[22] EERE will continue to play a number of roles to increase the energy savings from building energy codes, including developing and testing new technologies and practices, assessing cost-effective options to incorporate into the code updates administered by the nation's code bodies, and developing better tools and practices to make it easier for states and local governments to adopt and comply with codes. These efforts—along with increased adoption by states and localities and strong compliance monitoring —will provide significant reductions in building energy use over their useable lifetimes.

Provide Technical Assistance across Market Sectors to Improve Adoption of Energy Efficiency Practices

DOE has a long history of assisting small and medium-sized industries with understanding the savings that can be achieved through energy efficiency, and EERE will continue this tradition by providing targeted technical assistance to address persistent market barriers to improved energy efficiency. One important area is Combined Heat and Power (CHP), which can offer a 30% improvement in efficiency over separate sources of heat and power. There is sufficient CHP potential in the United States to increase the current installed capacity of 82 GW by 50% and save more than $10 billion annually. In support of the President's goal of 40 GW of new CHP by 2020[23], EERE will continue to provide technical assistance across diverse market sectors through its regional CHP Technical Assistance Partnerships to help increase the use of CHP—emphasizing its cost competitiveness.

Improve and Standardize Methods for Assessing the Energy Efficiency and Potential Energy Savings

EERE will continue to address the lack of consistent and reliable information on energy savings from efficient technologies and practices, a well-established barrier to the greater adoption of energy efficiency. Efforts will include the development of standardized methods to assess building efficiency and cost-effective savings options, improve data analysis capabilities for the expected savings from building improvement measures, and establish uniform approaches for measuring savings from energy efficiency programs.

Assist State and Local Governments in Developing and Adopting Energy Efficiency Best Practice Programs and Policies

State and local governments own and control about 20% of the nation's commercial building space across building types—such as office buildings, libraries, universities, and correctional institutions—many with sizable opportunities for energy savings. Furthermore, they engage public organizations, businesses, and the public in efforts such as clean energy planning and goal setting, building energy benchmarking and disclosure, improved access to utility bill information and financing options, building code adoption, distributed generation policies, and utility regulatory policies, all of which have a large impact on energy bills and carbon pollution. EERE will engage with state and local government decision makers who are developing new approaches to overcome long-standing market barriers and catalyze robust energy efficiency and clean energy industries.

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[20] In 2012, energy conservation standards promulgated to date saved an estimated 3.6 quads of primary energy or 3% of total U.S. energy consumption, providing cost savings totaling $51.4 billion and carbon emissions savings totaling 198 million metric tons.

[21] This estimate is over the 2010 baseline, and relative to the 2012 AEO forecast. See *Annual Energy Outlook 2012*, EIA, 2012.

[22] *Building energy codes program: national benefits assessment, 1992–2040, PNNL*, 2014

[23] *Combined Heat and Power: A Clean Energy Solution*, DOE and EPA, 2012.

Support Home Weatherization, Including Improved Technical Tools and Work Quality

EERE will continue to support the national network of weatherization providers that can address the 20 million to 30 million households that are income-eligible for weatherization assistance, which can significantly lower their energy bills. Since the program began in the mid-1970s, about 6 million of these homes have received assistance using EERE funding. Weatherization lowers the energy bills of these households by about 16% to 18%, or $250 to $480 annually,[24] depending upon housing type, fuel source, and location—yielding a more than $4 ROI in energy and non-energy benefits for every dollar used to weatherize homes.[25] EERE's efforts will focus on developing and disseminating best practices in home weatherization technical tools, training, and workforce certifications.

Provide Easy Access to Information on Leading Energy Efficiency Best Practices

EERE will accelerate market adoption by actively engaging and providing information to industry and other related interest groups on the results from its efforts to develop and demonstrate energy efficiency technologies, practices, and other solutions, a critical step for widespread market adoption. Examples of these engagements include the new solution centers for (1) Building America to assist home builders, (2) the Better Buildings Neighborhood Program to assist utilities, home contractors and others, and (3) the Better Buildings Challenge showcasing a broad set of commercial and industrial solutions.

Improve the Quality and Consistency of Training Programs

EERE will continue to address the lack of trained, skilled energy efficiency professionals to help enable a growing and robust energy efficiency industry.[26] Skilled workers are necessary to diagnose savings opportunities, provide quality upgrades, operate and maintain high-performance buildings and industrial facilities, provide quality control, and certify savings. EERE has made significant progress improving the national training and certification framework and associated guidelines for home upgrades in support of EERE's Weatherization Assistance Program and with application to the broader marketplace. These guidelines improve workforce quality and consistency, improve consistency in certifications so workers can work in different regions, and reduce unnecessary confusion and cost associated with the current patchwork of workforce training and credentialing programs.

[24] Large variations in energy savings and expenditure savings exist based on weather conditions, housing type, and energy costs. As a result, households that reduce energy use by the same percentage will not necessarily save the same amount of money.

[25] *Evaluation of the National Weatherization Assistance Program during Program Years 2009–2011*, ORNL, 2011. Non-energy benefits include reduced home maintenance costs, uncollectible utility bills, carbon monoxide and environmental pollutants, hospital stays, emergency room visits, heat-related illness and death, and risk of death from home fires due to utility disconnection; occupancy retention; and other increases in life quality.

[26] "*Bonneville Energy Efficiency Summit*," Bonneville Power Administration, 2010

Goal 4: Stimulate the Growth of a Thriving Domestic Clean Energy Manufacturing Industry

American leadership in clean energy manufacturing is critical, both for our nation's considerable economic benefit and to inform further innovation. The American manufacturing sector is a significant, strategic sector for U.S. competitiveness and economic growth, fueling 12% of U.S. GDP and 60% of U.S. exports. High impact innovation in conjunction with the potential for low-cost energy can foster U.S. competitive advantages and help rejuvenate domestic manufacturing.

As part of DOE's Clean Energy Manufacturing Initiative (CEMI),[27] EERE seeks to extend U.S. leadership in clean energy innovation to leadership in manufacturing competitiveness, ensuring that the technologies we have helped to develop are also made in America, and that the United States establishes itself as the global manufacturing leader in the emerging multitrillion dollar clean energy market. EERE's strategic crosscutting domestic manufacturing effort has two objectives that help guide investments across its portfolio: (1) increase U.S. competitiveness in the production of clean energy products; and (2) increase U.S. manufacturing competitiveness across the board by increasing energy productivity and leveraging low-cost fuels and feed stocks.

In addition to the strategies below, EERE efforts for its Clean Energy Manufacturing goal will include the manufacturing-related strategies described under the preceding strategic goals that contribute to this comprehensive EERE-wide effort.

Success Indicators

1. Growing numbers of companies that produce clean energy technologies choose to locate manufacturing facilities in the United States.
2. Growing numbers of U.S. manufacturers choose to implement energy efficiency measures.
3. EERE-supported technologies mature to be substantially manufactured in the United States.
4. By 2025, reduce the life-cycle energy consumption of EERE-targeted manufactured goods by 50%.

Cost Reduction and Performance Improvement

Reduce Cost and Improve Performance of Specific Clean Energy Technologies by Developing Manufacturing and Materials Technologies and Processes

EERE will focus research and development activities on specific high-impact clean energy technologies that can give the United States a competitive advantage and an increased manufacturing market share. These activities will be supported by rigorous techno-economic analysis, technology development road mapping, and global manufacturing competitiveness analysis.

For example, according to a 2010 estimate, wafer processing made up nearly 25% of the total cost of silicon PV modules,[28] including substantial silicon losses in the wafering process. In addition, the labor intensity of this process, which involves sawing large silicon ingots into individual wafers and separating these wafers by hand, drove most of this activity to take place in Asia. EERE-sponsored R&D in new manufacturing methods for wafers—such as direct wafering where silicon wafers are essentially cast individually—not only has the potential to reduce the cost of solar modules by eliminating process steps and silicon losses, but could disrupt the incumbent supply chain with innovative processes well-suited for U.S. manufacturing.

[27] CEMI is a DOE Secretary level initiative across the Department to strengthen U.S. clean energy manufacturing competitiveness. The objectives of the initiative are to increase U.S. competitiveness in manufacturing clean energy technologies and increase U.S. manufacturing competitiveness through increased energy productivity and leveraging low-cost domestic energy resources and feedstocks. *http://energy.gov/eere/cemi/clean-energy-manufacturing-initiative*.

[28] Sunshot Vision Study, New West Technologies, LLC, Energetics, Incorporated, NREL, 2012

Increase Industrial Energy Productivity by Developing Foundational Advanced Manufacturing and Materials Technologies and Processes that Benefit Multiple Clean Energy Technologies

EERE will conduct research and development in a number of key foundational advanced manufacturing technologies and materials that can advance U.S. leadership in the manufacture of multiple clean energy products or in increased manufacturing energy productivity, increasing U.S. competitiveness. Specific technical opportunities include: wide bandgap power electronics, carbon fiber, advanced composites and lightweight materials, additive manufacturing, advanced characterization and metrology, low-temperature processes, novel industrial heating, and process intensification, innovative membranes, and information technology for manufacturing processes. EERE will pursue programs in areas such as these and others based on input from industry, academia, and other government organizations, as well as consideration of potential energy, environmental, and economic impacts.

Reduce Risk to Clean Energy Manufacturing Competitiveness from Potential Supply Chain Disruptions by Developing Critical Materials Technologies

In addition to the crosscutting materials described above, EERE will continue research on critical materials and their alternatives. Producing clean energy technologies relies on a broad array of critical materials inputs, and uncertainty in the availability of these materials is a potential threat to U.S. manufacturing of clean energy products. These critical materials, which are essential to the manufacture and/or performance of a technology, currently have no readily available substitutes and are subject to severe supply risks. Examples of such critical materials include neodymium and dysprosium for magnets in electric motors and generators; europium, terbium, and yttrium in phosphors for efficient lighting; lithium and cobalt in batteries; and tellurium in solar panels.[29]

EERE will support DOE in its strategy for mitigating issues related to critical materials for clean energy technologies, which includes the following steps: (1) enhance the availability of supply, (2) develop alternatives in use, and (3) reduce life-cycle losses (including increased recycling). EERE has efforts related to critical materials in several of its technology offices; however, the central EERE effort in this area is the Critical Materials Institute (an Energy Innovation Hub funded through the Advanced Manufacturing Office). This multi-year, industry/national laboratory/university consortium led by Ames Laboratory is focused on finding clean energy, critical materials solutions across the supply chain with advanced material recovery and recycling, and on identifying ways to reduce or eliminate the need for these materials.

Definitions: Clean Energy Manufacturing and Advanced Manufacturing

EERE invests in strategies to enhance both clean energy manufacturing and advanced manufacturing, defined as follows:

Clean Energy Manufacturing: Manufacturing of clean energy products (renewable energy, sustainable transportation and energy efficiency technologies) and boosting U.S. manufacturing across the board by increasing energy productivity and low-cost domestic fuels and feedstocks.

Advanced Manufacturing: Making products with technology as competitive difference.

EERE works to advance clean energy manufacturing broadly, with an emphasis on efforts where clean energy and advanced manufacturing intersect—on activities related to clean energy manufacturing and where a technology provides a competitive advantage over practices widely in use.

[29] Critical Materials Strategy, U.S. Department of Energy, December 2011.

Technology Validation and Risk Reduction

Reduce Technology Scale-Up Risk by Supporting Manufacturing Demonstration and User Facilities

The substantial level of private sector investment required for pilot, demonstration and commercial scale manufacturing of clean energy technologies has been difficult for companies to raise due to the high degree of technical and market uncertainty. EERE will invest in two key areas across its portfolio to address validation and risk reduction for clean energy manufacturing technologies: (1) cost-shared partnerships with the private sector to support pilot, demonstration, and (more rarely) pioneering commercial-scale clean energy manufacturing facilities; and (2) shared manufacturing demonstration user facilities available to a wide variety of companies and researchers to de-risk the manufacturing scale-up of new clean energy technologies. These approaches will help address challenges in scaling technologies to manufacturing that are shared across a wide array of industry participants and are best overcome by co-funding or leveraging a shared facility model.

One key example of EERE's commitment to build out this shared infrastructure is its continued support for existing and new Clean Energy Manufacturing Innovation Institutes consistent with the proposed National Network for Manufacturing Innovation (NNMI).[30] EERE is currently supporting Clean Energy Manufacturing Innovation Institutes in the areas of additive manufacturing (called "America Makes") and next-generation wide bandgap power electronics manufacturing. EERE will seek to continue to establish institutes in line with the proposed NNMI network in the years ahead.

Reducing Market Barriers

Inform Manufacturing Efforts Through Detailed Analysis of American Clean Energy Manufacturing Competitiveness in a Global Context

EERE will conduct a suite of comprehensive, objective analyses to evaluate global supply chains, trade flows, and the costs of producing clean energy products in the United States. These analyses will help provide a data-driven basis for EERE to guide its R&D portfolio toward the areas where technology advancements will most likely improve the competitive advantage of domestic manufacturers and elucidate market barriers that must be overcome to enhance U.S. manufacturing competitiveness. EERE will apply this approach to specific technologies—for example, solar PV, wind turbines, and EV batteries—and crosscutting materials and applications, including carbon fiber and wide bandgap semiconductors. EERE will also seek to use the results of these clean energy manufacturing competitiveness analyses to inform the development of specific new strategic EERE initiatives to enhance U.S. clean energy manufacturing competitiveness.

Work With Key Stakeholders for State and Regional Clean Energy Manufacturing Economic Development

EERE will engage and support state and regional partners in their critical role to help accelerate the deployment of clean energy technologies as an engine of economic growth. As an example, EERE has supported a National Governors Association Policy Academy focused on assisting states in aligning their economic development and clean energy strategies to support economic growth that includes increasing clean energy manufacturing competitiveness. In addition, through its State Energy Program, EERE has provided direct financial support to several states to perform clean energy manufacturing economic development plans. These awards require recipients to baseline the region's existing clean energy manufacturing assets, examine clean energy market opportunities, assess the alignment of the existing regional manufacturing capabilities, and identify areas of regional competitiveness and means for improving competitiveness.

[30] National Network for Manufacturing Innovation, DOE (accessed May 2013).

Recognize, Demonstrate, and Share Energy-Savings Approaches for U.S. Manufacturing Facilities

Key barriers to the successful implementation of energy-saving approaches in manufacturing include a lack of awareness of the potential impact of energy efficiency improvements at senior executive levels of manufacturing companies and a lack of sharing of best practices for energy-saving solutions across the manufacturing sector. To address these, EERE will highlight and recognize companies that demonstrate and share energy-savings approaches to help manufacturers of all types and sizes save energy and boost productivity. Example programs include EERE's Better Plants Program and Better Plants Challenge that corporately recognizes firms that establish long-term savings targets, implement cost-effective energy efficiency improvements, and report on their results. More than 120 industrial firms are currently participants in the Better Plants Program and Challenge, representing more than 1,700 plants—almost 8% of the total U.S. manufacturing footprint—and spanning sectors representing more than 75% of U.S. industrial energy use. To date, the participants in the Better Plants Program and Challenge have saved about $1 billion in energy costs and 190 trillion Btu.[31]

Maximize Impact of EERE Manufacturing RD&D Investments through Export Promotion and U.S. Manufacturing Commitments

EERE will maximize the impact of its clean energy manufacturing RD&D investments by soliciting, negotiating, and enforcing U.S. manufacturing plans and commitments for all EERE-funded RD&D projects, as well as working with federal agency partners and other nations to promote exports of clean energy technologies manufactured in the United States. Starting in 2014, EERE has required applicants to its funding opportunities to submit a "U.S. Manufacturing Plan" as a key part of their applications. EERE will use the strength of these plans as an evaluation factor in the selection of its awardees and will negotiate and enforce explicit U.S. manufacturing commitments as part of its cooperative agreements going forward. The goal of this effort is for more awardees to successfully develop competitive manufacturing in the United States—maximizing the impact of EERE investments in expanded economic activity and follow-on R&D that is informed by insights from manufacturing.

EERE will also work closely with private sector partners and other U.S. government agencies to maximize access of U.S. manufacturers to foreign markets. EERE will also identify and act on opportunities to prime targeted international markets for clean energy technologies made in the United States (such as, helping develop high-quality codes and standards for buildings and equipment in China and India) and will connect U.S. manufacturers with other U.S. government programs and resources that support the export of clean energy goods and services.

[31] Better Plants Progress Report, DOE, 2013.

Goal 5: Enable the Integration of Clean Electricity into a Reliable, Resilient, and Efficient Grid

Historically, EERE has focused on driving down the costs and improving the performance of clean energy technologies. These long-term efforts have helped an array of clean energy technologies become more cost competitive and more widely integrated into the electrical power system. Expanding this integration introduces new challenges for the operation of the U.S. power system that will require the development and deployment of new tools and technologies to ensure the electrical power system continues to operate in a safe, reliable, and cost-effective manner.[32] However, it also provides new opportunities to transform our grid into a platform for cleaner energy, greater prosperity, growth, and innovation.

EERE's grid integration activities focus on the seamless integration of energy efficiency, renewable power, and sustainable transportation technologies into the electrical power system. Clean energy technologies connect through the grid and form power systems at a variety of physical scales, from individual buildings to distribution systems to regional systems that can stretch across continents. Interactions and interdependencies are increasing within and among power system infrastructures and other interrelated systems such as communications networks. These interactions can have profound implications for the reliability and security of the energy system.

The suite of technologies and techniques required for successful grid integration includes improved renewable power forecasting; energy storage technologies; advanced power electronics; "grid responsive" building technologies; vehicle-to-grid technologies; and new grid sensing, control, and operations approaches. Furthermore, close engagement and collaboration with and among industry, regulators, and other stakeholders are needed to develop and deploy the standardized communication and control protocols that enable these devices to successfully interface and interact, enabling grid operations at the lowest cost possible while maintaining or improving grid reliability.

Success Indicators

1. By 2020, develop and demonstrate at scale the technologies and tools required to enable distributed energy resources to supply up to 50% of the electricity, on average, across a distribution system while maintaining a safe, reliable, and cost-effective power system.
2. By 2035, enable up to 35% of the nation's electricity to come from variable generation while maintaining a safe, reliable, and cost-effective power system.
3. By 2035, develop the technologies and tools for active devices including smart building loads, electric vehicles, and distributed generation to provide 10% of the nation's flexibility needs.
4. Provide to regulators, policy makers, and other stakeholders the technologies, tools, and technical assistance necessary to accelerate the establishment of policies, markets, and other institutions needed to achieve the Nation's goals.

To foster this collaboration and accelerate progress towards our Nation's energy goals, DOE has developed the Grid Modernization Initiative (GMI), a strategic partnership between the DOE and its National Laboratories. The Initiative defines an integrated approach by DOE and the National Laboratories to ensure that DOE-funded studies and research activities, across multiple DOE Offices and national laboratories, are appropriately integrated and efficiently coordinated to deliver on the outcomes described in the DOE Grid Modernization Multi-Year Program Plan (MYPP) currently under development. EERE has identified several critical challenges that, working as part of the GMI, can specifically address over the next five years to enable clean energy technologies to be successfully deployed and contribute to our nation's climate and energy goals.

[32] See *glossary of transmission grid integration* terms for common terms and concepts.

Device Development and Integrated Systems Testing

Develop Advanced Power Electronic Interfaces, Energy Storage Systems, Controllable Loads, and Other Grid Devices

Proper operation of clean energy technologies (wind and solar generators, demand managed buildings, advanced vehicles, fuel cells, etc.) connected to the grid requires a new generation of supporting technologies that can ensure and enhance reliable and safe operation, while also providing new services. Supporting technologies include advanced power electronic inverters for wind turbines and solar PV systems that allow for real and reactive power control, providing critical load control functionality. EERE will pursue these technologies as well as communication and control technologies that further enhance device performance and grid operations and fully evaluate these in integrated system configurations. Under this activity, EERE will also investigate the use of energy storage technologies–both in standalone configurations as well as part of EVs–to enable grid systems to host more clean energy technologies and provide a variety of enhanced grid services.

Develop Standards and Test Procedures for Interconnection, Interoperability, and Devices

Standards, evaluation metrics, methodologies, and other criteria for testing the grid interaction characteristics of clean energy technologies and integrated systems are essential to ensure their optimal and safe integration into a modern grid. As new devices and systems continue to be integrated into the grid at multiple scales from both sides of the utility meter, these standards and test procedures will form the basis for a collective understanding and evaluation of performance expectations. This activity works with standards development organizations (SDOs) to accelerate the development and validation of standards and test procedures for operational characterization of devices, including their grid interconnection, interoperability, performance, and safety. SDOs typically use a consensus-based process to develop these kinds of procedures. National Laboratories can provide an independent party to develop and assess the procedures prior to publication and use with certification agencies. Currently there is a need to accelerate updates to existing interconnection and interoperability standards and to develop new standards that define grid services and provide standardized performance metrics in response to a new generation of technologies and business models.

Demonstrate Multi-Scale Systems Integration

This activity seeks to ensure that integrated systems (devices, sensors, communications, and control systems brought together) are capable of effectively connecting, communicating, and operating in a coordinated fashion that maintains the desired grid results across a range of physical scales (buildings, campus, microgrids, distribution, and transmission) and stakeholders. This activity provides clarity to research efforts and stakeholder groups so they can effectively address existing technology gaps and adopt new innovations as they become available.

Sensing and Measurement

Develop a New Generation of Sensors and Communications Protocols for Distributed Assets

As distributed energy systems become more complex, measurement and monitoring of those systems will be needed on increasingly shorter response times and smaller scales. EERE will foster the development of a new generation of grid-connected sensors and control devices that will increase system visibility and allow more rapid assessment of grid health in real time, better prediction of grid behavior and needs, and more effective response to abnormal events. These sensors and devices will use open, standards-based communications protocols with flexibility to accommodate ongoing technology advances and changing market structures. EERE will also work with its partners to develop methods to manage data exchange and processing to minimize impacts of distributed energy systems on grid operations. This will allow system operators to engage, manage, and control a range of distributed assets, providing reliable, low cost grid services while synchronizing the operation of potentially billions of grid-connected devices.

Develop Common Data Standards, Models, and Controls to Enable Buildings Technologies to Provide Grid Services

A major barrier to the effective integration of distributed clean energy technologies in buildings is the lack of common data, communications, and control standards for equipment from different manufacturers. As more information becomes available to building owners, utilities, and other stakeholders, the ability to manage this data, perform the appropriate analysis, and then take proper action will be critical. To address these needs, EERE will focus on developing advanced analytical models and tools to accurately diagnose and predict vital component and system behavior, controls in operation and management of building assets, and two-way communication technologies and interoperability standards for building appliances and equipment.

Improve Capability to Forecast Changes in Clean Energy Generation and Consumption

Successfully addressing the intra-hour variability and steep ramps in the net load from growing amounts of variable renewable power sources on the grid will require both better predictability of their power output and greater system flexibility. To address these issues, EERE will work to increase the accuracy of renewable power forecasting, demonstrate enhanced forecasting capabilities in real-world applications, and incorporate these approaches into system operations. In addition, EERE will develop new approaches and predictive tools to improve real-time forecasting and control of the main commercial, industrial and residential building loads in a way that provides important grid services.

System Operations, Power Flow, and Control

Enable Multiple Clean Energy Assets to Be Holistically Controlled at the Distribution Level

The sudden, rapid, and simultaneous response of dispatchable distributed assets, such as energy storage, stationary fuel cells, electric vehicles (EVs), and demand response—such as in response to a pricing signal—could result in adverse impacts to distribution circuits. To mitigate these potential impacts, EERE will develop advanced distribution system controls that incorporate high levels of variable renewables and controllable loads into voltage management and protection systems. EERE will also develop operational models and tools for distribution system operators that will provide better visibility into current and forecasted output levels, and that reflect and account for the uncertainty and variability of distributed renewable power resources.

Develop Building Management Systems That Can Coordinate Multiple Distributed Assets

For buildings to simultaneously accommodate clean energy technologies that operate reliably and cooperatively and provide value to building owners and service providers, tools must be available to continuously manage and optimize these resources and assets. EERE will focus on developing decision-support tools that can help both building owners/operators and load serving entities reduce costs and realize benefits. In addition, EERE will focus on developing control applications that will enable the response of a wide variety of customer assets for grid services—which range from peak load management to ancillary services—without compromising the energy efficiency of the devices and systems involved.

Design and Planning Tools

Develop Tools to Better Integrate Clean Technologies into a More Dynamic Grid

EERE will expand on its existing suite of modeling and simulation tools to enable those tools to handle emerging needs driven by changing technologies and operational capabilities, larger and more complex models, more challenging forecasting, and new types and sources of data. For example, to help regional load-serving entities and independent system operators successfully manage the variability and uncertainty associated with variable generation, EERE will support the development of new transmission, generation, and resource planning tools based on natively stochastic methods that more accurately represent the variability of wind and solar technologies. As distributed energy systems become more prominent, EERE will lead development of a new class of interconnected design and planning tools that can assess simultaneously the optimal operation of individual devices, buildings, distribution systems, and bulk power operations taking into account a variety of market and operational conditions.

Security and Resilience

Ensure the Native Security and Resilience of Clean Energy Devices

The potential introduction of billions of connected clean energy devices provides risks and opportunities for security and resilience of the grid systems those devices are connected to. EERE will work with the existing cyber security programs in the Office of Electricity Delivery and Energy Reliability to ensure that intrusion protections are inherent in the manufacture of clean energy.

Institutional Support

Investigate Market Mechanisms for Efficient Operation of Clean Energy and Conventional Generation Technologies

The introduction of variable generation into the grid is fundamentally changing system operations by dramatically altering the net load profile of the grid, presenting new opportunities and challenges to develop optimal bulk power system services, markets, and rules. EERE will investigate market mechanisms that allow for the value of distributed generation and controllable loads to be recognized at all scales. At the same time, EERE will develop analysis methods and tools for bulk power system markets to ensure that the value of conventional generation can remain financially viable.

Investigate New Business Models for Grid Operators and Consumers

To successfully achieve national energy goals, regional electricity stakeholders will need new ways to provide revenue recovery for distribution utility investments and operations, while also enabling the installation and interconnection of more distributed power technologies. EERE will work with regional electricity stakeholders to develop independent analytical capabilities to inform new business models and regulatory approaches. EERE will also provide analysis related to retail rate recovery and revenue stream implications for upgrades to the distribution system that may be required to accommodate higher penetration of distributed assets.

Similarly, new platforms such as smart buildings with advanced sensors and controls have the potential to reward building owners and users for investing in assets with the ability to help integrate clean energy and improve the reliability of the system. To fully capture this potential, EERE will investigate new market and business models—integrating energy supply, demand, and related building services—that provide new avenues and incentives for consumer participation in clean energy. One potential model is that of transaction-based energy services, which make use of grid-responsive building assets to improve system reliability, while ensuring optimal outcomes for all parties based on pre-defined boundaries.

Goal 6: Lead Efforts to Improve Federal Sustainability and Implementation of Clean Energy Solutions

As America's largest energy consumer, the federal government has a tremendous opportunity and an acknowledged responsibility to lead by example in cutting energy waste and advancing America's clean energy future. With more than 500,000 buildings and a large vehicle fleet, the federal government can serve as a model for successful approaches, stimulate private markets, and make a significant contribution to our national energy goals. EERE provides guidance, tools, trainings, and technical assistance to all federal agencies—in addition to leading DOE's own efforts—in meeting the federal government's aggressive national clean energy and sustainability goals.

Federal energy use is significant. In 2014, the federal government used 1.4 quads of energy (1.4% of total U.S. energy use) at a cost of $23 billion. Federal GHG emissions in 2014 totaled 82 million metric tons (1.2% of the nation's total). Buildings and facilities represent about one-third of these totals, with vehicles and equipment accounting for the other two-thirds. DOE accounts for about 3% of these totals.[33]

Success Indicators

1. By 2025, facilitate the reduction of scope 1 and 2 greenhouse gas emissions from federal facilities by 40%, compared to a 2008 baseline.
2. By 2025, facilitate the use of renewable energy to meet 25% of federal electricity needs.
3. By 2020, reduce greenhouse gas emissions from the DOE complex by 28% and meet other sustainability goals, compared to a 2008 baseline.

The federal government is pursuing—and making substantial progress toward—a number of challenging national energy and sustainability goals established through Executive Orders and legislation. Meeting the following goals offers federal energy and water cost savings to the taxpayer of approximately $18 billion by 2025:[34]

- Reduce GHG emissions from the federal government by 40% by 2025, compared to 2008.
- Ensure 25 percent of total energy (electric and thermal) consumption is from clean energy sources by 2025.
- Reduce energy use in Federal buildings by 2.5 percent per year between 2015 and 2025.
- Reduce per-mile GHG emissions from Federal fleets by 30 percent from 2014 levels by 2025, and increase the percentage of zero emission and plug in hybrid vehicles in Federal fleets.
- Reduce water intensity in Federal buildings by 2 percent per year through 2025.[35]

The federal government employs leading policies and programs in the pursuit of these goals, including building new federal facilities to high performance levels; engaging in performance contracting and power purchase agreements to leverage third-party expertise and financing; testing, verifying, and procuring high-efficiency products; increasing on-site renewable power; procuring alternative fuel-capable vehicles; establishing metering in support of whole-building benchmarking and improved energy management; and making information on building energy use publicly available. Through these approaches, federal agencies demonstrate what works; help provide commercialization pathways for new technologies; accelerate the penetration of new technologies, tools, and practices into broader commercial markets; and save taxpayers money.

EERE plays a central role in helping federal agencies achieve these goals and lead by example through four key strategies.

[33] Federal Comprehensive Annual Energy Performance Data, 2014, FEMP website.
[34] *White House Fact Sheet on EO 13693*, 2015.
[35] *Executive Order 13693*, Federal Leadership on Climate Change and Environmental Sustainability, 2015.

Assist Federal Agencies in Meeting Energy and Sustainability Goals

EERE will continue to support all federal agencies in pursuit of statutorily required and Executive Order goals for energy and sustainability by providing guidance, tools, training, and other assistance, and will provide annual reports to Congress on the progress of the federal government toward these goals. Areas of emphasis will include:

- Engaging a broad array of public and private sector stakeholders in the collaborative development of federal goals, policies, and guidance that will maintain the leadership of the federal government
- Providing accredited training (Web-based and in-person) to address the essential core capabilities—identified in partnership with the federal community—that agencies need for energy, water, and GHG management excellence
- Using government awards and other efforts to recognize and share successes in best-in-class facilities, programs, and teamwork
- Developing centers of expertise to address specific clean energy technical challenges facing federal agencies, as well as public and private sector organizations broadly.

Improve Federal Agency Access to Third-Party Financing

EERE will place a particular emphasis on facilitating the use of performance contracting to help federal agencies meet their sustainability goals, including by improving processes and procedures to shorten project development timeframes and reduce transaction costs. Through performance contracting, the upfront capital costs of facility improvements are provided by a third party that is repaid using a portion of the savings from the agency's energy bills, thus reducing the need for direct appropriations. Since 1999, federal agencies have entered into $5 billion in performance contracts and EERE estimates that continued performance contracting investments of approximately $1 billion per year will be required in order for the federal government to achieve the national federal sustainability goals that have been established by Congress by statute and by the President by Executive Order.[36]

In May 2014, President Obama challenged agencies to invest $4 billion through Energy Savings Performance Contracts (ESPCs) by the end of 2016.[37] EERE's Federal Energy Management Program (FEMP) supports the agencies in achieving this goal. FEMP's support will include helping Federal agencies develop ESPC projects and access contractors qualified under DOE's ESPC federal contracting vehicle. Since 1999, about 62% of federal ESPC awards have been made using this contracting approach. Additional EERE support will include increased agency use of Utility Energy Service Contracts,[38] and exploration of innovative new approaches for financing energy-efficient and renewable energy technology installations. EERE will establish and continually update a database of performance-based projects, which will house federal and non-federal projects and improve the consistency in performance contracting across federal and non-federal markets—helping to standardize processes and reduce transaction costs.

[36] Federal Facility Efficiency Investment and Progress toward Sustainability Goals, DOE, 2013.

[37] The initial goal, set in 2011, was to invest $2 billion in ESPCs by 2013. The new goal of $4 billion in contracts is cumulative.

[38] See *Utility Energy Service Contracts*.

Enable Federal Agencies to Be Early Leaders in Testing, Validating, and Deploying Advanced Clean Energy Technologies, Tools, and Practices

EERE will work with all federal agencies to identify their energy needs and potential pathways for moving technologies out of the laboratory and into the commercial market. Federal buildings, facilities, and installations can often host individual technology demonstrations and larger systems demonstrations, while vehicle fleets can utilize alternative fuels, infrastructure, and improved management tools. EERE will continue to work with technology developers and federal agencies to create mutually beneficial partnerships that demonstrate replicable solutions and help agencies achieve their goals. For example, the U.S. Department of Defense (DOD) and DOE entered into a Memorandum of Understanding in July 2010, with one of the thrusts being for DOE to help identify, develop and deploy DOD energy efficiency, renewable energy, and transportation technologies in installations and field operations. DOD alone spent $19.3 billion on energy in FY 2011 and allocated $2.7 billion to energy improvements in FY 2013. EERE is also working with NASA, GSA, and DOD—including specific efforts with the Navy, Army, and Air Force—to create a consistent approach to validate vendor claims on the energy efficiency and other performance characteristics of a variety of technologies and to share the results of technology demonstrations (e.g., GSA's Green Proving Ground).

Collaborate With Multiple Partners across Sectors to Develop, Test, and Implement Effective Energy Management Practices and Systematic Energy Technology Deployment

EERE will work with states, municipal governments, universities, hospitals, schools, and the private sector to share federal advances and learn from them as they utilize technologies, practices, and tools. This effort will emphasize the following:

- Performance contracting for energy efficiency and renewable energy
- Energy management excellence
- High-performance buildings and technologies
- Procurement strategies and policies
- Distributed generation and energy resiliency
- Fleet alternative fuel coordination.

Key initiatives that will help disseminate the federal advances include the Better Buildings Challenge and Accelerators, the Combined Heat and Power Technical Assistance Partnerships, and the Federal Energy Management Program's Centers of Expertise. Through these efforts, EERE will look to improve consistency and reduce the costs of these projects across all markets. Furthermore, EERE will work to ensure federal tools, practices, and training can translate into benefits for non-federal applications.

Goal 7: Enable a High-Performing, Results-Driven Culture through Effective Management Approaches and Processes

To deliver on EERE's mission to create and sustain American leadership in the transition to a global clean energy economy, EERE will continue to invest in its people and processes. Building on early progress of a recently-initiated set of multi-year organizational reforms, EERE will continue its efforts to build a government-leading culture of operational excellence critical to return the greatest value to the U.S. taxpayer.

Success Indicators

1. By 2017, each EERE Technology Office has completed an updated Multi-Year Program Plan.
2. Perform at least two new EERE impact evaluation studies each year.
3. For the "Best Places to Work" component of the Federal Employee Viewpoint Survey, increase average EERE scores by 10 percentage points by 2017 and 20 percentage points by 2020 relative to 2014 baseline.
4. By 2017, 100% of applicable EERE projects will submit quarterly reports and receive formal EERE quarterly assessments through a single information technology portal.
5. Starting in 2017, approve all National Laboratory Annual Operating Plans prior to the fiscal year.
6. By 2017, launch at least two new programs to increase technology transfer from EERE's investments at DOE's National Laboratories.

Support and Invest in EERE's Talented People and Partners

Further Enhance and Maintain EERE's Highly Skilled, Diverse, and Productive Workforce

To maximize its mission impact, EERE must recruit, retain, and further develop a workforce with world-class talent and capabilities. As EERE competes with other organizations for top scientists, engineers, information technology specialists, operational specialists, and other disciplines, it must be proactive to become and remain an "employer of choice" to attract the best talent. To this end, EERE will more aggressively recruit highly qualified and diverse individuals from within and outside the government, with highly relevant federal, industry, and technology expertise, and provide significant career development opportunities for existing employees to achieve and maintain world-class relevant expertise. To better inform our workforce development efforts, EERE will place greater emphasis on using tools and analytics to ensure proper career planning, training, workforce balancing, succession planning, and employee recognition programs. This will enable the organization to better assess, anticipate, and estimate current and future needs to ensure that its workforce is flexible and equipped to make EERE a leading organization in transitioning the nation to a clean energy economy.

Enable a Tight-Knit Community of Open Communication, Collaboration, Mutual Respect, and Debate

EERE aims to improve the communication and collaboration between EERE senior leadership and staff to more effectively generate, evaluate, and execute new program concepts and operational improvements by actively supporting activities that encourage the development of trust, respect, and open dialogue within the organization, including:

- Clear, timely, and regular communication of priorities and priority initiatives throughout the enterprise, with consistent follow up
- Meaningful regular feedback and idea-generation mechanisms for small group engagement with senior leadership
- Frequent and well-planned cross-office convenings of leaders and staff in similar technology and operational functions, as well as continued support of a range of organically formed communities of practice

- Purposeful, mission-driven, periodic convenings and seminars to facilitate intellectual engagement, discussion, and debate among EERE staff through open brainstorming, idea generation, and debate sessions, including with key external partners
- The creation of regular, informal forums for interaction among EERE leadership and staff to reinforce a culture of trust, mutual respect, and debate, and to enable the building and maintaining of stronger personal and working relationships.

Formalize the Principles and Strategies That Define Our National Laboratory Partnerships

The intellectual and physical capabilities of the DOE national laboratories provide U.S. industries with a unique competitive advantage in the global clean energy economy, offering a wealth of world-class scientific capabilities and facilities to assist in R&D, testing, and scaleup of new technologies. Over the last two years, EERE has worked with national laboratory leadership to establish a more strategic partnership in stewarding national laboratory capabilities and in delivering greater market impact on energy, security, economic, and environmental challenges facing the United States. The foundation for this partnership is the **EERE-National Laboratory Guiding Principles**,[39] which is designed to foster greater innovation, promote entrepreneurship, and maximize market impact. Four core principles guide interactions between the U.S. Department of Energy's (DOE's) Office of Energy Efficiency and Renewable Energy (EERE) and DOE's National Laboratories: (1) World-Class Science and Technology; (2) Long-Term Commitment and Stewardship; (3) Mutual Respect and Accountability; and (4) Industry and Market Impact.

EERE will make it easier for national laboratories to work across EERE, building on recent improvements in EERE's national laboratory annual operating plan process, and will continue its work to put uniform, consistent processes in place while maintaining flexibility to continually innovate and develop new best practices. EERE will identify and steward core capabilities at the national laboratories so laboratories can make the long-term investments needed to address our nation's major energy problems. Working closely with the national laboratories, outside stakeholders, and other parts of DOE, EERE will develop innovative new programs and policies that will significantly increase the amount of successful engagement between the national laboratories and U.S. industry and increase the contributions of the national laboratories to U.S. industrial competitiveness in the clean energy sector.

Establish, Update, and Share Clear Plans and Processes to Deliver on EERE's Mission

Ensure EERE's Program Planning, Prioritization Methodologies, and Review Approaches Are Uniform, Clear, and Transparent to our Stakeholders

EERE develops its investment priorities using rigorous analytical approaches that are guided by EERE's Five Core Questions (see p.5). EERE will continue to clearly articulate and communicate its plans and program priorities, internally and externally through regular updates to this EERE Strategic Plan and to EERE technology office Multi-Year Program Plans (MYPPs). MYPP activities and priorities will flow from the EERE Strategic Plan and will clearly and transparently describe each EERE technology office's goals, priority multi-year programs, roadmaps, and prioritization methodologies. The development of these priorities and approaches will be informed by extensive stakeholder engagement, such as through regular external workshops and expert peer reviews of our technology office portfolios. By ensuring a process of regular updates to major EERE plans and engaging in rigorous dialogue with national laboratory experts and other stakeholders, EERE will move into highly promising new program areas and terminate programmatic thrusts that are no longer highly relevant or impactful.

[39] See the full *National Laboratory Guiding Principles* document for more information.

Conduct Rigorous Technology Tracking and Program Impact Evaluations of EERE's Portfolio

EERE will continue to expand the application of its current standardized approach to performance and evaluation assessment, increasingly involving more comprehensive quantification and evaluation of EERE's contributions in creating and diffusing knowledge, speeding commercialization of clean energy technologies, increasing market share, and reducing energy use and carbon pollution. Furthermore, EERE will seek to implement a project-level impact tracking process across its portfolio going forward, improve its capabilities to track and evaluate its projects throughout their life cycle and out to where market impacts occur. At the same time, EERE will continue to put in place improved data collection processes to support this tracking, in order to enable more routine and transparent analysis and reporting on these metrics over the next several years.

Adopt Active Project Management Approaches to Enhance EERE's Stewardship of Project Portfolios

To be an effective steward of taxpayer dollars and produce the highest impact from its investments, EERE will continue to enhance its project portfolio oversight approach, called Active Project Management, inspired by best practices developed at the Defense Advanced Research Projects Agency and DOE's Advanced Research Projects Agency–Energy. EERE has begun to execute this approach, which provides clearer accountability regarding roles and responsibilities in project execution, enhanced project management standard operating procedures, uniform guidance on project objectives for each project, and project deliverables clearly oriented toward impact in the energy marketplace. EERE will also more actively assist its project performers in reaching success and will empower and encourage its technology managers to terminate projects that fail to reach key go, no-go milestones and are unlikely to deliver continued value to the taxpayer, to reallocate funds to efforts with higher potential for success.

Establish Uniform, Efficient, and Effective Business Processes

To achieve its mission more efficiently and effectively, EERE's technology offices and their external performer community need processes and functions that are oriented toward customer service. EERE will develop more formalized standard operating procedure documentation, developed in consultation with EERE leadership and staff, for all key EERE business processes and will provide associated standard operating procedure training in key planning and execution areas such as EERE's funding opportunity process, national laboratory management, program and project management, risk management, and financial management.

Conclusion

EERE is tackling what we believe is the greatest challenge and opportunity of the 21st century: developing and delivering affordable clean technology to transform the world's energy system and avoid the full impacts of global climate change. But it will take the coordinated work of EERE employees, our partners at the national laboratories, and our stakeholders to turn that vision to reality.

We stand at the cusp of a clean energy revolution, thanks in large part to highly successful past investments made by EERE into clean energy technology development. With steady and strategic EERE investments in cutting-edge RD&D in the years ahead, a rapidly growing array of clean energy technologies will become cost-competitive and will be deployed in growing numbers across the globe, while enabling the United States to emerge as the global leader in the transition to a clean energy economy.

This Strategic Plan provides the necessary framework for responding to the global challenge of climate change and ensuring that the U.S. is a global leader in the clean energy economy. Over the next five years, EERE will make the strategic investments in the innovation and creativity of our nation's scientists, engineers, entrepreneurs, and industry leaders to fulfill this vision while working to enhance U.S. energy productivity and competitiveness. The result will be energy solutions that make America more prosperous and secure and our energy systems cleaner and more affordable.

Front cover photos (top): iStock 24304597; Dennis Schroeder, NREL 20040; Dennis Schroeder, NREL 27196.
Page 1 photo from U.S. Department of Energy. Back cover photos from U.S. Department of Energy.


Dedicated to EERE employees and our colleagues in the national laboratories.

EERE's Values – IMPACT

I: INNOVATION

Innovation is at our core. We take smart risks.

M: MISSION

Our clean energy mission is critical. We must stay laser-focused.

P: PEOPLE

Our people are our greatest asset. We invest in our people and work environment to make EERE a great place to work.

A: ACCOUNTABILITY, STEWARDSHIP & EFFICIENT OPERATIONS

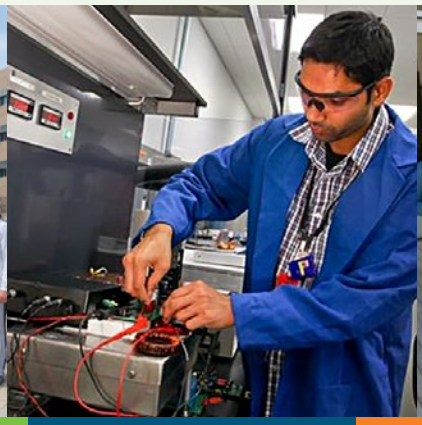
We are accountable to each other and we are good stewards of taxpayer investments. Efficient operations allow us to maximize time and effort on our clean energy mission.

C: COMMUNICATION & ENGAGEMENT

We foster open communication and engagement all across EERE.

T: TEAMWORK & RESPECT

The effectiveness of our community relies on teamwork, respect, and open debate.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