Energy & Infrastructure Program

Energy Project

America's Energy Resurgence:
Sustaining Success, Confronting Challenges

A Report from the Bipartisan Policy Center's Strategic Energy Policy Initiative | February 2013

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Executive Summary

As the United States struggles to emerge from a historic recession, energy has emerged as both a bright spot and a source of ongoing challenges for the nation's long-term prosperity and security. On the one hand, when adjusted for economic growth and inflation, the United States has cut its energy needs by more than 50 percent since 1973, and the trend shows no signs of slowing. Treating this 40-year reduction as the equivalent of new energy supply, the resulting resource is significantly larger than the expansion of output from all other energy resources combined over the same period. In addition, there have been major positive developments on the supply side: Domestic oil, natural gas, and renewable energy production are up, while energy imports are down; new energy development is driving a jobs boom in many parts of the country; and lower energy costs are helping the U.S. manufacturing sector recover.

The combination of these trends means that the nation is arguably more energy secure than it has been in more than a generation. But the news is not all good: Affordable energy is still a challenge for many households and businesses; the oil and gas boom comes with environmental challenges; the electric grid faces hurdles in upgrading infrastructure and integrating new renewable sources; public research and development (R&D) in energy is insufficient to maintain an international competitive edge; and the issues of climate change, global energy market volatility, and competition for energy resources by countries with growing economies remain.

The Strategic Energy Policy Initiative, a project of the Bipartisan Policy Center (BPC) and led by a diverse 20-member Energy Board, was launched in 2011 to build the bipartisan consensus needed to tackle these challenges in the years ahead. Americans are fortunate: The nation has enormous energy strengths, greatly exceeding those of most industrialized nations. Building on these strengths to deliver affordable, secure, and reliable energy in an environmentally responsible manner is the overarching goal of the recommendations outlined in this report. Specifically, we, the Energy Board, believe U.S. energy policy should be designed to advance four core objectives:

(1) pursue a diverse portfolio of energy resources;

(2) improve the energy productivity of the U.S. economy;

(3) accelerate innovation and technology improvements across the energy sector;

(4) improve energy policy governance and accountability.[1]

It is important to emphasize at the outset that the actions we propose in each of these areas should be viewed as a package—no single Energy Board member necessarily agrees with each individual recommendation in isolation. Taken together, however, we believe this set of recommendations provides the blueprint for a balanced and effective plan for enhancing the nation's prosperity, energy security, and sustainable environmental quality in the 21st century.

A critical energy and environmental policy issue is whether the United States should adopt a comprehensive climate change policy to reduce greenhouse gas emissions. We agree that climate change is a significant issue and addressing it can and should be a matter of bipartisan consensus. It is our view that government policy development and prudent business planning should incorporate cost-effective greenhouse gas emissions reductions, and support market-based efforts to accelerate the integration of low-carbon energy technologies. We call on Congress and the Administration to find a way forward together on responsible and efficient policies to reduce greenhouse gas emissions and to work with other governments in seeking a global approach that both promotes the most cost-effective emissions reductions and addresses the competitiveness issues associated with carbon policy. We look forward to assisting the effort.

America's New Energy Landscape

The United States has long benefited from a diversity of energy resources, including a rich endowment not only of conventional fuels, such as oil, natural gas, and coal, but an abundance of renewable energy from water, wind, solar, and geothermal sources. Equally important, the U.S. has an abundance of the innovative capacity, entrepreneurial energy, and technological know-how needed to continuously improve the energy productivity of the economy. **Indeed, over the last four decades, energy savings achieved through improvements in energy productivity have exceeded the contribution from all new supply resources in meeting America's growing energy needs.** These improvements have also helped to reduce the domestic economy's sensitivity to abrupt energy price increases, particularly oil price shocks. **Our report highlights the importance of treating demand and supply-side resources on an equal footing, from the standpoint of assembling a resource portfolio that can meet the nation's future energy needs as cost-effectively and as environmentally responsibly as possible.**

On the supply side, meanwhile, dramatic developments in the last decade have already produced a major positive shift in the nation's energy position and prospects. The domestic supply outlook for oil and natural gas, in particular, has vastly improved thanks to advances in drilling technology that have made it possible to develop previously inaccessible onshore and offshore resources, including large oil and gas shale plays. Significant progress has also occurred in the renewable energy industry, which responded to state and federal policies by growing at a rapid rate—installed wind energy capacity alone increased 16-fold over the last decade—while driving down cost and improving performance.[2]

Developing America's abundant indigenous energy resources provides multiple benefits: It spurs local and regional economic activity and job creation; generates revenues for federal, state, and local government; opens the door to potential export opportunities while simultaneously allowing the United States to reduce energy imports; increases the amount of global oil and gas supply from stable sources; and spurs technological innovation that benefits long-term U.S. competitiveness. Our recommendations focus on expanding access to, and promoting investments in, America's diverse domestic energy supply resources in environmentally responsible ways, improving the energy productivity of the economy, accelerating energy technology innovation, and overhauling federal energy tax expenditures.

Pursue a Diverse Portfolio of Energy Resources

Maintaining a diverse portfolio of energy resources requires an energy system that relies on a varied mix of fuels and technologies from diverse geographic areas, as well as continued progress in energy efficiency improvements. A diverse system is inherently more robust and resilient than one heavily dependent on a limited number of resources. Such a system helps insulate the U.S. economy from the supply shocks and price volatility that can affect the market for a particular energy resource. Our recommendations below are organized by major energy resources.

Oil and Natural Gas

To expand the production of domestic oil and natural gas resources in a manner that protects the environment and addresses the interests of all stakeholders, we recommend the following:

- **Congress should expand access to oil and gas exploration and production in the Eastern Gulf of Mexico, and the Department of the Interior should accelerate the timetable for leasing areas off the coasts of the Mid- and South Atlantic states—provided that the areas involved have**

been reviewed and approved based on a rigorous coastal and marine spatial planning process. Stakeholders should work together to identify substantial new acreage in the Eastern Gulf that could be opened to exploration and production in concert with other, ongoing activities, and request that Congress remove the moratorium in these areas; in both the Eastern Gulf and the Atlantic region, we recommend an open, collaborative and science-based planning approach, and we recommend that in conjunction with such planning processes, the Department of the Interior consider reopening its current five-year plan to include at least one lease sale in the Atlantic.

- **Working with all stakeholders, Congress and the Department of the Interior should improve permitting and leasing for onshore oil and gas production on federal and tribal lands by (1) assuring adequate resources; (2) providing consistent requirements; (3) creating a new commission to identify options for regulatory reforms; (4) creating more litigation transparency; and (5) improving the collection and dissemination of statistics for energy projects on federal lands.**
- **Federal and state regulators should implement the environmental performance recommendations for shale resource development recently issued by the Natural Gas Subcommittee of the Secretary of Energy Advisory Board and the National Petroleum Council.**

The first of these recommendations is intended to promote responsible development of the significant crude oil and natural gas resources that exist on North America's outer continental shelf (OCS). Offshore oil production in the United States had been on an upward trajectory since 2008, until the 2010 *Deepwater Horizon* disaster in the Gulf of Mexico prompted a temporary moratorium on offshore activities.[3] Production has since resumed, following a lifting of the moratorium and the implementation of significant reforms in the regulatory processes and institutions that govern offshore oil and gas development in the United States. The Department of the Interior (Interior) in particular, has implemented a series of major changes touching on almost every aspect of offshore oil and gas development (including drilling safety, workplace safety, and environmental regulation), while the oil and gas industry has also taken steps to improve the integrity of its offshore operations and enhance its capacity to prevent and respond to accidents. However, the Oil Spill Commission Action (a successor group to the National Oil Spill Commission) issued an April 2012 report noting that much remains to be done to execute the Commission's recommendations, including but not limited to improvements in Interior's regulatory programs, Congressional action to codify key Commission recommendations, implementing a number of specific actions in the context of spill response and containment, and ensuring adequate resources to effectively oversee offshore oil and gas development.[4] Expanding access to selected OCS areas that have previously been off-limits to oil and gas development would provide substantial regional and national economic benefits, provided that risks to important ecological and economic resources can be minimized. To move forward, we recommend that Interior rely on coastal and marine spatial planning processes to promote an open, collaborative, regional, and science-based approach that fully incorporates the views of all stakeholders.

Our second recommendation focuses on the development of onshore resources—specifically, the ability to access oil and gas resources on federal lands. A recent BPC survey of domestic oil and gas producers points to pervasive frustration about the inefficiency of existing leasing and permitting processes for areas administered by the Bureau of Land Management (BLM) and other federal agencies.[5] These frustrations persist despite recent efforts by BLM to introduce reforms to improve some aspects of these processes. In particular, oil and gas producers point to a lack of staff and resources at these agencies and to frequent inconsistencies and redundancies in the interpretation and implementation of federal rules. Together, these factors serve to significantly lengthen permitting lead times, heighten the risk of litigation, and increase project uncertainty. Our recommendations on this issue are intended to improve current leasing and permitting processes in ways that address these shortcomings while remaining responsive both to environmental concerns and to the need to balance multiple uses on federal lands. Specifically, we recommend actions to: (1) ensure that state and federal agencies have adequate resources and staff to effectively and expeditiously discharge their resource management responsibilities; (2) promote clear and consistent requirements, guidance, and timelines; (3) establish a commission or task force at Interior consisting of multiple stakeholders to review options for further regulatory reform; (4) increase litigation transparency; and (5) improve the collection and dissemination of statistics for energy projects on federal lands.

Recognizing that much of the recent growth in domestic oil and gas production has come from the development of newly accessible shale resources, our third recommendation focuses on the drilling technique known as hydraulic fracturing.[6] As hydraulic fracturing activity has expanded, with much of the new drilling occurring on private lands in parts of the country that are less familiar with energy development, environmental concerns, land-use issues, and other challenges have received increased attention from the industry and from state and federal regulators.[7] Along with a number of recent initiatives to define and share industry best practices, recommendations developed by the Natural Gas Subcommittee of the Secretary of Energy Advisory Board and the National Petroleum Council provide a useful foundation for future efforts to improve safety and mitigate community and environmental impacts from shale gas development.[8] These recommendations address a range of issues—including best practices, transparency and disclosure, air emissions, groundwater protection, and regulatory resources—and should be implemented expeditiously.

Coal

As America's most abundant fossil fuel resource, coal has played a large role in the nation's energy portfolio for well over a century.[9] Coal is expected to maintain a significant role in providing reliable and affordable power to serve the U.S. market, but the industry faces clear challenges in the decades ahead, including low natural gas prices, which are already prompting a shift to gas in the dispatch of existing generators and in building new capacity; new environmental regulations; and the prospect of longer-term carbon constraints.[10] Our recommendation aims to accelerate progress on innovations that allow for cost-effective capture, utilization, and storage of carbon:

- **The Department of Energy should continue public-private efforts to develop and demonstrate cost-effective, commercial-scale technologies for carbon capture, utilization, and storage and should begin developing a comprehensive, integrated legal and regulatory framework to govern long-term carbon storage.**

We believe that resources for carbon capture and storage (CCS) technologies should be balanced between basic research, product/process development, and demonstrations that fully integrate the technology. Furthermore, resources should be directed to those technologies that (1) show promise for reducing the extra increment of energy and costs associated with capturing carbon dioxide on an ongoing basis and/or (2) can be applied to multiple types of fossil fuel–based electricity generation. Widespread cost-effective deployment of CCS will depend on the development of a comprehensive legal framework to address liability of storage. Working with states, industry, environmental organizations, and other stakeholders, the Environmental Protection Agency (EPA) and the Department of Energy (DOE) should take the lead to create a comprehensive, integrated legal framework specifically directed at defining and allocating long-term liability for carbon dioxide storage.

Energy Exports

Increases in domestic energy production coupled with reductions in demand will result in decreased dependence on net imports of energy. With certain fuels, the changing dynamics of increasing production and decreasing consumption can result in a new opportunity for net exports. Although the United States already exports many domestically produced fuels to some extent, the rapidly changing dynamics for some fuels have raised controversy over the potential for increasing energy exports. While controversy has surrounded other exports, primarily those with potential national security implications, the policy solution rarely has been to abandon completely the nation's traditional commitment to free trade, as reflected in our recommendation on energy exports:

- **Restricting international trade in fossil fuels is not an effective policy to reduce global greenhouse gas emissions or to advance domestic economic interests, and we recommend against any such restrictions.**

Domestic production of natural gas has been increasing more rapidly than natural gas demand. Expectations of liquefied natural gas (LNG) imports have given way to discussions of LNG exports. However, this new interest in exporting LNG has raised serious concerns among a number of analysts and policy makers who remember well the high natural gas prices of the 2000s and who worry that exports will drive up domestic natural gas prices. After reviewing several recent studies on the impacts of LNG exports,[11] we concluded that LNG exports are likely to have only modest impacts on domestic natural gas prices—LNG exports will adjust as domestic prices rise or fall. Moreover, abundant low-cost supplies abroad (particularly from Qatar) and the significant costs of liquefaction and transport from the United States will constrain U.S. export volumes. As long as state and federal regulators—along with both industry and stakeholders—continue to make strides to mitigate the environmental impacts of shale gas production, the federal government should allow LNG exports.

Our recommendation also addresses the controversy that has arisen in connection with several proposals to build new bulk commodity export terminals that plan to export coal. Opposition to these proposals has been motivated by a combination of local concerns, including the potential for adverse impacts in terms of traffic, air quality, coal dust, and marine pollution.[12] However, the current rigorous permitting process can provide ample opportunity to identify and address local environmental concerns linked to the construction and operation of new export facilities in the United States. Some of the opposition, however, is also motivated by a broader set of concerns, notably the idea that expanded U.S. exports would open the door to increased coal use in China and other growing markets and in turn lead to an increase in net global emissions of carbon dioxide. (Another concern is global emissions of mercury, which can be transported long distances in the atmosphere.) Recent analyses have come to different conclusions about the net effect of U.S. coal exports on international coal prices and global greenhouse gas emissions.[13] Given the magnitude of global coal reserves relative to international demand, it is our view that U.S. coal exports would have only a minor influence on the global coal market, and that other countries will fill the gap if U.S. exports are limited. More importantly, we do not believe that impeding the global trade of fossil fuels is an effective or efficient means of reducing global greenhouse gas emissions.

Renewable Electricity Production

Wind, solar, biomass, and other non-hydroelectric renewable energy technologies have made remarkable gains in a few short years, roughly doubling their contribution to the nation's overall electricity supply portfolio—from 2.5 percent of generation to nearly 5 percent of generation—between 2007 and 2011.[14] This expansion has been possible as a result of falling production costs and supportive state and federal policies—notably the federal production tax credit and state renewable portfolio standards, which typically require utilities to include a minimum percentage of renewable energy in their supply portfolio.[15] Currently, 29 states and the District of Columbia have renewable or alternative energy portfolio standards, and many states as well as the federal government provide tax incentives for renewable energy development.[16] Nonetheless, technological, financing, and siting challenges remain. Our recommendations for expanding renewable electricity production focus on three areas (recommendations concerning the renewable energy production tax credit are covered in a later section, as part of a broader discussion of financial incentives in the energy arena):

- **The Department of the Interior and other federal agencies should continue to fully fund and implement reforms initiated over the past few years for approving renewable energy projects on federal lands as expeditiously as possible.**
- **The Department of Defense should continue efforts and initiatives to achieve greater energy efficiency and harness renewable and alternative energy investments in direct support of its national security mission.**
- **Electric-sector regulators and stakeholders should identify and implement strategies to modernize the grid and enable investment in necessary transmission and non-wires solutions in order to more efficiently integrate renewables into the electric power system.**

Our first recommendation is prompted by a dramatic upsurge in interest over recent years in siting renewable energy facilities on federal lands. Prior to 2009, the federal government awarded right-of-ways on these lands for 1,508 megawatts of renewable generating capacity; since 2009, right-of-ways were granted to projects totaling more than 10,000 megawatts.[17] At the current pace of project approvals and construction, Interior is on pace to meet and exceed the goal of hosting 10,000 megawatts of renewable energy projects on federal lands by 2015.[18] Meanwhile, Interior has also implemented numerous reforms to its siting and permitting processes for renewable energy projects on federal lands (these processes currently differ for varying technologies), and Interior should continue to fund and implement these reforms.[19]

Our second recommendation centers on the role of the Department of Defense (DOD), which accounts for more than half of the federal government's overall electricity consumption. Even before the 2007 National Defense Authorization Act codified the goal of producing or procuring 25 percent of the military's total facility energy use from renewables by 2025, DOD had been working to increase its use of renewable energy and alternative fuel resources as a way to promote self-sufficiency, improve service reliability for military bases, reduce energy costs, and help manage increasing operational energy demands from battery-powered devices and equipment, and reduce operational vulnerabilities.[20] We support DOD's efforts to achieve greater energy efficiency and harness renewable and alternative energy investments and solutions that are supportive of its national security roles and missions.

More broadly, critical longer-term challenges for the renewable energy industry include the need for new transmission infrastructure to connect promising renewable energy sites with population centers, technology improvements to address cost and grid integration issues, and better grid management techniques and energy storage options so that intermittent renewable resources can help meet demand during all hours. As more renewable generators come on line, infrastructure and grid-integration challenges will become more important as issues that have the potential to constrain the industry's future growth unless they are adequately addressed. Specific policy priorities should be: (1) the construction, where cost-effective, of long-distance transmission lines to connect remotely located renewables to load centers; (2) market access for cost-effective, non-wire alternatives such as demand response and distributed generation; (3) research and development targeted at reducing the costs and improving the capacities of energy storage technologies; and (4) pursuing planning and coordination processes within and across jurisdictions.[21]

Energy-Sector Workforce Needs

All key energy sectors and their stakeholders, including the oil and gas industry, the electric power sector, and the renewable energy and energy efficiency industries, require a highly skilled, well-trained workforce to deliver clean, reliable, and affordable energy to the U.S. economy. Many sectors will face significant workforce challenges due to a rapidly aging employee pool and high future demand for qualified workers. Congress, the executive branch, and stakeholders in industry and academia should cooperate to ensure that these workforce challenges are met and that the proper institutions and systems are put in place to achieve them. We support several specific actions to help prepare for future workforce needs in the U.S. energy sector.

- **Congress should direct the Department of Energy and the Department of Labor to work with states to evaluate training needs and facilitate multi-stakeholder energy-sector training programs.**
- **Congress should appropriate funds and direct the Department of Energy, the Department of Labor, and the Department of Education to improve existing systems for collecting, managing, and disseminating workforce and educational data.**
- **Congress should appropriate funds and direct the Department of Labor to identify training standards and best practices for energy-sector jobs.**
- **Congress should provide support for individuals who seek relevant technical training and experience.**
- **Congress should reauthorize the America COMPETES Act.[22]**

Nuclear

Nuclear power has been part of the U.S. electricity mix since the 1960s and today supplies nearly one-fifth of the nation's overall electricity needs.[23] But the nation's fleet of 104 operating reactors is aging and only two new reactors are currently under construction. The question for policy makers, the utility industry, and other stakeholders now is whether the long-term benefits of retaining nuclear energy as a viable, non-carbon component of a diversified energy supply portfolio justify the investments needed to continue to move the technology forward while also addressing long-standing challenges related to waste management, financing, safety regulation, national security, and nonproliferation.

- **Broadly speaking, we endorse the key strategic goals set out in the Bipartisan Policy Center's 2012 report, *Maintaining U.S. Leadership in Global Nuclear Energy*, and in the report of the Blue Ribbon Commission on America's Nuclear Future to guide policy makers on this issue.**

We concur with the view—expressed in BPC's 2012 report—that the United States has a strong national interest in maintaining a leadership role in the evolution and management of nuclear energy technology.[24] To maintain this leadership role, we agree with former Senator Pete Domenici and former Assistant Secretary for Nuclear Energy Pete Miller, who co-chaired the BPC report, that the United States should take several steps to strengthen and maintain its leadership role in nuclear safety and security. (Our specific additions and caveats appear in italicized text):

- The industry and the U.S. Nuclear Regulatory Commission should continue efforts to strengthen nuclear plant safety and security, *and provide the industry with regulatory certainty and uniform standards*, particularly in light of lessons learned from Fukushima.
- The administration and Congress should act quickly to implement the recommendations of the Blue Ribbon

Commission on America's Nuclear Future (see text box on page 53) and adopt an effective, long-term strategy for managing and disposing of the nation's spent nuclear fuel and high-level radioactive waste. *As a first step, S. 3469, introduced in the 112th Congress by then Senator Jeff Bingaman (D-NM), should be reintroduced and passed.*

- Historically, the United States has been a leader in nuclear technology research and commercialization. To extend this tradition and assure further innovation, the United States must continue to support research and development efforts within the nuclear industry, the national labs, and U.S. universities. *Specifically, the Board recommends focusing future federal research, development, and deployment efforts on two core areas: reactor safety and small-scale reactors that may be better suited to the diversity of electricity markets and to the regulatory structures that currently exist in the United States. These small-scale reactors potentially could serve installations, complexes, campuses, and other institutional aggregations on a cost-effective basis.*

Alternative Transportation Fuels

Oil plays a critical role in the U.S. energy portfolio and in the broader economy, and it has been at the center of America's energy security concerns for nearly a half-century. A large share of global oil supplies comes from regions or countries that are either unstable and/or conflict-prone. The U.S. transportation sector remains overwhelmingly dependent on oil, which leaves American consumers and businesses exposed to the fluctuations of the world oil market.[25] This exposure exists even with expanded U.S. domestic oil production. In this context, the development of alternative transportation fuels has long been seen as a complement to fuel efficiency as well as a way to improve U.S. energy security and reduce pollution.

A variety of policies and programs have been introduced since the 1970s to promote alternatives to petroleum-based fuels for the U.S. transportation sector. One of the most significant policies has been the renewable fuels standard (RFS), which—in combination with other federal incentives—has brought significant volumes of ethanol into the vehicle-fuel market. To date, most of this ethanol has been corn-based, but further growth in biofuel volumes under the RFS will be in advanced fuels, such as ethanol made from cellulosic (woody or fibrous) feedstock, and in "drop-in" fuels, such as biobutanol. These second-generation biofuels offer advantages compared with first-generation biofuels (including corn-based ethanol) because they generally use nonedible biomass (including algae), have significantly lower lifecycle greenhouse gas emissions, and may be drop-in replacements that can be used with existing tanks, pipelines, and pumps without costly modifications. Continued investment in advanced renewable fuels and progress toward reducing the cost of large-scale cellulosic biofuels production should remain an important priority given the benefits these fuels offer in terms of environmental impacts and feedstock diversity.

DOD, which has pursued advanced biofuels for their strategic value in supporting the military's mission, is currently limited to entering into five-year procurement contracts.[26] Longer-term contracting for biofuels would improve price certainty and provide greater market stability to support expediting the commercialization of alternative fuels.[27]

In addition to other challenges, all alternative fuels generally face economic and logistical challenges associated with deploying fuel-dispensing infrastructure in a timely manner to facilitate the growth of alternative vehicle demand. Aside from biofuels, natural gas and electric vehicles have received attention in recent years as alternative transportation technologies. Natural gas, in either compressed or liquefied form, is potentially suitable for a range of transportation applications; vehicle price and refueling infrastructure remain key challenges, but a growing number of initiatives are underway to introduce natural gas vehicles and refueling stations, especially for fleet vehicles. The conversion of natural gas to diesel is another important and promising opportunity to diversity the transportation energy mix. Meanwhile, electric and hybrid-electric vehicle technology has also improved substantially in recent years and a number of analysts predict that large numbers of these vehicles could enter the fleet in the next decade. Electric and hybrid electrics offer several advantages, but they too face cost and performance hurdles, as well as—in the case of all-electric vehicles—challenges related to battery range and recharging infrastructure.

Given the potentially large energy security and environmental benefits that could be achieved by increasing fuel diversity in the transportation sector, we recommend continued federal support for R&D to improve fuel and vehicle technology and to address related infrastructure needs. Specifically we recommend the federal government focus its resources in four areas:

- **The federal government, by itself or in combination with industry, should pursue sustained investment in research and development for transportation fuels, vehicles, and infrastructure to advance more efficient and cleaner energy consumption in the transportation sector.**
- **Local, state, and federal governments should continue and expand efforts to encourage early infrastructure investments for those alternative fuel–vehicle systems that offer a path to long-term viability, considering their lifecycle costs and long-term benefits.**
- **While we have diverse views regarding the Renewable Fuels Standard provisions for conventional renewable fuels, we uniformly believe the nation should continue to develop advanced renewable fuels, and we support the role that the Renewable Fuels Standard can play in promoting these fuels.**
- **We support longer-term Department of Defense procurement contracts, consistent with the fulfillment of its national security mission, for advanced biofuels and urge the Congress to authorize extended procurement contracts.**

Improve the Energy Productivity of the Economy

Energy productivity is a measure of the useful output achieved for a given amount of energy used.[28] Output can be a quantity of something produced (such as a ton of steel), or it can be a service rendered (such as heating or lighting provided). Energy productivity improvements deliver multiple benefits in terms of cost savings, enhanced competitiveness, and pollution reductions. Over the last 40 years, such improvements have allowed the United States to more than triple its economic output while increasing energy usage by only 44 percent—in fact, if one counts the total energy savings achieved by the U.S. economy since 1973 as a separate resource, these savings exceeded the supply added from all other energy resources over this 40-year period.[29]

Despite this impressive record of progress, however, the United States is not close to exhausting opportunities to save energy at a lower cost than it can be produced. This point is well-illustrated by recent studies from the American Physical Society and National Academy of Sciences, which find that cost-effective energy savings in the buildings sector alone over the next 20–25 years could completely offset the projected increase in energy use in this sector over the same period.[30] To capture these savings, supportive policies are needed at the federal, state, and local levels. Our specific recommendations aim to capture opportunities for improved energy productivity in five sectors: the electric power sector, the residential and commercial sectors, the industrial sector, and the transportation sector.

Electric Power Sector

Electric utilities play a unique role in improving energy productivity, because they can help drive energy efficiency on both sides of the electric meter. On the customer's side of the meter, utilities are well-situated to spur the implementation of cost-effective energy efficiency measures across a variety of economic sectors, given their access to customers and consumption data, their technical expertise, and their access to capital. On the utility side of the meter, opportunities exist to improve efficiency in the production, transmission, and distribution of electricity. To capture these opportunities, we support several policies that can spur cost-effective actions.

States and local utility boards should:

- **Establish utility ratemaking policies that reward investments in cost-effective customer energy efficiency as a distributed resource and remove disincentives to these investments.**
- **Encourage all cost-effective energy efficiency through Energy Efficiency Resource Standards, incentive programs, and/or resource procurement planning and measure the effectiveness of these policies.**
- **Encourage the adoption of dynamic retail pricing of electricity and continue to evaluate the use of this option in the residential sector.**

In addition, to enhance energy productivity:

- **Congress and the U.S. Environmental Protection Agency should design environmental programs that encourage efficiency improvements (e.g., output-based emissions standards that account for both electricity and steam output).**
- **Congress, the Federal Energy Regulatory Commission, other relevant federal agencies, state public utility commissions, and local utility boards should encourage investment in new, more efficient transmission and distribution infrastructure.**

Residential and Commercial Sectors

Residential and commercial buildings account for more than 40 percent of total U.S. energy consumption; despite large productivity gains over the last four decades, both sectors offer significant opportunities for further efficiency improvements.[31] Residential energy consumption, for example, is lower today than it was in 1980 on a per-household basis, even though the average house size has increased and most households have many more electronic devices than they did a generation ago.[32] Meanwhile, energy consumption per unit of commercial floor space has also declined by roughly 20 percent over the same time period.[33]

A variety of policies have been instrumental in boosting energy productivity throughout the residential and commercial sectors; they include appliance standards, product labeling and other information-based programs, building codes, tax credits and other subsidies, and performance contracts for government buildings. In addition, the federal government has supported R&D efforts to advance the next generation of efficient building technologies. Finally, utility programs have played a key role, particularly in states that have adopted supportive ratemaking reforms and other policies. To continue and expand upon the last several decades of positive trends in residential and commercial energy productivity, we recommend continued R&D investments to advance a new generation of highly efficient residential and commercial building technologies, along with renewed efforts to overcome market barriers and remove disincentives to cost-effective efficiency investments, to strengthen codes and standards, and to ensure that energy efficiency is treated as a resource comparable to new generation in utility planning.

State legislatures should:

- **Adopt the latest energy codes and upgrade continually state building standards for new buildings and major renovations, based on life-cycle cost effectiveness.**

State public utility commissions and local utility boards should:

- **Promote demand-side efficiency with improved customer information (e.g., smart meters, dynamic pricing) and other innovative uses of customer information (e.g., comparing energy usage among peers).**
- **Support state agencies and contractors that administer building codes and standards through encouragement of partnerships with utilities.**

Congress and the Executive Branch should:

- **Continue to assign high priority to timely issuance of and upgrades to all its statutorily authorized performance-based efficiency standards for appliances, lighting, and equipment.**
- **Continually upgrade federal model building standards based on life-cycle cost-effectiveness.**
- **Support the creation of university-based energy efficiency centers.**
- **Promote energy performance labeling in both new and existing buildings through voluntary programs and/or by utilizing labels as a compliance mechanism for incentive programs.**
- **Improve and harmonize federal energy efficiency programs, including the Department of Energy appliance standards, the Department of Energy and the Environmental Protection Agency's ENERGY STAR program, and the Federal Trade Commission's Energy Guide Program.**

Industrial Sector

The industrial sector spans a large variety of entities with diverse energy needs. Industrial energy consumption currently accounts for a little less than one-third of total U.S. energy demand, with much of this consumption concentrated in energy-intensive manufacturing industries such as bulk chemicals, refining, paper products, iron and steel, aluminum, food, glass, and cement.[34] The industrial sector as a whole has achieved significant energy productivity gains over time, in part because fierce global competition has created sustained pressure on manufacturers to keep costs low. Nonetheless, cost-effective opportunities to further increase energy productivity remain widely untapped in a number of specific industries. Promising technologies include more efficient motors, pumps, and other equipment; process optimization; waste heat recovery; and demand management. Significant gains can also be achieved by replacing inefficient boilers that generate industrial steam with natural gas turbines that co-generate electricity and steam in a combined heat and power (CHP) system.

As the economy recovers and business investment rebounds, there will be an important window for promoting investments that offer long-term energy savings in the industrial sector. To some extent, the effectiveness of various policy interventions depends on the timing and the current business environment in which they are applied. Thus, it is beneficial to have an array of policy tools to choose from to match current conditions and industry needs. Our recommendations include a variety of policies and approaches aimed at overcoming barriers to cost-effective industrial efficiency improvements:

- **Congress, state public utility commissions, and local utility boards should create incentives and remove disincentives for utility promotion of cost-effective industrial efficiency on-site.**

- **State public utility commissions and local utility boards should explore the feasibility of including combined heat and power and waste-energy-based generation in state energy efficiency resource standards.**
- **The Department of Energy should accelerate the development and adoption of cost-effective DOE efficiency standards and establish cost-effective industrial standards for certain types of products (e.g., pumps and other relatively homogenous mass-produced equipment).**
- **State public utility commissions and local utility boards should create incentives for utilities to implement sub-metering at industrial and commercial facilities.**
- **State public utility commissions and local utility boards should support electric utility investment in cost-effective industrial efficiency through grants, loans, training, funding for audits/retrofits, and other programs.**
- **The Department of Energy, together with state public utility commissions and local utility boards should support utility-industrial partnerships, including dedicated staff to establish energy management best practices and to promote greater deployment of cost-effective efficiency technologies that deliver benefits to utilities and industry.**

Transportation Sector

In 2011, the transportation sector accounted for 28 percent of total U.S. energy consumption.[35] Transportation energy demand is expected to remain relatively constant for the next 25 years according to U.S. Energy Information Administration (EIA) projections, as the effect of rising average vehicle efficiency is roughly matched by expected growth in miles traveled.[36]

For decades, the most important policy-driven improvements in vehicle efficiency have been the federal corporate average fuel economy (CAFE) standard. First enacted by Congress in 1975, CAFE standards were substantially increased in 2007; under current law, the average fuel economy requirement for new light-duty vehicles will increase gradually to a target level equivalent to 54.5 miles per gallon by 2025.[37] The new requirements will also encourage innovative natural gas vehicles, electric vehicles, plug-in hybrid electric vehicles, and fuel-cell vehicles. According to U.S. government estimates, the new standards will reduce oil consumption by an estimated 2.2 million barrels per day by 2025, which is more oil than the United States imports in net from any one member of the Organization of the Petroleum Exporting Countries (OPEC).[38] To further reduce oil consumption and reduce the U.S. economy's exposure to volatile world oil prices, however, these vehicle efficiency improvements will have to be paired with greater efforts to reduce vehicle miles traveled (VMT) and diversify transportation energy sources. To that end, and in conjunction with efforts to develop and commercialize alternative transportation fuels (discussed earlier):

- **Congress, the U.S. Department of Transportation, states, and localities should encourage the adoption of cost-effective policies aimed at reducing energy demand for transportation services and should make full use of existing authorities to ensure continuous improvement in fuel economy for new vehicles under, for example, the bipartisan 2007 Energy Independence and Security Act.**

Accelerating Energy Innovation

Technological innovation holds the key to meeting the energy challenges of the 21st century, therefore accelerating the pace of innovation—from early research and development through demonstration and commercialization—must be seen as a central goal of U.S. energy policy. Unfortunately, our nation starts from a position of deficit: measured against other sectors of the economy and other countries, several studies find that the United States is already experiencing a substantial shortfall in overall investments in energy innovation—both public and private—relative to the scale and importance of the national interests at stake.[39] Addressing this shortfall is thus one of the most urgent tasks confronting policy makers today; given the current fiscal and economic climate, it is also one of the most difficult. Accordingly, our recommendations for accelerating energy innovation focus on ensuring that federal investments are not only as effective and efficient as possible, but also oriented to promoting private innovation.

- **Congress should require a regular, rigorous retrospective review of the Department of Energy's research, development, and demonstration energy portfolio conducted by an outside body (e.g., the National Academy of Sciences) that includes examining the effectiveness and management of the Department of Energy's portfolio while also providing options to maximize the benefits from these federally funded programs.**
- **Congress should significantly increase federal investments in basic and applied energy R&D.**
- **Congress and federal agencies should, when appropriate, consider mechanisms to leverage public-sector resources to demonstrate and deploy energy technologies.**
- **Congress should reauthorize the America COMPETES Act, important provisions of which are set to expire at the end of FY2013.**
- **As a component of the government-wide Quadrennial Energy Review, the Department of Energy should undertake a regular review of its technology programs (a "Quadrennial Technology Review") to rebalance its energy R&D portfolio and guide budget priorities in light of energy market conditions, technology advances, and emerging national priorities.**
- **The Department of Energy should reform elements of its institutional structure to prioritize energy innovation. While it may be too early to conduct a robust analysis of the relative effectiveness of ARPA-E (Advanced Research Projects Agency-Energy) and other new energy programs and entities, we conclude that many of the organization and management characteristics they are piloting could serve as broad best practices for driving innovation across the department.**
- **The Department of Energy should take additional action to address intellectual property issues in its funding and collaboration processes.**
- **The section 1703 Department of Energy loan guarantee program should be maintained and reformed.**
- **The Department of Defense, in direct support of its national security missions, and other federal departments and agencies should strive for continued improvement in aligning their energy innovation activities with broader national energy goals.**
- **The Department of the Treasury, the Department of Energy, and Congress should assess the effectiveness of the tax code in spurring private-sector energy innovation.**

Federal Interventions in Energy Markets

For energy, as in other key sectors of the economy, the United States generally relies on markets to produce an efficient allocation of resources and to ensure that the demands of consumers and businesses for high-quality, reliable energy services are met as cost-effectively as possible. That said, U.S. energy markets have always been influenced to a significant extent by government interventions. These interventions can take a variety of forms, including regulation, mandates, incentives, and tax expenditures. Whatever their form, interventions are typically intended to advance societal interests—such as energy security, the protection of health and the environment, and long-term competitiveness—that policy makers believe are not being adequately addressed by the market alone.

A survey of the different types of federal support currently available to different fuels and technologies reveals a growing tendency on the part of Congress to influence energy markets through tax preferences rather than through direct federal expenditures. For FY2011, the Congressional Research Service estimated the total value of energy-specific tax expenditures, including Section 1603 grants and excise tax credits for alternative fuels,[40] at approximately $21.8 billion—equivalent to about 0.9 percent of government revenues and 1.7 percent of the annual deficit.[41] Of this total, approximately 30 percent was directed to renewable energy, 34 percent was directed to alternative fuels, 15 percent was directed to fossil fuels, and 9 percent was directed to energy conservation.[42] Because a number of energy tax provisions expired at the end of 2011 and more were expected to expire at the end of 2012, federal energy tax expenditures were expected to decline by approximately 24 percent in FY2012 and nearly 50 percent by FY2013.[43] However, the American Taxpayer Relief Act of 2012—passed on January 1, 2013, to avoid the fiscal cliff—extended and modified many energy tax credits, adding nearly $4.7 billion for FY2013, an increase of approximately 45 percent more than the previous FY2013 energy tax expenditure estimate.[44]

Despite their popularity, tax expenditures are widely regarded as a poor tool for implementing energy policy. First, because they work by reducing revenues to the government, their costs are masked. Second, the costs are often difficult to predict, because they vary depending on factors outside congressional control. Third, tax expenditures often start as a temporary form of support but then are routinely renewed or extended so they later become effectively permanent. Most importantly, tax expenditures are not cost-effective: To the extent they succeed in incentivizing private investment, they often do so at far greater cost to taxpayers than equivalent direct expenditures.[45]

For all of these reasons, we believe the long-term goal should be to phase out all energy-specific tax expenditure subsidies. Where tax expenditures or similar mechanisms are the best or only available option to address market failures, they should be enacted for only so long as necessary to meet their intended goals with a clear sunset date. Finally, once enacted, these policies should be reviewed periodically and ended if not effective. While we recognize there are numerous debates regarding whether specific tax expenditures constitute a subsidy to a particular industry, these debates are beyond the scope of this report. Rather, we urge Congress to closely consider the full range of tax energy expenditures with the goal of ensuring that mature fuels and technologies compete with one another on a level playing field. Specifically, we recommend:

- **As part of broad, comprehensive tax reform, Congress should review the full range of tax energy expenditures and develop a reasonable phase-out plan for those tax expenditures that constitute subsidies for mature fuels and technologies.**

With respect to the renewable energy production tax credit in particular, we recommend:

- **Congress should extend the renewable energy production tax credit, initially at its current level and develop a specific path to achieve a complete phase-out by the end of 2016.**

Nearly all production tax credits support wind, and the reduction and phase-out of the tax credit would align the federal incentive for wind electricity production with reported reductions in wind project and energy costs. A clearly defined, gradual phase-out of current energy-related tax expenditures is desirable to avoid needless disruption and potential harm to industries, companies, and investors that have made plans and long-term investments on the basis of current policy. In addition, we wish to avoid an unproductive debate about which technologies are more deserving of support compared with other technologies. Broad-based, comprehensive tax reform and/or energy subsidy reform offers a better framework for changing current incentive policies than piecemeal efforts to target a particular industry or technology. Our bottom line is that we believe the same principles and criteria for federal support should apply to all energy technologies, and all energy technologies should have an equal opportunity to compete—on the merits—for an appropriate share of public resources.

Conclusion: Continuing the Bipartisan Tradition in Energy Policy Today

The United States finds itself—thanks in part to technological progress and policy interventions of the last decade—in a stronger position to shape its own energy destiny and with a greater sense of energy security than it has enjoyed for some time. Arguably, the state of U.S. domestic energy sectors, energy productivity, and energy security is the best it has been in many decades. But the country also confronts an array of daunting energy challenges. Tackling these challenges in the midst of a slow economic recovery while addressing an unsustainable federal deficit creates difficult but necessary policy choices—choices that are unlikely to be resolved without the same willingness to work through differences, reconcile regional issues, and reach across political party lines that characterized earlier legislative successes.

Fortunately, Congress has a long history of taking bipartisan action to promote broadly held energy goals. For example, appliance standards were first authorized in 1975 by the Energy Policy and Conservation Act.[46] They have since been codified and updated multiple times, each time with bipartisan support. The 2005 Energy Policy Act was passed by a Republican-controlled Congress, while the 2007 Energy Independence and Security Act was passed by a Democratic-controlled Congress; both pieces of legislation were signed by President George W. Bush. As recently as December 2012, Congress passed the American Energy Manufacturing Technical Corrections Act, an energy efficiency bill that amends specific appliance efficiency standards and bolsters industrial and federal government efficiency efforts, with overwhelming bipartisan support.[47]

If the United States can draw on this bipartisan tradition to forge a long-term vision and strategic approach to wisely using its energy resources and technical advantages, we are confident that the goal of achieving a diversified and balanced energy portfolio—one that provides energy security, economic prosperity, and sustainable environmental quality—is well within reach.

Endnotes

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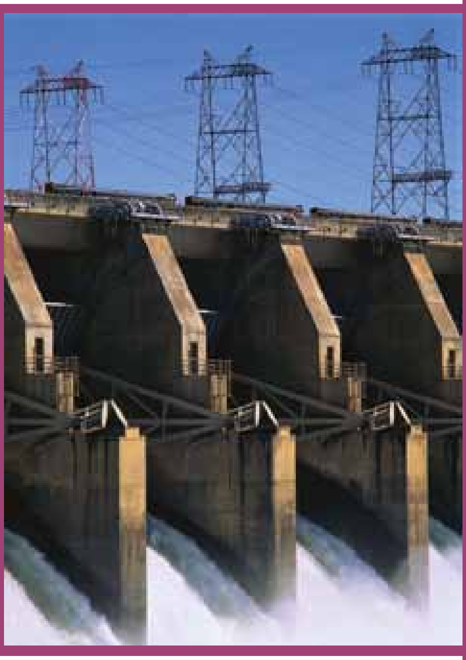


Introduction

We begin our report with a straightforward conclusion, based on exhaustive evidence compiled in the pages that follow: The state of U.S. domestic energy sectors, energy productivity, and energy security is the best it has been in many decades. Yet we unanimously reject any temptation for complacency; the nation will not retain its position of strength or its prosperity without action on multiple fronts, and the tradition of continuous improvement in U.S. economic and environmental performance now hangs in the balance.

Still, the highlights of the recent record are worth emphasizing:

- When adjusted for economic growth and inflation, the United States has cut its energy needs by more than 50 percent since 1973, and the trend shows no signs of slowing. Treating this 40-year reduction as the equivalent of new energy supply, the resulting resource is significantly larger than the expansion of output from all other energy resources combined over the same period.
- Just since 2005, the United States has reduced oil consumption by over 12 percent; that year will almost certainly rank as the all-time U.S. peak, given prospects for sustained progress in fuel economy, energy conservation, and continuing progress on alternative fuels.
- At the same time, domestic oil, natural gas, and renewable energy production are up, energy imports are down (dropping below half of domestic oil demand); new energy development is driving a jobs boom in many parts of the country, and lower energy costs are helping the manufacturing sector recover from a punishing recession.
- Estimates of U.S. natural gas reserves have soared, thanks in large measure to advances in drilling technology; the International Energy Agency predicts that the United States will soon once again be the world's largest producer of both natural gas and oil.
- Significant gains have been made in the cost-effectiveness of renewable energy and commensurate increases in deployment. Additionally, low natural gas prices have helped utilities reduce the cost of integrating renewable resources that are intermittent; and wind and solar generation have increased their output.
- U.S. energy-related carbon dioxide emissions have remained below the peak seen in 2007; emissions of sulfur dioxide and nitrogen oxides have been declining since the 1970s.

But the news is not all good: Affordable energy is still a challenge for many households and businesses; the oil and gas boom comes with environmental challenges; the electric grid faces infrastructure and integration hurdles; public investments in R&D in energy are insufficient to maintain an international competitive edge; and the issues of climate change, global energy market volatility, policy uncertainty, and competition for energy resources by countries with growing economies remain.

Part of America's current energy success—which is beyond the dreams of most who tried to predict energy supply and demand trends in the 1970s—is the result of bipartisan energy policy developed at both state and federal levels. As recently as 2007 and 2005, Congress passed meaningful and forward-looking national energy legislation with broad bipartisan support. These bills, along with earlier pieces of federal legislation and numerous reforms and initiatives at the state and local level, helped enable the private sector to bring about the positive energy developments highlighted in the opening to this report.

More important, there has existed, and still exists, broad agreement among policy makers and citizens alike that secure, affordable, and reliable energy is essential to American prosperity and the American way of life, as well as wide-ranging support for the principle that the means of producing, delivering, and using energy must continue to evolve in ways that reduce harmful impacts to the environment and public health. These long-standing, overarching goals of energy policy have provided the foundation for our deliberations and guided the formulation of the policy recommendations in this report. As the United States enters this new era of unprecedented energy opportunity, it is more important than ever to recognize, and meet, the nation's energy challenges. With a long-term vision and strategic approach to wisely using its resource abundance and technical advantages, the nation can create a diversified and balanced energy portfolio that provides energy security, economic prosperity, and sustainable environmental performance.

The Bipartisan Policy Center launched the Energy Project and Energy Board in 2011, recognizing that the nation, while clearly blessed with diverse and abundant domestic energy resources, nonetheless confronts an array of energy challenges that demand high-level attention in the years ahead. Tackling these challenges in the midst of a slow economic recovery while confronting the prospect of an unsustainable federal deficit creates difficult but necessary policy choices—choices that are unlikely to be resolved without the same willingness to work through differences, reconcile regional issues, and reach across political party lines that characterized earlier legislative successes. Unfortunately, the extreme partisanship that has stymied progress on other critical public policy issues in recent years seems to be creeping into the energy domain as well: Support for the 2009 stimulus bill, which included a substantial energy component, was divided sharply along partisan lines. The subsequent partisan debate over comprehensive climate and energy legislation in 2009 further sharpened the divide.

Our Energy Board developed an overarching strategic goal: The U.S. energy system should provide affordable, secure, and reliable supplies of energy—and do so in an environmentally responsible manner. To achieve the goal, we developed four enabling objectives: (1) pursue a diverse portfolio of energy resources; (2) improve the energy productivity of the economy; (3) accelerate innovation and technology improvements across the energy sector; and (4) improve energy policy governance and accountability.[1]

Through this report, we hope to jump-start the process of rebuilding a bipartisan consensus for the next generation of federal and state energy policy first by clarifying the important energy questions and trade-offs the United States confronts over the next several decades, and then by developing recommendations for resolving many of these trade-offs. These recommendations are offered as a package—no single Energy Board member necessarily agrees with each individual recommendation in isolation, but taken together they provide the blueprint for a balanced and effective plan for enhancing the nation's prosperity, energy security, and environmental quality in the 21st century.

A critical energy and environmental policy issue is whether the United States should adopt a comprehensive climate change policy to reduce greenhouse gas emissions. We agree that climate change is a significant issue and addressing it can and should be a matter of bipartisan consensus. It is our view that government policy development and prudent business planning should incorporate cost-effective greenhouse gas emissions reductions, and support market-based efforts to accelerate the integration of low-carbon energy technologies. We call on Congress and the Administration to find a way forward together on responsible and efficient policies to reduce greenhouse gas emissions and to work with other governments in seeking a global approach that both promotes the most cost-effective emissions reductions and addresses the competitiveness issues associated with carbon policy. We look forward to assisting the effort.

The remainder of this report is organized as follows. Chapter 1 provides background and context, describing in greater detail the trends and developments that have contributed to the “good news” energy story of the last decade, along with the challenges that remain. Chapters 2 through 5 cover policy recommendations to pursue a diverse portfolio of energy resources, improve energy productivity, accelerate energy innovation, and overhaul federal interventions in energy markets.

Energy & Infrastructure Program
Energy Project

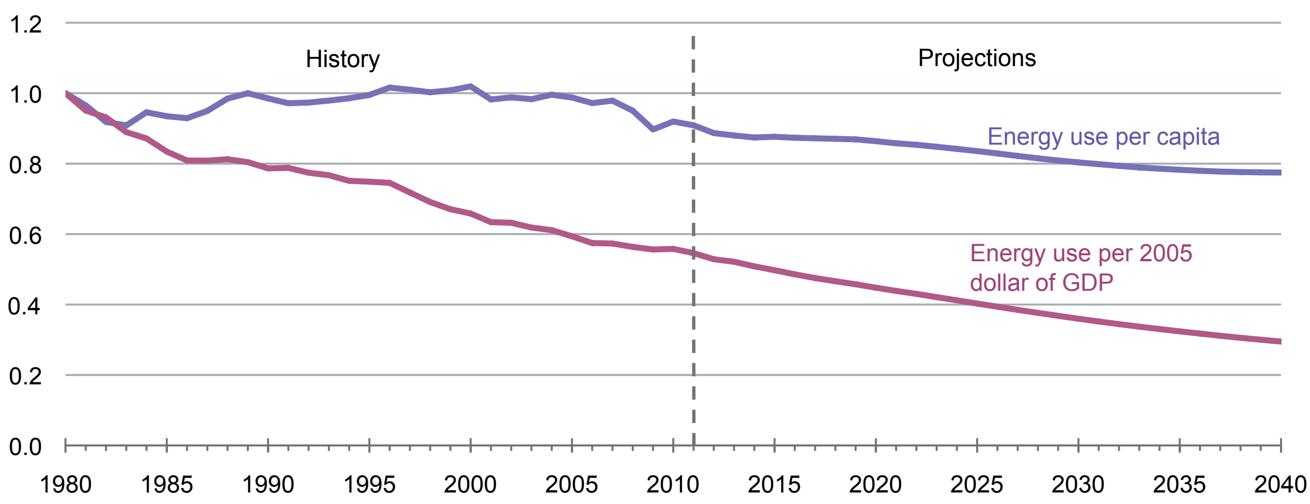


Chapter 1: America's New Energy Landscape

As noted in the introduction, America's energy outlook has shifted dramatically during the last few years. Fortunately, many elements of this shift have been positive in the sense that they offer optimism that improved energy security in the decades ahead can lead to greater prosperity for the U.S. economy. This relatively bright outlook contrasts sharply with the situation just a decade ago when concerns about supply adequacy—particularly with respect to domestic oil and natural gas—and high and volatile energy prices dominated policy discussions. Today's improved energy security outlook reflects a fortunate coincidence of technological progress and geological circumstance. And it also reflects the success of a number of policies introduced over the last decade to promote greater efficiency, boost investment in clean energy technologies, achieve environmental progress, and develop domestic resources.

A continuous increase in the energy productivity of the U.S. economy over the last four decades has been particularly important from a long-term energy security perspective. "Energy productivity" is defined as the quantity of goods and services generated for each unit of energy consumed.[2] Energy savings achieved through improvements in energy productivity have exceeded the contribution of all new energy supply resources in terms of meeting America's energy needs over the last four decades. These productivity gains began in the 1970s and accelerated between 1990 and 2010. They have made it possible for the U.S. economy to grow faster than overall energy consumption and for Americans to enjoy rising living standards without a commensurate increase in energy use. In fact, energy use per capita, after staying relatively flat from 1990 to 2007, has been declining since 2007, and the U.S. Energy Information Administration (EIA) projects energy use per capita will continue to decline: From 2011 to 2040, total U.S. population is projected to increase by 29 percent, but energy use grows by only 10 percent, with energy use per capita declining by 15 percent from 2011 to 2040.[3]

Figure 1-1: U.S. Energy Consumption Per Capita and Energy Use Per Dollar of GDP, 1980-2040 (1980 = 1)



Source: U.S. Energy Information Administration, "Figure 8. Energy use per capita and per dollar of gross domestic product and emissions per dollar of gross domestic product, 1980-2040," *Annual Energy Outlook 2013 Early Release*, December 5, 2012, http://www.eia.gov/forecasts/aeo/er/early_intensity.cfm.

Larger macroeconomic shifts—most notably a shift in the share of GDP from the manufacturing sector to the service sector and, within the industrial sector, from more energy-intensive products to less energy-intensive goods—have played a large role in driving these trends; the recession of 2008–2009 and the slow recovery has driven down overall energy consumption and spurred further gains in efficiency. Innovation in the private sector has increased the efficiency of many energy-using devices, including commercial and industrial HVAC (heating, ventilation, and air conditioning) systems.

Policy drivers, however, have also played a role. In the transportation sector, a significant increase in federal Corporate Average Fuel Economy (CAFE) standards was introduced as part of the Energy Policy Act of 2005. This ended a long period when the average efficiency of the U.S. light-duty vehicle fleet stagnated or even declined slightly. Light-duty new vehicle fuel economy rose to 32.6 miles per gallon (mpg) in 2011 from 24 mpg in 2004 as a result of the rise in fuel prices, reduction in sales of light-duty trucks, and tighter CAFE standards for light-duty trucks starting with model year 2008.[4] Current law requires manufacturers to achieve even higher standards in future years, specifically a fleet-wide light-duty vehicle average of 47.3 miles per gallon by 2025 that will increase to 54.5 miles per gallon when combined with a CO_2 standard of 163 grams per mile.[5]

Meanwhile, state and federal policies also led to efficiency improvements across a range of energy-using devices and appliances in the residential and commercial building sectors. As with vehicles, these positive trends are expected to continue thanks to a recent federal rule-making that updates efficiency standards for several types of residential

Energy Jobs and the Economy

Energy is the lifeblood of the U.S. economy. All energy resources—energy efficiency, oil, gas, coal, nuclear, and renewable—are responsible for supporting economic growth and, in turn, employment throughout the economy. The country is dependent on the energy sector's skilled workforce to maintain the reliability and affordability of current energy systems. In the future, the energy-sector skilled workforce will be the lynchpin that will enable the country to achieve future public policy goals with respect to energy, the economy, and the environment as the next generation of energy technologies is developed and deployed.

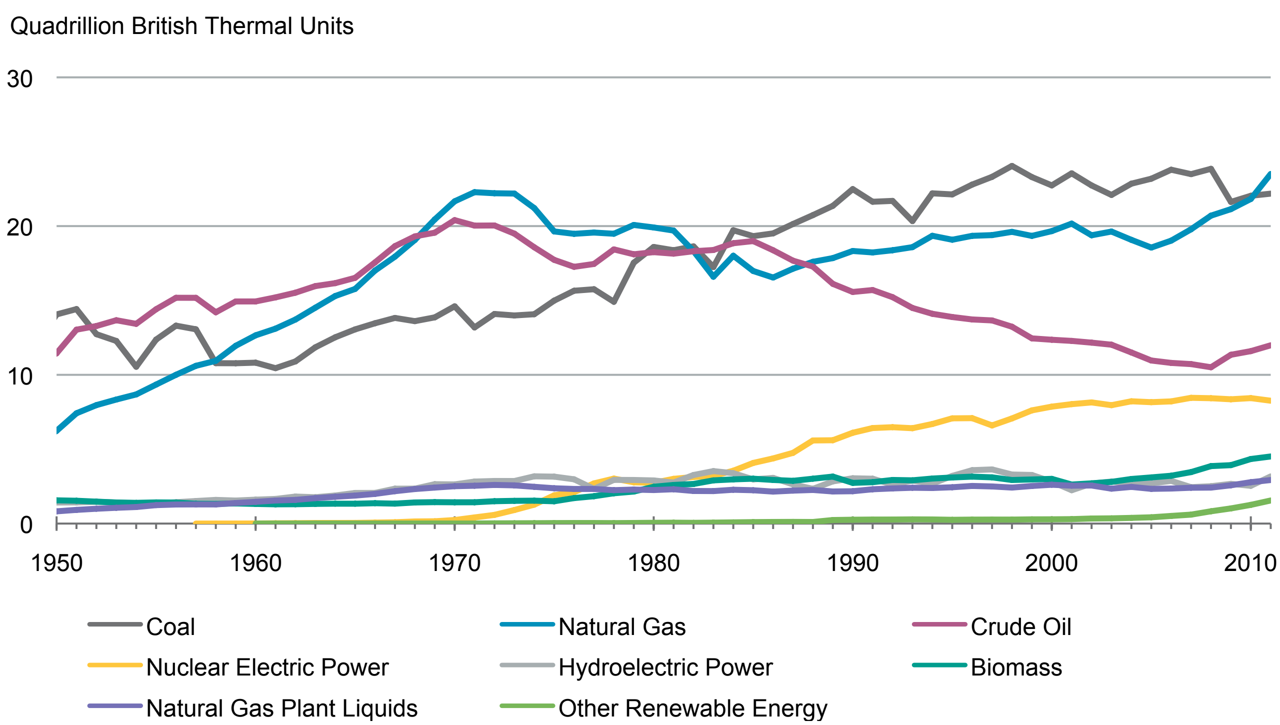
In 2011, energy-related industries accounted for roughly 4.4 percent of gross domestic product in the United States.[6] Though the three million jobs in energy-related industries accounted for only 2.4 percent of direct non-farm employment, indirect and induced jobs are much higher: Recent research shows that the energy industry supports many more jobs than it generates directly, owing both to its long supply chains and spending by employees and suppliers.[7] In addition, the natural gas boom, which induced lower natural gas prices, has resulted in benefits for U.S. manufacturing, which in turn is leading to even more job creation and economic growth.

The U.S. oil and gas and renewable energy industries have been growing despite the sluggish economy. The oil and natural gas extraction industry alone added approximately 150,000 jobs in 2011, which was 9 percent of all jobs created that year in the United States.[8] Global information company IHS/CERA forecasts that the oil and natural gas extraction industry will achieve average annual growth of 6.9 percent through 2015, compared with the overall growth forecast of non-farm employment of 1.5 percent per year.[9] In addition, investments in natural gas-fired combined cycle electricity generation, clean coal, onshore wind, and solar photovoltaic technologies, among others, have contributed to energy-related job growth. In the case of new power plants, most job creation occurs when the facilities are built, with direct jobs attributable to construction and the manufacturing of the equipment, and indirect jobs attributable to equipment manufacturing, such as production of the steel used to build power plant structures and wind turbine blades. Jobs in the construction phase are temporary, though once construction is complete, permanent, albeit fewer, jobs related to the operation of the new power supply sources remain.

equipment (including furnaces, central and room air conditioners, heat pumps, refrigerators, and freezers) based on consensus agreements reached among federal officials, efficiency advocates, and manufacturers.

The last few years have also brought dramatic changes on the supply side of the picture. Most notable, of course, has been a major shift in the U.S. supply outlook for natural gas. Advances in horizontal drilling techniques and hydraulic fracturing, developed in part with federal support, have made it possible to commercially develop tight gas and shale gas reserves in a number of geographically diverse areas.[10] Arkansas, Colorado, Louisiana, Ohio, Oklahoma, Pennsylvania, New York, Texas, and West Virginia all have the potential to become—if they have not already become—major shale gas–producing areas, provided local environmental concerns are successfully addressed. The result has been a dramatic increase in estimates of the economically recoverable North American natural gas resource base. Whereas domestic production was thought to be on a declining trajectory as recently as four years ago, the United States is now believed to have sufficient natural gas resources to meet demand for many decades and perhaps even a century at current rates of consumption. Responding to increased supply, natural gas prices have declined dramatically from the highs seen in 2006 and 2008 (when prices spiked to more than $12 per million Btu). Prices fell below $4 per million Btu in 2011 and have briefly dipped below $2 per million Btu more recently. Although long-term natural gas prices are difficult to project, the EIA currently projects the Henry Hub spot natural gas price to remain below $4 per million Btu (2011 dollars) through 2018. After 2018, the projected Henry Hub spot natural gas price increases steadily reaching reach $5.40 per million Btu in 2030 and $7.83 per million Btu in 2040 (2011 dollars).[11,12]

Figure 1-2: U.S. Energy Production by Source, 1950-2011



Source: U.S. Energy Information Administration, "Energy Perspectives 1949–2011," *Annual Energy Review 2012*, September 27, 2012, http://www.eia.gov/totalenergy/data/annual/perspectives.cfm.

Technological advances and policy decisions have also greatly improved the domestic-supply outlook for oil, both from shale oil reserves and from deepwater offshore resources. In fact, many of the shale formations that are being considered for natural gas development also contain oil. (Examples include the Eagle Ford shale in South Texas, the Bakken formation in North Dakota and eastern Montana, and the Niobrara in Colorado and Wyoming, among others.) Higher oil prices and better technologies have made it economically feasible to develop the liquid hydrocarbons trapped in these low-permeability/low-porosity formations. In a 2011 report, the National Petroleum Council estimated the recoverable, unconventional/tight oil resource base in Canada and the United States at 6–34 billion barrels, with potential production capacity in the range of 2–3 million barrels per day.[13] (To put these figures in perspective, total U.S. oil consumption is approximately 19 million barrels per day.[14]) Meanwhile, improvements in drilling technology and the opening of additional areas in the Gulf of Mexico and other areas of the U.S. Outer Continental Shelf (OCS) are expected to increase offshore oil production in the coming years. These changes have already begun to reverse the decline in domestic crude oil production that began in 1986.[15] EIA estimates that 2012 crude oil production will be 6.43 million barrels per day (the highest level of production since 1997).[16] By 2020, EIA projects crude oil production will be 7.47 million barrels per day (a level not seen since around 1990).[17]

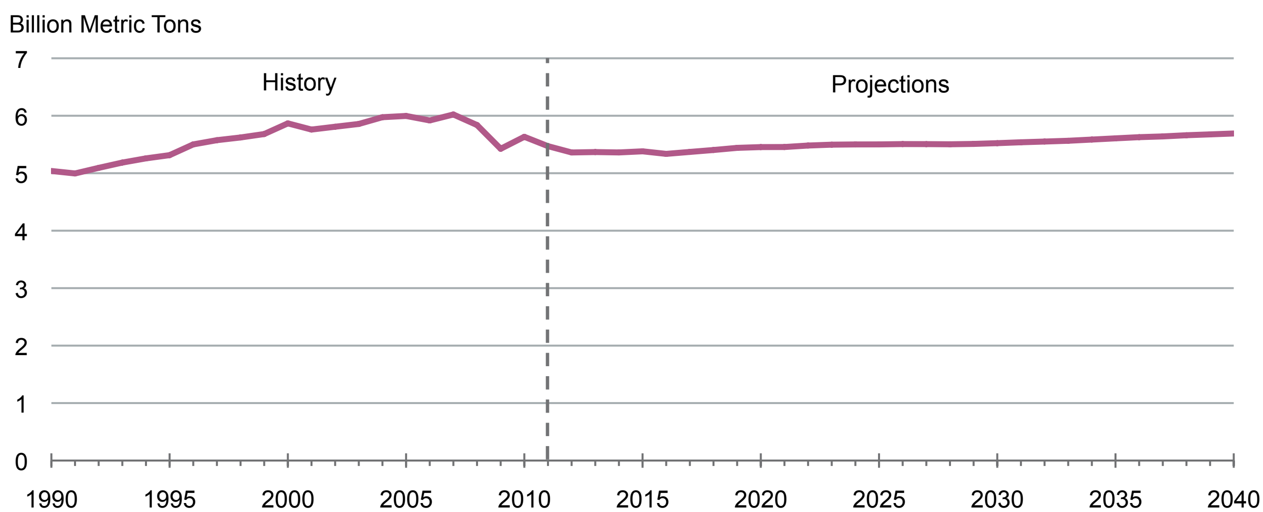
The first decade of the 21st century also saw dramatic growth in renewable energy capacity and output in the United States. Total installed generating capacity for non-hydropower renewables (i.e., wind, solar photovoltaic and thermal, geothermal, wood and other biomass) grew fourfold, from 15.6 gigawatts in 2000 to 60.6 gigawatts in 2011.[18] Much of this growth came from the U.S. wind energy industry, which increased its installed capacity base more than 16-fold over the same time period, from 2.4 gigawatts in 2000 to 45.2 gigawatts in 2011.[19] With increased capacity came expanded output: Electricity generation from renewable sources more than doubled from 81 billion kilowatt-hours in 2000 to 195 billion kilowatt-hours in 2011.[20] As a share of total U.S. electricity production, the renewable contribution (excluding hydropower) likewise roughly doubled over this period, from 2.1 percent of total generation in 2000 to 4.7 percent in 2011.[21] Government policies—including production and investment tax credits at the federal level and renewable portfolio standards at the state level—played a major role in spurring this expansion; in addition, high natural gas prices between 2003 and 2008, along with cost and performance improvements, particularly for wind, helped make renewable resources more competitive with conventional generating options.

Over the last decade, the federal government also made a major push to support the increased domestic production and use of petroleum fuel alternatives for the transportation sector. A variety of policies and subsidies—including incentives for alternative-fueled vehicles and infrastructure, federal tax credits for ethanol, and the renewable fuels standard—helped to drive up the production of ethanol, as well as smaller quantities of biodiesel. Ethanol production, in particular, grew from 1.62 billion gallons in 2000 to 13.9 billion gallons in 2011.[22] The Renewable Fuels Standard (RFS) targets 15 billion gallons per year of renewable fuel in 2015 and an additional 21 billion gallons per year of advanced renewable fuels in 2022.[23] Because the United States has nearly reached 15 billion gallons of grain ethanol capacity, future growth under the RFS will be in advanced biofuels, which generally use nonedible biomass, have significantly lower lifecycle greenhouse gas emissions, and may be "drop-in" replacements that can be used with existing tanks, pipelines, and pumps without costly modifications.

Taken together, the energy supply- and demand-side developments of the last several decades have resulted in an economy that is more energy efficient and more productive; that is creating good jobs in both new and established energy industries; and that is also less dependent on energy imports, less carbon intensive, and less exposed to fluctuations in world energy markets. Expanded domestic production of crude oil, natural gas, and biofuels, combined with slowing energy consumption as a result of efficiency gains, high oil prices, and the effects of the recession reduced the import share of overall U.S. energy consumption from 29 percent in 2007 to 22 percent in 2010.[24] With regard to liquid fuels, oil imports to the United States dropped from 60 percent in 2005 to less than 50 percent in 2010.[25] This is good news for the U.S. economy from multiple perspectives: reduced imports, job creation, infrastructure investment, and economic development.

Recent energy supply and demand developments along with regulatory policies have also been good for the environment in terms of reducing energy-related emissions of criteria pollutants (sulfur dioxide, nitrogen oxides, carbon monoxide, particulates, and tropospheric ozone)[26] and carbon dioxide (CO_2) emissions, though this is not the case for all greenhouse gas emissions.[27,28] U.S. CO_2 emissions declined between 2007 and 2009, before rebounding somewhat in 2009.[29] However, CO_2 emissions have remained below the peak seen in 2007, when energy-related emissions for the economy as a whole reached just over six million metric tons per year.[30] As the economy recovers, emissions growth is expected to continue, albeit to lag behind GDP growth, as the market share of natural gas in the electric power sector rises relative to coal and end-use efficiency continues to improve. In EIA's latest projections (which assume current policy, as EIA reference cases always do), CO_2 emissions remain below the 2005 level of six million metric tons through 2040, the end of the forecast period.[31] Per capita emissions are projected to fall by 15 percent from 2005 to 2040, while changes in the energy supply mix mean that energy-related CO_2 emissions in 2040 will be only 1 percent higher than in 2010 (despite a 10 percent increase in total energy use).[32] Overall, the carbon intensity of the U.S. energy mix is projected to fall by 7.7 percent between 2010 and 2040 (from 57.3 tons of CO_2 per billion Btu to 52.8 tons per billion Btu), while energy-related carbon emissions per dollar of GDP will decline even more (by 50 percent) over the same period.[33]

Figure 1-3: Energy-Related Carbon Dioxide Emissions, 1990-2040

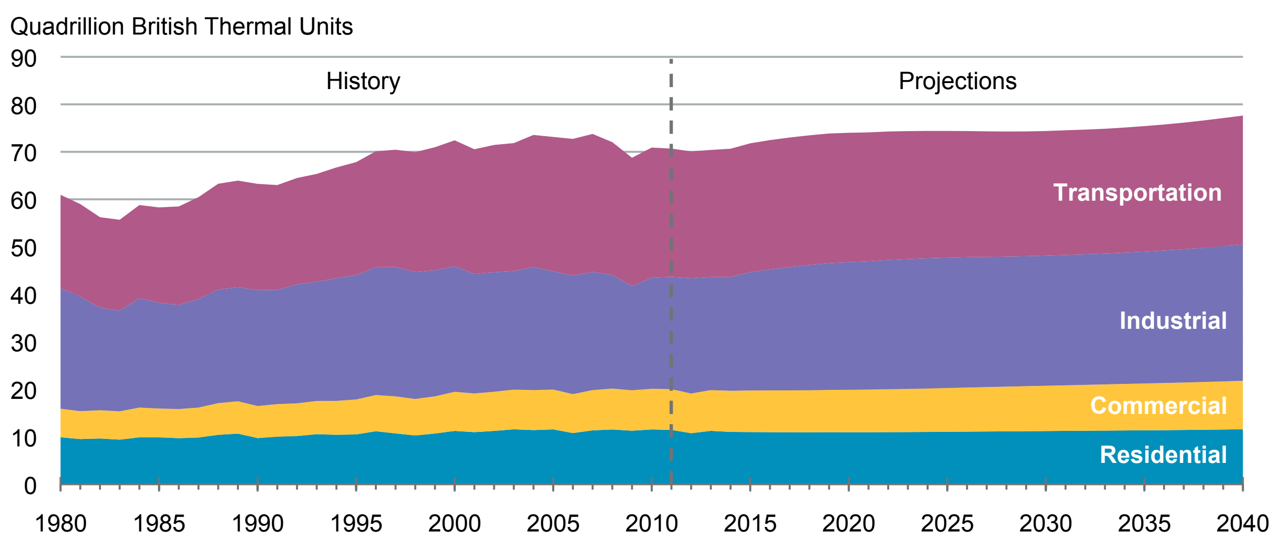


Source: U.S. Energy Information Administration, "Figure 4. U.S. energy-related CO2 emissions, 1990-2040," *Annual Energy Outlook 2013 Early Release*, December 5, 2012, http://www.eia.gov/forecasts/aeo/er/executive_summary.cfm.

Other positive trends in energy are likewise expected to continue. EIA projects U.S. energy demand to grow slowly for the next two decades (0.3 percent per year on average for the period 2008–2040)—more slowly than population and considerably slower than GDP.[34] As a result, EIA estimates that total energy use in 2040 will be just 10 percent higher than in 2010, even though the U.S. population will have grown by 29 percent and the economy will have grown by 108 percent over the same timeframe. (This translates to an average annual decline in per capita energy use of 0.5 percent per year and an overall decline in energy intensity of 15 percent.)[35] To some extent, this result reflects an ongoing shift from manufacturing to services within the broader economy (and from more energy-intensive to less energy-intensive goods within manufacturing), as well as an assumption that recovery from the recent recession will continue to be slow. But it also reflects the ongoing impact of a number of policies, particularly with respect to energy demand in the transportation and buildings end-use sectors.

While U.S. consumption slows, the development of domestic energy resources is expected to continue to grow, such that the U.S. position increasingly shifts from that of a major energy importer to that of a major producer and even a net exporter of natural gas. (The United States is already a net exporter of coal.)[36] In 2012, U.S. oil production grew more than in any other year since the first commercial well was drilled in 1859,[37] and EIA now estimates that expanded development of onshore oil resources and offshore resources in the Gulf of Mexico would allow for a 20 percent increase in domestic crude oil production over the next decade, potentially pushing crude oil production to 7.4 million barrels per day by 2020—a level not seen since the early 1990s.[38] On the natural gas side, U.S. production is expected to exceed consumption by early next decade, with the result that the United States could become a net exporter of liquefied natural gas (LNG) as early as 2016, an overall net exporter of natural gas by 2020, and a net pipeline exporter by 2021.[39] This is a marked departure from just a few years ago, when

Figure 1-4: U.S. Energy Consumption by Sector, 1980-2040



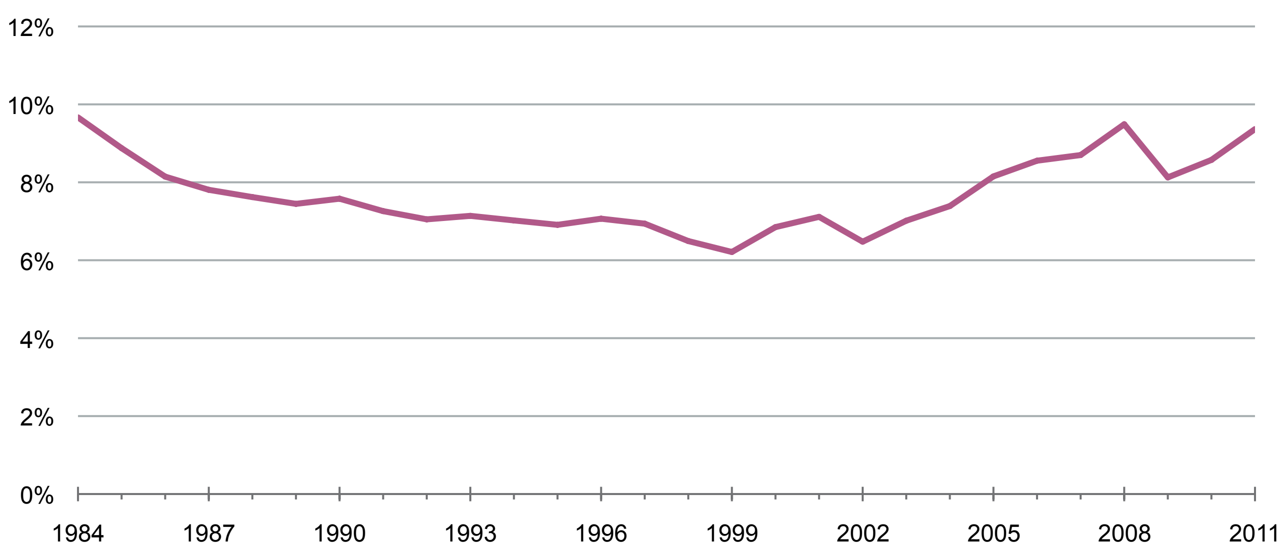
Source: U.S. Energy Information Administration, "Figure 6. Delivered energy consumption by sector, 1980-2040," *Annual Energy Outlook 2013 Early Release*, December 5, 2012, http://www.eia.gov/forecasts/aeo/er/early_consumption.cfm.

there was concern that domestic natural gas consumption would soon exceed production and experts were discussing the need to site and construct import terminals so that LNG could be brought in from overseas suppliers. Meanwhile, domestic natural gas prices are expected to remain relatively low at least through 2035.[40] Taken together, all of these shifts could have enormous benefits for the nation's overall economy and energy security—particularly in an era of continuing global demand growth.

Serious Challenges Along with the Opportunities

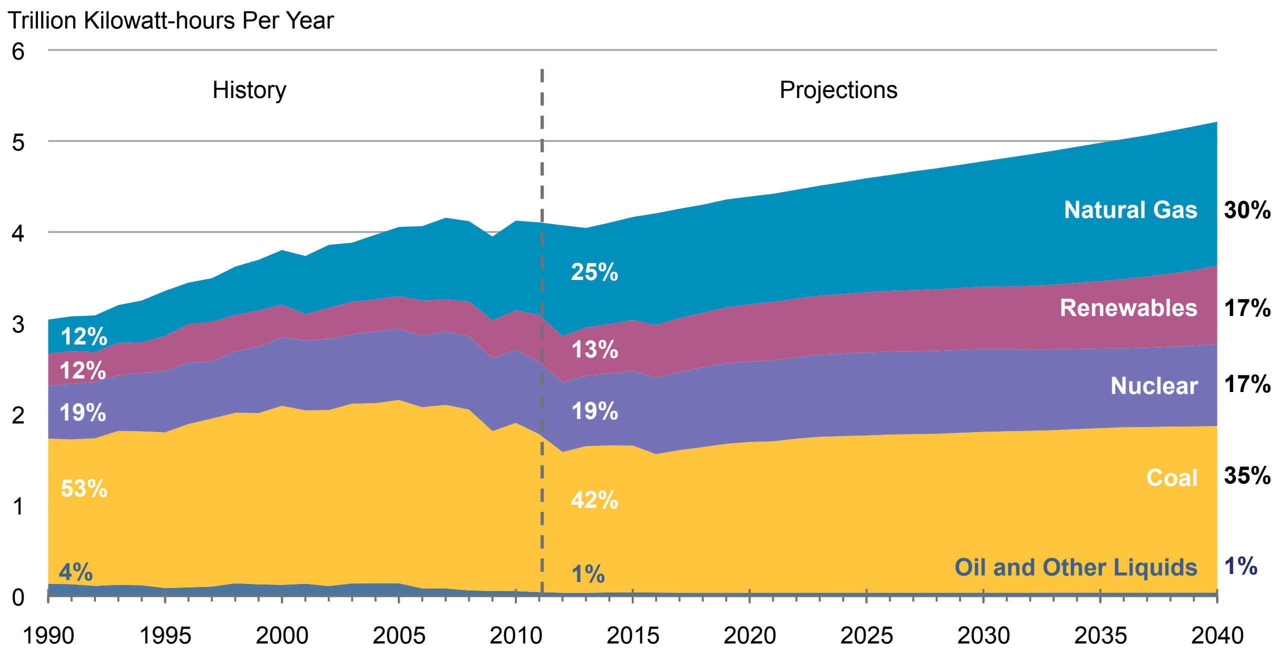
Though the energy outlook for the United States has clearly improved in significant ways, it is also undeniably the case that major challenges remain. These include economic, environmental, and infrastructure challenges, as well as challenges to specific energy industries and to states and the federal government as they grapple with complex energy-related regulatory and policy questions. High oil prices, for example, have recently resurfaced as a major concern for the economy and for American consumers. The drivers behind the latest run-up in prices—a combination of rising global demand, especially in Asia, and new tensions with Iran—serve as a reminder that the United States remains exposed, even with increased domestic production, to world oil-market fluctuations because oil prices are determined in the global marketplace, and increased domestic oil production does not have the same dampening effect on prices as does domestic natural gas production. And although considerable progress has been made in deploying biofuels and advanced vehicle technologies (including hybrid and electric vehicle technologies), the U.S. transportation sector remains heavily dependent on petroleum. Thus, energy security and lack of fuel diversity in the transportation sector remain important concerns for the future.

Figure 1-5: U.S. Household Energy Expenditures as a Share of Total Household Expenditures, 1984-2011



Source: U.S. Department of Labor, Bureau of Labor Statistics, *Consumer Expenditure Survey*, http://www.bls.gov/cex/.

Figure 1-6: U.S. Electric Power Sector Generation Mix, 1990-2040



Source: U.S. Energy Information Administration, "Figure 12. Electricity generation by fuel, 1990-2040," *Annual Energy Outlook 2013 Early Release*, December 5, 2012, http://www.eia.gov/forecasts/aeo/er/early_elecgen.cfm.

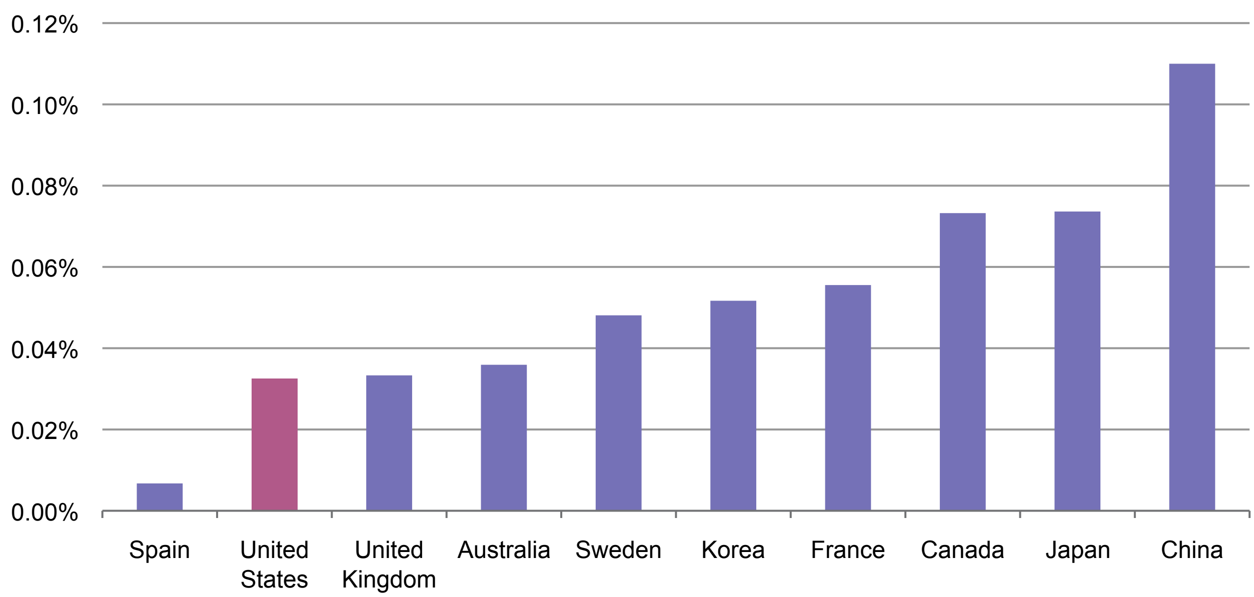
The electricity sector, by contrast, does not suffer from a lack of fuel diversity; moreover, it can expect to benefit directly from increased domestic natural gas and renewable energy production and lower natural gas and renewable energy prices.[41] But the electric utility industry also confronts new costs and challenges. For decades, coal has accounted for roughly half of U.S. electricity generation and—along with nuclear power—has played a major role in providing baseload capacity and grid stability in many parts of the country. However, the recent decline in natural gas prices has accelerated a shift toward natural gas–fired electricity generation, with EIA reporting that coal's share of the nation's electricity generation dropped to 35 percent in the second quarter of 2012 from 53 percent in 1997.[42]

Over the next decade, new air-quality, industrial-waste, and water-use requirements will put increasing cost pressure on coal-fired generators and, in combination with low natural gas prices and flattening electricity demand, are expected to result in the retirement of a number of older coal-fired power plants and may result in increased costs for many other coal-fired power plants. There have been positive developments in coal-fired technology: Electricity generators have spent an estimated[43] $103 billion on emission-control technology between 1960 and 2011, and have been able to achieve significant reductions in emissions of conventional pollutants, including sulfur dioxide, nitrogen oxides, and particulate matter per kilowatt-hour of electricity generated. Coal will remain an important part of the energy mix for decades to come and will continue to compete with natural gas, particularly if natural gas prices start to rise relative to coal.

Age is also an issue for the nation's fleet of nuclear power plants (which currently supply 20 percent of the electricity supply.)[44] The average age of U.S. commercial reactors is about 32 years. U.S. commercial nuclear reactors are licensed to operate for 40 years by the U.S. Nuclear Regulatory Commission, though companies may apply for 20-year extensions prior to termination of the original license. Currently, 71 out of the country's 104 reactors have been relicensed. In many cases, owners and operators of these plants likewise face new costs to keep older reactors operating safely, to meet more stringent post-9/11 and post-Fukushima safety and security requirements, and to manage growing stockpiles of spent fuel. (Many nuclear power plant operators, for example, have begun moving spent fuel from pools to on-site dry-cask storage while they wait for the federal government to provide a more permanent disposal option.) The nuclear power industry has been developing and improving reactor technology for more than five decades and is starting to build the next generation of nuclear power reactors (so-called Generation III reactors), with improved fuel technology and efficiency, and standardized design for reduced maintenance and capital costs. Yet financial hurdles for new nuclear plant construction look increasingly daunting. As noted earlier, EIA's latest forecast points to a flat or declining role for coal and nuclear power over the next two decades and an uncertain longer-term future for these fuels and technologies.

The contribution from renewable energy sources, by contrast, is expected to continue expanding over EIA's forecast horizon, albeit likely at a slower pace than in recent years. Nevertheless, significant challenges loom for these industries, too. The uncertainty created by off-and-on federal subsidies—notably an investment tax credit for solar and a production tax credit for wind—is a particularly critical issue for investments in expanding deployment. Given this policy uncertainty, combined with the current focus on federal deficits and fiscal uncertainty, it is not clear that deployment and consumption will continue or continue at the same level: Sustained funding for renewable energy R&D could be at risk as well. And if existing incentives are not extended, renewable energy sources may find it increasingly difficult—

Figure 1-7: Public Energy RD&D Spending as Share of Gross Domestic Product, 2010



Note: France data is 2009; China data is 2008.
Source: International Energy Agency, "Energy Technology RD&D 2012 edition (free access)," http://wds.iea.org/wds/ReportFolders/ReportFolders.aspx?CS_referer=&CS_ChosenLang=en; Central Intelligence Agency, "The World Fact Book," https://www.cia.gov/library/publications/the-world-factbook/.

like coal and nuclear—to compete with low-cost gas in the near term.[45] As noted in the previous section, a number of states have adopted portfolio requirements that mandate a certain minimum role for renewable technologies and serve as demand signals for investors and developers; many states have reached or are about to reach their minimum targets. Many of these states also limit any cost premium that customers can be asked to pay to meet renewable energy requirements. Though not often used thus far, these cost "off-ramps" are important safeguards for customers. Meanwhile, the renewable energy industry and its utility partners have been and need to continue to make progress on issues of cost and reliability, including the need to develop cost-effective storage technologies and other strategies to deal with the variable output of wind and solar resources.

Within the oil and gas industry, successfully developing shale gas and other unconventional or less readily accessible resources presents its own technical, environmental, and public-acceptance challenges. The BP-*Deepwater Horizon* oil spill in the Gulf of Mexico in April 2010, for example, dominated headlines for months and made the public much more aware of the risks of deepwater oil production; it also triggered new regulations and greater scrutiny of the industry. As exploration and drilling expand to new offshore areas, avoiding future accidents is critical. Environmental concerns are also being raised with greater prominence and urgency in the context of onshore oil and natural gas operations, particularly with respect to the impacts of hydraulic fracturing.[46] Citing concerns with surface and groundwater contamination from chemicals used in hydraulic fracturing and other air- and water-quality as well as land-use impacts in the vicinity of fracturing operations, some states and localities have adopted moratoria on shale gas development, and the federal government and many states where hydraulic fracturing is occurring are considering new regulatory requirements. Other issues getting more attention lately involve the potential for earthquakes triggered by wastewater disposal practices and the potential for methane leaks from expanded natural gas drilling and transport operations.[47] Meanwhile, methane leaks, even if relatively small as a percentage of total system throughput, are of concern from a climate standpoint because methane is itself a potent greenhouse gas—much more potent than carbon dioxide.

Climate considerations must remain important in any discussion of the nation's energy future, despite the current lack of enthusiasm—in the United States and elsewhere—for aggressive actions to reduce greenhouse gas emissions. While many recent domestic energy developments are positive in the sense that they slow the predicted growth of U.S. greenhouse gas emissions, they are still not sufficient to produce an absolute reduction in global emissions, let alone to produce reductions of the magnitude scientists say are needed to help reach widely discussed climate stabilization goals.[48] Achieving actual reductions, in other words, will require further policy interventions. Given this reality and the continuing scientific case for concern, it would be shortsighted to disregard climate impacts in making long-term energy infrastructure commitments. It would also be shortsighted to disregard the need for policies, innovation, and investment necessary to keep existing low-carbon options available and to advance a next generation of fossil fuel alternatives. On the contrary, maintaining a diverse menu of energy options remains the surest way to protect America's long-term interests in a context where the uncertainties are large and the economic and ecological stakes—and the downside risks of complacency—are also high.

Market conditions coupled with the U.S. government's negative fiscal outlook have made it harder to muster private and public support for increasing investments in basic energy R&D and/or to make potentially game-changing low-carbon technologies—such as carbon capture and storage—commercially feasible. Nor is the problem limited to public spending on technological innovation for the future: Some regions of the nation face a substantial private investment shortfall when it comes to maintaining and modernizing the energy infrastructure that the U.S. economy relies on today. Several well-publicized grid and pipeline failures in recent years have drawn attention to the consequences of inadequate maintenance and often overstretched energy production and delivery systems in some regions. In other cases, infrastructure investments may be needed to take full advantage of new resources. These situations require assessment of the costs and benefits of investments needed to reach these resources. For example, accessing the best wind and solar resources may require new long-distance transmission lines, just as shale gas development in areas far from traditional producing regions may require new pipelines, roads, and gathering facilities. Moreover, smart infrastructure investments are needed and must be made with appropriate due diligence, such as weighing the economic benefits of siting renewable generation in the location where solar or wind resources exist against other energy-supply alternatives and against the cost of the infrastructure investment necessary to transmit generated electricity to population centers. Even making the most of cutting-edge energy efficiency and demand management technologies will eventually require a smarter, better-integrated grid.

In sum, the nation finds itself—thanks in part to technological progress and policy interventions of the last decade—in arguably a stronger position to shape its own energy destiny and with a greater sense of energy security than it has enjoyed for some time. But significant challenges remain, as volatile gasoline prices and too-frequent power outages continue to remind consumers. Recognizing those challenges and identifying where and how government—in concert with the private sector—can act effectively and within its means to develop and implement solutions is the task for policy makers today.



Chapter 2: Pursue a Diverse Portfolio of Energy Resources

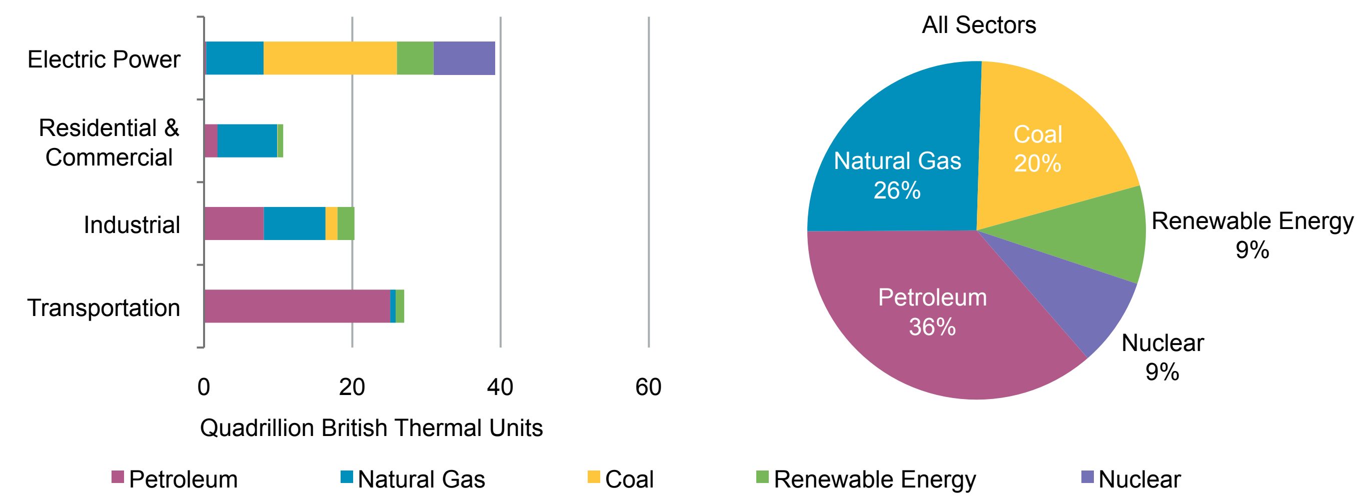
The introduction to this report stressed the importance of secure, affordable, and reliable energy as a critical driver of American prosperity, economic competitiveness, and national security—now and in the future. Consistent with this view, we identified the pursuit of a diverse portfolio of energy resources as one of three key strategies to achieve the nation's overarching energy goals. This chapter describes recent developments in the outlook for a number of America's key energy resources. It also offers a number of recommendations aimed at ensuring that the nation is well-positioned—with a diverse portfolio of energy resources, fuels, and technologies—to meet the critical energy-related challenges ahead.

Before delving into a discussion of specific energy options, however, it is worth pausing to underscore the importance of diversity. An energy system that relies on a varied mix of fuels and technologies from diverse geographic sources, as well as continued progress in energy efficiency improvements, is inherently more robust and resilient than one that is heavily dependent on a limited number of sources. Energy diversity helps to insulate the U.S. economy from the supply shocks and price volatility that can affect the market for a particular energy source.

The value of diversity is well-illustrated by contrasting the experience of the U.S. electric power sector to that of the U.S. transportation sector over the last several decades. When the global price of oil rises, households and businesses generally have few short-run options other than to pay more or drive and fly less, given the near total reliance of the transportation sector on petroleum-based fuels and the lack of readily available alternatives. The electric power sector, by contrast, can draw upon a variety of fuels and technologies to make near- and medium-term adjustments—including coal, natural gas, nuclear, and, increasingly, renewable generators, as well as energy efficiency and demand response programs. This means changes in the price or availability of one kind of fuel or generator can usually be at least partially offset by increased reliance on other types of generators and energy savings.

A second point worth highlighting at the outset concerns the importance of treating demand- and supply-side resources

Figure 2-1: U.S. Fuel Mix by Source and Sector, 2011



Source: U.S. Energy Information Administration, "Energy Consumption by Sector," *Annual Energy Review 2011*, September 27, 2012, http://www.eia.gov/totalenergy/data/annual/index.cfm#consumption.

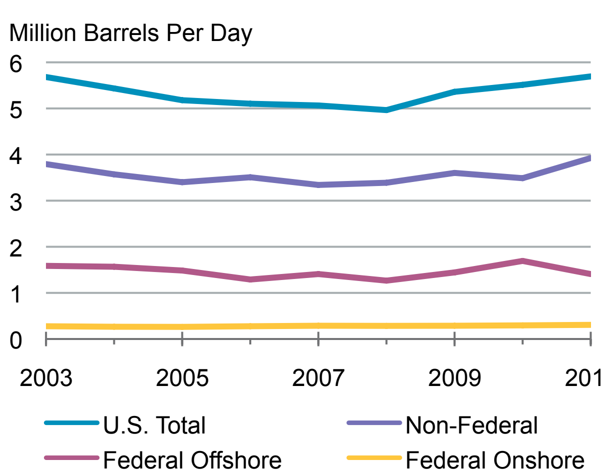
on equal footing from the standpoint of assembling a resource portfolio that can meet America's future energy needs as cost-effectively and environmentally responsibly as possible. Chapter 3 details the scale of the resource opportunity associated with improved energy productivity and recommends actions to accelerate the development and deployment of more energy-efficient appliances, vehicles, industrial equipment, and other energy end-use technologies. As noted in the overview discussion of this report, energy savings achieved through improvements in energy productivity have more than equaled the contribution of all new energy supply resources in terms of meeting America's energy needs over the last four decades. Such improvements in energy productivity and efficiency help to reduce the domestic economy's sensitivity to abrupt energy price increases, and oil price volatility in particular.

The remainder of this chapter is organized by major energy resource (except for energy efficiency, which is addressed separately in Chapter 3). In each case, the report provides an overview of recent trends and developments, and identifies the key issues or policy questions that our recommendations seek to address. Because most of the recommendations for oil and natural gas focus on expanding domestic production, permitting, and other land-use and environmental issues affecting access to oil and natural gas resources in the United States that are largely the same, we group these two fuels for purposes of discussion in the first section of the chapter.

Oil and Natural Gas Production on Federal Lands

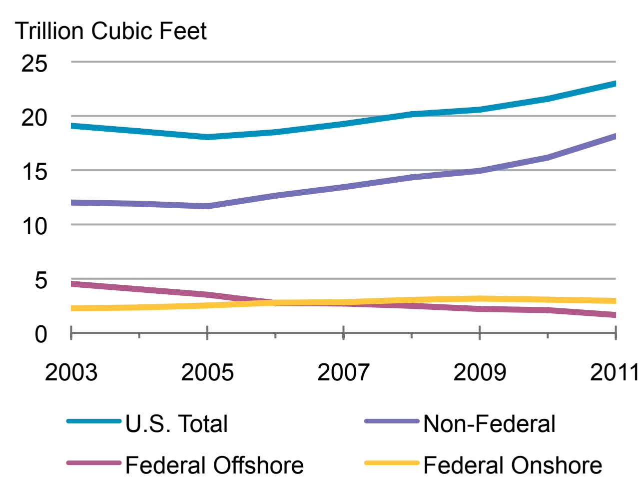
A dramatic change in the supply outlook for domestic oil and natural gas has been one of the most important energy developments for the United States in recent years. This change came about largely because advances in drilling technology have made it economically feasible to drill for these fuels in previously inaccessible places, such as oil and gas shale and deepwater offshore areas. Today,

Figure 2-2: U.S. Crude Oil Production, 2003-2011



Source: U.S. Energy Information Administration, "Table 2. Sales of crude oil and lease condensate production from Federal and Indian Lands, FY 2003 – FY 2011," *Sales of Fossil Fuels Produced from Federal and Indian Lands, FY2003 through FY2011*, March 14, 2012, http://www.eia.gov/analysis/requests/federallands/pdf/eia-federallandsales.pdf.

Figure 2-3: U.S. Natural Gas Production, 2003-2011



Source: U.S. Energy Information Administration, "Table 3. Sales of natural gas production from Federal and Indian Lands, FY 2003 – FY 2011," *Sales of Fossil Fuels Produced from Federal and Indian Lands, FY2003 through FY2011*, March 14, 2012, http://www.eia.gov/analysis/requests/federallands/pdf/eia-federallandsales.pdf.

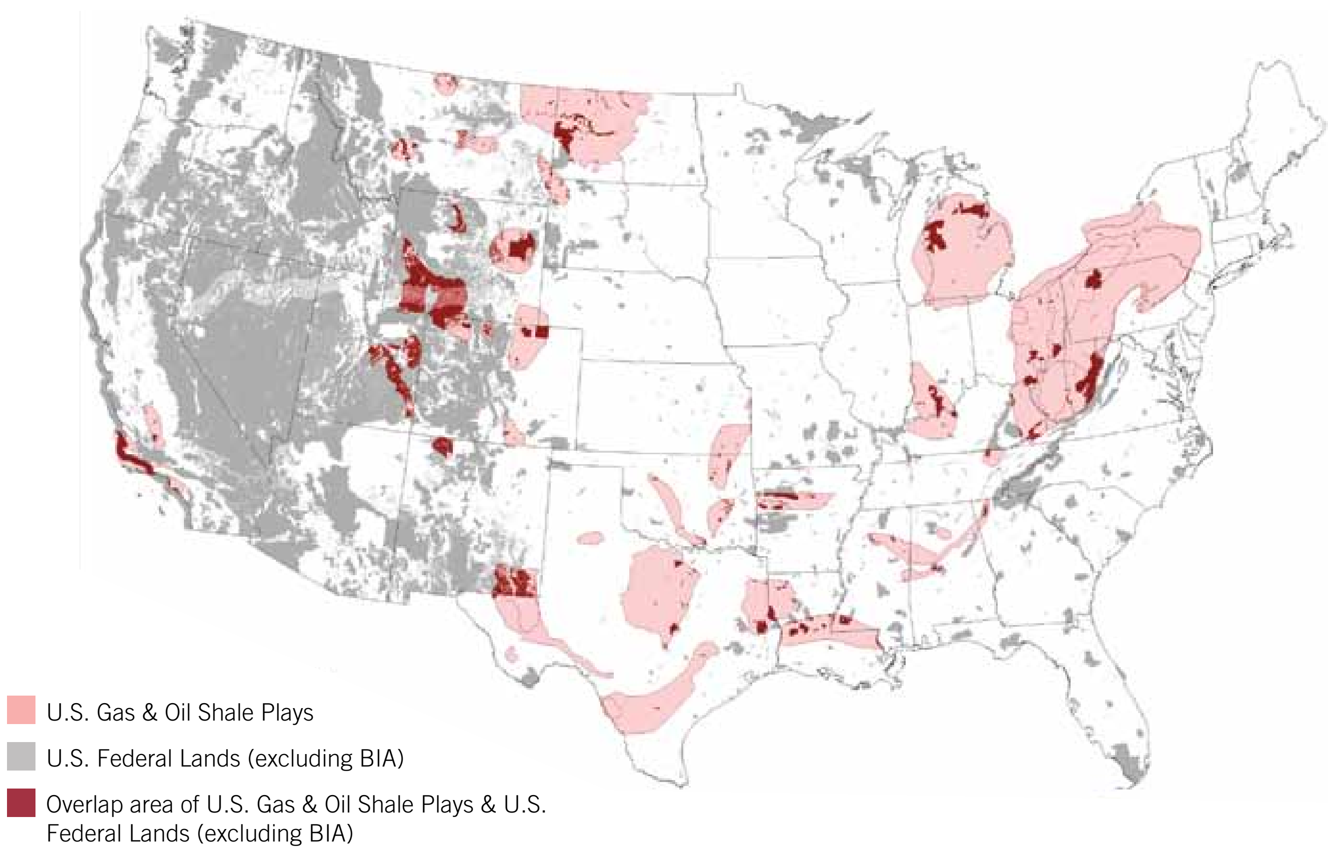
estimated undiscovered technically recoverable resources of U.S. natural gas total 1,504 trillion cubic feet (tcf), while U.S. oil resources are estimated at 124 billion barrels.[49] By comparison, annual domestic natural gas consumption in 2011 was 24 tcf and oil consumption was 6.9 billion barrels.[50]

Developing America's abundant indigenous energy resources provides multiple benefits: It spurs local and regional economic activity and job creation; generates revenues for federal, state, and local government; opens the door to potential export opportunities while allowing the United States to reduce energy imports; increases the amount of global oil supply from stable sources;[51] and spurs technological innovation that benefits U.S. competitiveness. The policy challenge to fully capturing these benefits is to expand access to, and promote investment in, America's domestic oil and gas resources in a manner that protects the environment and addresses the interests of all stakeholders.

U.S. Oil and Gas Production is Increasing

Figures 2-2 and 2-3 chart recent trends in U.S. crude oil and natural gas production. Both figures show a marked

Figure 2-4: Oil and Gas Shale Formations and Federal Lands in the Lower 48



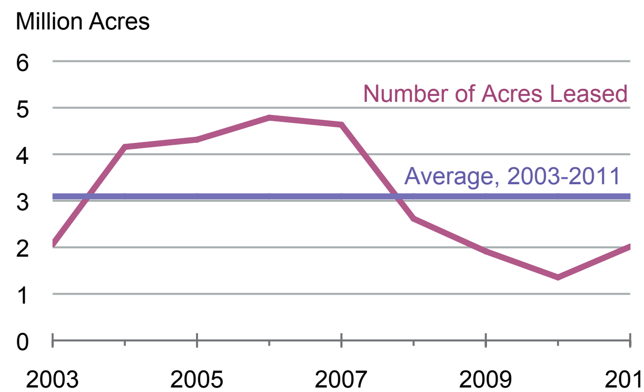
Source: U.S. Energy Information Administration, "Summary of Statement of Adam Sieminski, EIA Administrator," Testimony before the House Energy and Commerce Committee, August 2, 2012, http://www.eia.gov/pressroom/testimonies/sieminski_08022012.pdf.

The Debate over Energy Development on Federal Lands

The issue of access to federal lands has become increasingly politicized over the last several years, as some have pointed to a decline in the number of leases and permits issued for these lands as evidence of a more restrictive policy toward energy development. Figures 2-5 through 2-8 show acres of federal land leased, leases issued, permits requested and approved, and producing acres from 2003 through 2011 (note that these data are for onshore federal lands only). They reveal a clear peak in leases issued and number of drilling permits requested in 2006, followed by a marked decline in activity. This peak coincides with a significant increase in shale gas development in 2006, most of which occurred on private lands for reasons discussed in the main text. In 2009, 2010, and 2011 the number of drilling permits processed for federal lands actually exceeded the number of permits requested as the Department of the Interior worked to clear a backlog of pending requests. Nonetheless, a large backlog remains: More than 4,000 drilling permits were still awaiting approval at the end of FY2011.[55] The reasons for this backlog have been much debated. A shortage of resources, including staff and funding, at the federal agencies is one explanation. The Department of the Interior and industry have pointed to an increase in the number of protests and environmental challenges being raised over the past decade in connection with drilling requests as another reason for the persistent delay in approving permits; although in recent years these challenges have decreased.[56]

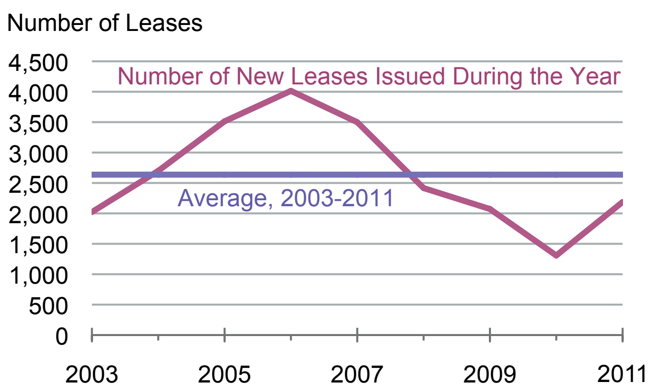
Critics of the oil and gas industry, meanwhile, have pointed to the gap between leased acres and producing acres (Figure 2-8) to suggest the industry is deliberately not pursuing more rapid development on federal lands, which seems highly unlikely. First, current oil prices provide a strong incentive to move forward with drilling and production on any leases with commercially viable amounts of oil. Moreover, there are a variety of legitimate reasons why this gap exists: Even where the land has been leased, companies may be awaiting drilling permits, the rigs and supporting resources needed for drilling may not yet be in place, or the leased area may not contain oil or natural gas in quantities sufficient to support commercial production. In such cases, companies must eventually return their leases to the government under existing "use-it-or-lose-it" laws and regulations. In any case, significant upfront "bonus bids" are paid to the federal government to acquire leases as well as annual rental fees until these leases expire. In 2012, when Interior held its first Central Gulf of Mexico sale since 2010, pent-up demand led to record-setting offers and brought in $1.7 billion in winning bids—almost double the $949 million from the previous auction in 2010.[57]

Figure 2-5: Number of Total Acres Leased, 2003-2011



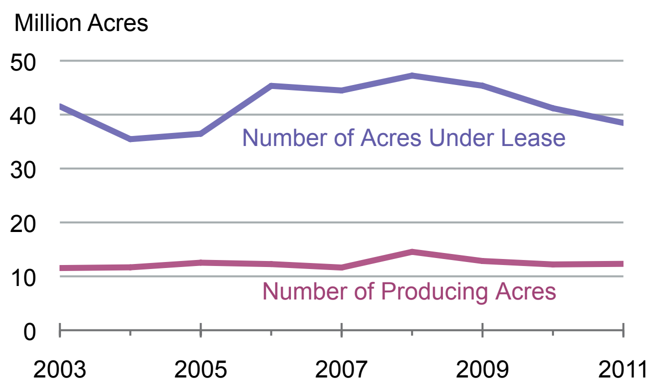
Source: U.S. Department of the Interior, Bureau of Land Management, "Oil & Gas Statistics by Year for Fiscal Years 1988-2011," June 22, 2012, http://www.blm.gov/wo/st/en/prog/energy/oil_and_gas/statistics.html.

Figure 2-6: Number of New Leases Issued, 2003-2011



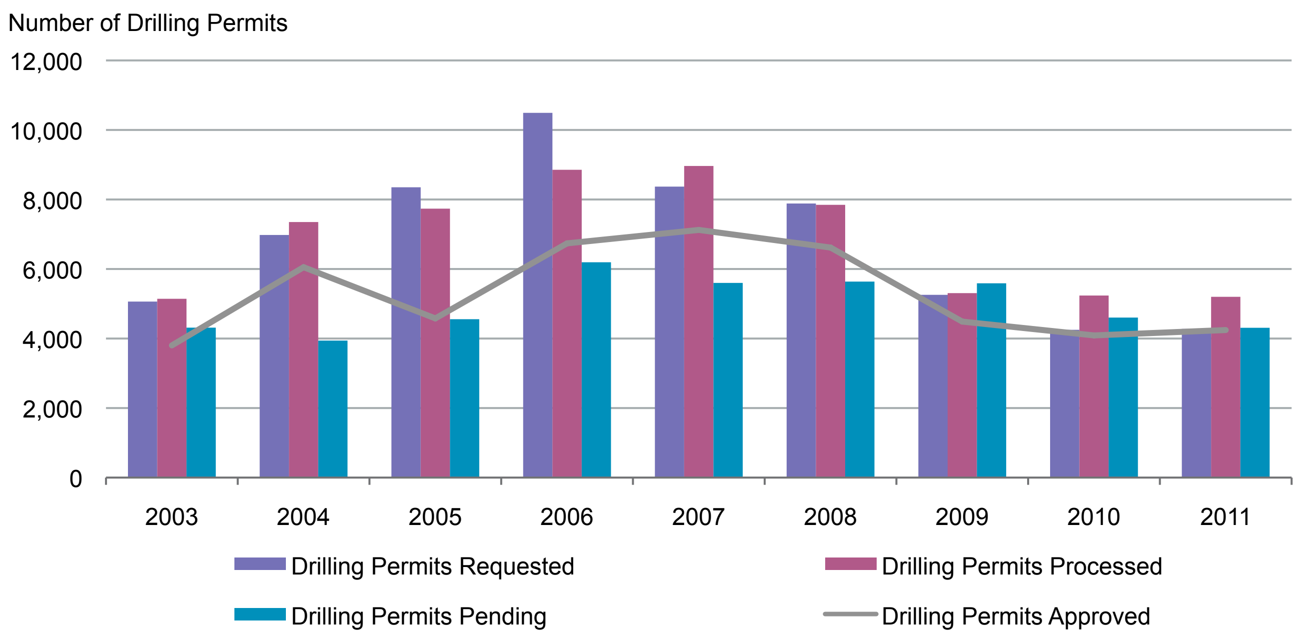
Source: U.S. Department of the Interior, Bureau of Land Management, "Oil & Gas Statistics by Year for Fiscal Years 1988-2011," June 22, 2012, http://www.blm.gov/wo/st/en/prog/energy/oil_and_gas/statistics.html.

Figure 2-8: Status of Acres Under Lease, 2003-2011



Source: U.S. Department of the Interior, Bureau of Land Management, "Oil & Gas Statistics by Year for Fiscal Years 1988-2011," June 22, 2012, http://www.blm.gov/wo/st/en/prog/energy/oil_and_gas/statistics.html.

Figure 2-7: Number of Drilling Permits Requested Processed, and Approved, 2003-2011



Source: U.S. Department of the Interior, Bureau of Land Management, "Oil & Gas Statistics by Year for Fiscal Years 1988-2011," June 22, 2012, http://www.blm.gov/wo/st/en/prog/energy/oil_and_gas/statistics.html; U.S. Department of the Interior, *Oil and Gas Lease Utilization, Onshore and Offshore: Updated Report to the President*, May 2012, 14, http://www.doi.gov/news/pressreleases/loader.cfm?csModule=security/getfile&pageid=296238.

increase in domestic production starting in 2006, with especially strong growth in domestic natural gas production. Overall, domestic crude oil production was up 11 percent (to 2,067 million barrels) and domestic natural gas production was up 24 percent (to 23 tcf) in 2011 compared with 2006.[52] Notably, much of this increase in natural gas production occurred onshore, driven largely by shale gas production on private lands. Offshore production of natural gas, by contrast, has been declining gradually throughout the decade, while offshore production of oil—after rising steadily since 1990 from 299 to 591 million barrels—fell in 2010 as a result of a temporary moratorium issued in the immediate aftermath of the *Deepwater Horizon* oil spill and subsequent permitting delays.[53]

In terms of onshore activity, Figures 2-2 and 2-3 also document a shift in where domestic oil and gas production is occurring: Whereas production of these fuels on federal lands has been relatively flat over the last decade (in the case of onshore oil and natural gas) or modestly declining (in the case of offshore natural gas), production on *non*-federal lands has increased markedly. This shift generally reflects a coincidence of geography. The large shale formations that have attracted most of the recent development activity are located in parts of the country where the federal government simply does not have large land holdings (including notably the Bakken, Barnett, Haynesville, Marcellus, and Fayetteville plays). Figure 2-4 shows the location of major shale formations and federal lands; it indicates that much of the new oil and gas production potential in the United States is located on private lands. However, leasing and permitting challenges on federal lands along with increased litigation over federal permits have also played a factor in the shift toward production on private lands. (This topic discussed in greater detail later in the chapter.) Thus, while there has been much debate in the political sphere over these issues, both the industry's recent focus on shale oil and gas development on private lands as well as regulatory delays appear to be key factors in the recent decline in activity on federal lands. Nonetheless, these resources remain an important source of oil and gas production, accounting for roughly 25 percent of total U.S. production.[54]

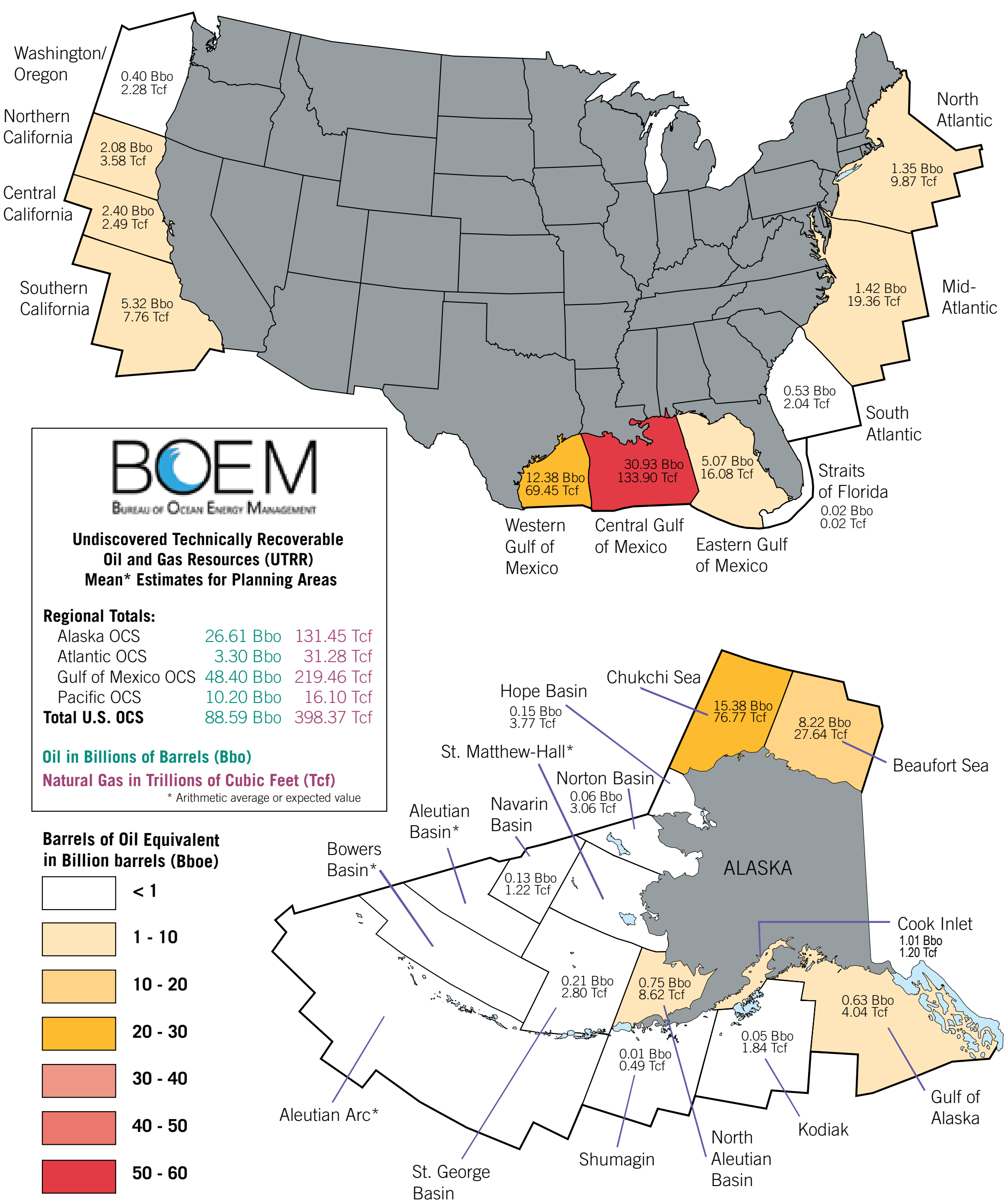
Current Issues and Challenges in Offshore Oil and Gas Development

North America's Outer Continental Shelf (OCS) holds significant resources of crude oil and natural gas. According to estimates from the Bureau of Ocean Energy Management, there are roughly 398.4 trillion cubic feet of natural gas and 88.6 billion barrels of oil that are technically recoverable in the Gulf of Mexico, Pacific, Atlantic, and Alaska regions of the OCS under U.S. jurisdiction (Figure 2-9.)[58] Based on what is currently known (which is likely to be conservative for reasons explained below), these resources account for a significant portion of the nation's oil and gas resource base—roughly 70 percent for oil and 25 percent for natural gas.[59] Technological advances in deepwater drilling technology, together with rising oil prices, have made these resources more economically attractive over the past several years.

After staying relatively constant over the last decade, offshore U.S. oil production trended upward starting in 2008, followed by a steep decline starting in 2010.[60] The downturn in offshore oil production had a specific cause—the BP *Deepwater Horizon* oil spill in the Gulf of Mexico in April 2010. The spill released over four million barrels of oil into the Gulf before the well was capped roughly three months after the initial explosion.[61] As a result of the spill, the Obama administration issued a 6-month moratorium on deepwater drilling and required active deepwater drilling operations to cease.[62] This temporary shutdown in 2010, which is no longer in effect, was the primary reason for lower offshore oil production in 2011.

The *Deepwater Horizon* disaster marked a significant turning point for U.S. offshore oil and gas producers and

Figure 2-9: Federal OCS Areas of the United States



Source: U.S. Department of the Interior, Bureau of Ocean Energy Management, *Assessment of Undiscovered Technically Recoverable Oil and Gas Resources of the Nation's Outer Continental Shelf*, 2011, http://www.boem.gov/uploadedFiles/BOEM/Oil_and_Gas_Energy_Program/Resource_Evaluation/Resource_Assessment/2011_National_Assessment_Map.pdf.

for the federal agencies tasked with managing the nation's offshore resources. A national commission appointed by the president to investigate the causes of the disaster found widespread and longstanding problems in the agencies charged with regulating offshore drilling operations—including, most notably, Interior's Minerals Management Service (MMS), which had front-line responsibility for promoting and managing lease sales and ensuring that drilling activities were conducted in a safe and environmentally sound manner.[63] To address these problems, the National Commission on the BP *Deepwater Horizon* Oil Spill and Offshore Drilling recommended a sweeping overhaul of MMS and of the rest of the federal government's approach to regulating offshore energy projects more broadly. According to the Commission, three core issues needed to be tackled to ensure the success of these reforms and prevent future accidents of similar severity: (1) The federal government should develop ways to require industry to identify and manage risk more effectively in light of rapid changes in technology in the oil and gas industry; (2) government institutions would have to demonstrate greater independence, capability, and integrity; and (3) government agencies would need adequate resources and qualified staff to exercise effective oversight. The Oil Spill Commission members have issued a follow-up report noting that much remains to be done to fully execute the Commission's recommendations, including but not limited to improvement in Interior's regulatory programs, congressional action to codify key Commission recommendations, a number of specific actions in the categories of spill response and containment, and ensuring adequate resources to effectively oversee offshore oil and gas development.[64]

Since the Commission's report was issued in January 2011, Interior has adopted a series of major regulatory and organizational reforms touching on almost every aspect of offshore oil and gas development, including drilling safety, workplace safety, and environmental protection. The oil and gas industry has also taken steps to improve its offshore operational integrity and its ability to prevent and respond to such incidents. More than 30 companies joined the industry-sponsored Center for Offshore Safety, which was established by the American Petroleum Institute after the *Deepwater Horizon* disaster. The Center was established to serve the U.S. offshore oil and gas industry "with the purpose of adopting standards of excellence to ensure continuous improvement in safety and offshore operational integrity."[65] Meanwhile, Interior has also sought to respond to the Commission's call for greater independence and separation between the different oversight functions formerly housed within MMS; as the Commission pointed out, the organizational structure of MMS at the time of the spill inevitably produced conflicts and tensions among the agency's competing missions of promoting resource development, enforcing safety and environmental regulations, and maximizing revenues from offshore leases. Interior has now established three new and independent bureaus to handle each of these functions as recommended by the Commission.[66]

While post–*Deepwater Horizon* reforms are still new and it is too early to fully evaluate their impacts, by the end of 2012 permit approvals had generally returned to pre-spill levels for most types of wells as operators and regulators worked through the new system. Analysts at Wood Mackenzie estimate that production in the Gulf could reach up to two million barrels per day by 2018/2019 (compared with 1.3 million barrels per day in 2011[69]), and expect "more than US$70 billion to be spent on exploration in the region by 2030, more than all the other key deepwater provinces combined."[70] These production expectations for the Gulf "are materially surpassed only by Brazil."[71] Numerous other oil and gas market analysts hold similar views.[72]

A significant issue from the standpoint of expanding domestic offshore oil and gas production is the ability to access new areas offshore. Under existing law, Interior's leasing program for OCS areas is governed by a series of

Advances in Well Containment

In July 2010, realizing that industry needed to develop deepwater well–containment capability to ensure comprehensive response to any future deepwater well–control incidents, two industry groups came together to develop comprehensive well-capping and containment solutions. Both Marine Well Containment Company (MWCC) and the Helix Well Containment Group (HWCG) were developed as not-for profit well-containment cooperatives for the Gulf of Mexico.

The founding companies of the MWCC recognized the need to be better prepared in the event that an operator lost complete control of a well and was subsequently unable to contain it. As a result, in February 2011, MWCC's interim containment system became available for use in the U.S. Gulf of Mexico. The interim capping and containment system improves the industry's ability to respond to a complete loss of well control in the deepwater of the U.S. Gulf of Mexico. The company has expressed its commitment to being continuously ready to respond to a well- control incident in the Gulf and is committed to advancing its capabilities to keep pace with its members' needs. Membership is open to all oil and gas operators in the U.S. Gulf of Mexico.

Twenty members of Clean Gulf Associates—a Gulf of Mexico oil spill response cooperative—came together along with Helix Energy Solutions Group (a company deeply involved in the *Deepwater Horizon* response) to develop what has become the Helix Well Containment Group (HWCG). Soon after formation, HWCG grew to 24 member companies. HWCG has developed a deepwater well–containment response system capable of being immediately deployed in the event of a deepwater well–control incident. Further, each HWCG member company has committed to a mutual-aid agreement, allowing any member to draw upon the collective technical expertise, assets, and resources of the group.

In May 2012, Secretary of the Interior Ken Salazar directed MWCC to conduct a live drill as an opportunity to deploy systems, test readiness for a worst-case scenario, and train under real-time conditions.[67] In July 2012, the Bureau of Safety and Environmental Enforcement (BSEE) announced the successful full-scale deployment of the well-control equipment.[68] HWCG will complete a similar deployment exercise in the future.

five-year plans. The current five-year plan covers 2012 to 2017 and includes lease sales in the Western and Central Gulf of Mexico, the Arctic, and in the small portion of the Eastern Gulf of Mexico currently not under a congressionally mandated moratorium.[73] Although an early draft of the five-year plan allowed for leasing in areas off the Mid- and South Atlantic states, the final version does not include any lease sales in the Atlantic but does allow seismic surveys to be conducted in this region in order to begin assessing the extent of the resources.[74]

Interior's new five-year plan was finalized in June 2012. It will make all remaining un-leased acreage in the Western and Central Gulf of Mexico available in five annual lease sales for each area, beginning in the fall of 2012 for the Western Gulf and the spring of 2013 for the Central Gulf. Areas of the Eastern Gulf of Mexico that are not currently under congressional moratorium will be made available in two sales scheduled for 2014 and 2016. Two additional areas off the shore of Alaska, one in the Chukchi Sea and one in the Beaufort Sea, will be made available in 2016 and 2017, respectively. In both cases, Interior has scheduled these lease sales later in the five-year period to allow additional time for environmental studies and for bolstering response capabilities in the case of an accident.[75] Of course, completion of the five-year leasing plan is only a first, albeit important, step. Additional environmental reviews and significant coordination with other federal agencies, as well as with state, local, and tribal governments, are needed before lease sales can go forward and before plans for resource assessment (seismic), exploration, development, and production can be approved.

In parallel with these changes, the 2010 Presidential Executive Order 13457 has established a National Ocean Council, composed only of members from federal agencies, to support policy goals for stewardship of the ocean, the coasts, and the Great Lakes. Among the stated national ocean policies are many relevant to offshore energy production, including supporting "sustainable, safe, secure, and productive access to, and uses of the ocean."[76] The executive order calls for reliance on coastal and marine spatial planning (processes similar to land-use planning but directed at coastal and marine resources) as a platform to better inform actions affecting the ocean and development of the resources located there, because such planning relies on ecosystem-based management, using the "best available science and knowledge to inform decisions affecting the ocean, promoting efficiency and collaboration, and strengthening regional efforts. Coastal and marine spatial planning identifies areas most suitable for various types or classes of activities in order to reduce conflicts among uses, reduce environmental impacts, facilitate compatible uses, and preserve critical ecosystem services to meet economic, environmental, security, and social objectives."

Coastal and marine spatial planning offers a promising framework to provide greater transparency and collaboration that could lead to increased access to the areas of the Outer Continental Shelf not now open for development. Engaged stakeholder processes will have an important role to play in developing the discipline of Ecosystem Based Management. They should include balanced participation from all affected interests.

Recommendations for Offshore Oil and Gas Production

RECOMMENDATION: Expand access to oil and gas exploration and production in the Eastern Gulf of Mexico and accelerate the timetable for leasing off the Mid- and South Atlantic states, provided that the areas involved have been reviewed and approved based on a rigorous coastal and marine spatial planning process.

Expand Access in the Eastern Gulf of Mexico

Although the Gulf of Mexico has been a key source of oil and gas production for decades, recent advances in technology and favorable market conditions have made the Gulf of Mexico one of the premier plays for deepwater and ultra-deepwater drilling. Responsible development of our Gulf of Mexico resources can help to further expand domestic oil and gas production, preserve and create domestic jobs, and support the local and regional economies of the Gulf States.

The United States has the ability to build upon these economic gains by expanding access to oil and gas drilling in the Eastern Gulf of Mexico. The Bureau of Energy Management estimates the U.S. Gulf of Mexico overall holds over 48 billion barrels of oil and nearly 220 trillion cubic feet of natural gas.[77] Of this amount, over five billion barrels of oil and 16 trillion cubic feet of natural gas are located in the Eastern Gulf.[78] While this amount might seem relatively small compared with estimates for the entire Gulf, resource assessments can change dramatically over time as exploration proceeds and new geological and geophysical data and information become available, as analysts refine their methodologies for estimating resources, and as new technologies enable the production of previously unrecoverable oil and gas. For example, the 1996 MMS resource assessment estimated the Gulf of Mexico held 8.3 billion barrels of oil; those estimates were revised upward to 37 billion in 2001 and 45 billion in 2006.[79] Natural gas estimates from MMS resource assessments have demonstrated a similar upward pattern. Given the lack of exploration in the Eastern Gulf to date coupled with the rich resources in the region as a whole, there is ample reason to believe that exploration in the Eastern Gulf of Mexico would yield substantial new resources, production, and attendant economic benefits.

In 2006, Congress passed the Gulf of Mexico Energy Security Act (GOMESA). Among other measures, GOMESA established a moratorium through 2022 on drilling for a small portion of the Central Gulf of Mexico Planning Area and the majority of the Eastern Gulf of Mexico Planning Area.[80] Though many concerns affect access to the resource, including the use of these waters for military training purposes, potential environmental impacts, and tourism issues, we concluded that it is time for Congress to revisit this issue. Given the major advances in deepwater drilling technology and safety, and the abundant resources likely to be found in the Eastern Gulf, the country should allow access in this region. Key stakeholders, including Florida officials, the Department of Defense, commercial and recreational users, and the National Ocean Council, should work together to identify substantial new acreage in the Eastern Gulf that could be opened to exploration and production in concert with other, ongoing activities, and request that Congress remove the moratorium in these areas and direct Interior to re-open the current five-year program to pursue new lease sales in these areas.

Accelerate Leasing off the Mid- and South Atlantic Coasts

In March 2010, Interior released its *Preliminary Revised Program: Outer Continental Shelf Oil Leasing Program 2007–2012.* Included in the revised program was a proposal to open the Mid-Atlantic to offshore drilling with a new lease sale off the coast of Virginia.[81] The proposed lease sale was eventually cancelled, and new lease sales in the region were not included when the final 2012–2017 OCS leasing program was released. Interior cited a lack of oil spill response capability and Department of Defense conflicts as the primary impediments to including lease sales in this region. Although not making any Atlantic acreage available for lease in the 2012–2017 five-year plan, Interior decided to move forward with a Programmatic Environmental Impact Statement (EIS) for conducting seismic surveys only off the Mid- and South Atlantic coasts to gain a better understanding of the potential resources in the region.[82]

Existing estimates of the amount of oil and gas in the Atlantic are relatively small compared with other offshore areas, largely due to the limited seismic and exploration data available to assess the resource endowment in this area. Interior's final OCS leasing program for 2012–2017 stated: "Current [geological and geophysical] information regarding oil and natural gas resource potential in the Mid- and South Atlantic is based on older data collected in the 1970s and 1980s.[83] Tremendous advances in instrumentation and technology for the acquisition and analysis of G&G data have been made in the intervening decades." Without question, seismic surveys in the region are needed, and will help to begin the process of better characterizing potential resources there.

But seismic surveys are expensive, and these costs will be borne by industry. Though the current 2012–2017 program sends strong signals that leasing will eventually be allowed along the Atlantic coast, industry is unlikely to undertake costly seismic surveys without firm assurances that exploration and production will be possible. Further, proposed restrictions on seismic surveys in the draft of the Programmatic Environmental Impact Statement (PEIS) would make them even more expensive and potentially impossible to conduct. As the PEIS indicates, concerns have been raised about potential adverse effects on marine mammals from techniques used in the surveys.

Exploration is needed to understand the resource base and to confirm reserves discovered through the seismic surveys. Indeed, Secretary of the Interior Ken Salazar noted in his "Statement and Summary" in the revised 2007–2012 program that "the lack of recent data on the potential resource base in the Mid-Atlantic area can only be remedied by opening at least a portion of the planning area to potential leasing and exploration."[84]

One way to move forward would be to rely on coastal and marine spatial planning processes to help promote an open, collaborative, regional, and science-based approach. In many parts of the Mid- and South Atlantic offshore areas, existing regional ocean organizations (such as the Mid-Atlantic Regional Council on the Oceans) are developing platforms and portals for making information about ocean resources better available for public policy and private-investment decisions. The National Ocean Policy Coalition is another organization of diverse interests founded to ensure that the creation and implementation of a new National Ocean Policy proceeds in a way that it is helpful to the national interests, including the interests of commercial and recreational users of the oceans and marine-related natural resources as well as other stakeholders. Working in connection with the National Ocean Council, coastal and marine spatial planning could provide a way to bring all stakeholders—including the federal agencies with jurisdiction and interest, states, the energy industry, commercial fishing and transportation industries, fisheries organizations, environmental groups, and other interested parties—to the table to discuss these issues.

In conjunction with such planning processes, we recommend Interior consider re-opening its current five-year plan to include at least one lease sale in the Atlantic. Scheduling a lease in the region sale would provide industry the assurances it needs to undertake seismic surveys, while working through the ocean planning process to assure others that access would occur in appropriate places and ways in the future.

Current Issues and Challenges in Onshore Oil and Gas Development

This section focuses on the permitting and licensing procedures that govern private developers' abilities to access federal and tribal lands. These are obviously some of the areas where the federal government has the most direct leverage to promote expanded domestic production while insisting on high standards of environmental and safety performance. The U.S. Bureau of Land Management (BLM) and other federal agencies have a long history of managing natural resource extraction and balancing private development activities with the range of multiple uses on the federal government's extensive land holdings. However, demands on these agencies have grown enormously over the past decade without a commensurate increase in staff and funding available for carrying out their expanded stewardship responsibilities. The number of employees in the Energy & Minerals Management division of the Bureau of Land Management, for instance, grew 14 percent between 2003 and 2012 to 1,132 employees. The budget appropriation for Energy & Minerals Management, however, has remained relatively constant at $106 million (in nominal dollars) in 2003 to about $108 million in 2012.[85] In addition to the federal government's appropriations, the Energy & Minerals Management division's budget is supplemented through cost-recovery mechanisms, such as fees on applications for permits to drill. Total intake from cost-recovery mechanisms has ranged from about $20 to $30 million over the past four years.[86]

This lack of commensurate resources to match the agency's increased responsibilities has had a rather clear impact on oil and gas development on federal lands. In 1998, only 1 percent of leases drew protests, whereas in 2009 half of proposed leases drew protests.[87] Many of these cases stem from poorly managed environmental reviews and mitigation efforts by BLM. A 2005 report by the General Accounting Office concluded that "BLM's ability to meet its environmental mitigation responsibilities for oil and gas development has been lessened by a dramatic increase in oil and gas operations on federal lands over the past 6 years," and pointed to a tripling in the number of permits approved from 1999 to 2004 as a key indicator of the agency's increased workload.[88] BLM officials interviewed for the report identified the lack of resources to meet the agency's oil and gas program needs as a key challenge, and that appeals and litigation of agency decisions had further exacerbated workload pressures.[89] A number of onshore leasing plans, energy projects, and permits have been suspended, substantially reduced, or canceled altogether in recent years as a result of court rulings that Interior had not met its statutory obligations for environmental reviews (see Appendix A). We support the right to protest and challenge Interior's leasing decisions, but the agencies must have the tools and resources to objectively balance considerations of multiple uses and environmental protection in a consistent manner. Otherwise, litigation and challenges by stakeholders will continue to slow the leasing process.

In recent years, BLM has undertaken a number of reforms aimed at improving the leasing and permitting process for energy projects on federal lands. In January 2009, for example, Secretary Salazar proposed changes in the approach to individual lease sales, steps to increase public involvement in leasing decisions, a more proactive process to identify areas for future lease sales, as well as reducing the use of "categorical exclusions" from the environmental review process for oil and gas drilling activities on BLM lands.[90] At the same time, the federal government has taken steps to improve coordination, both within the Department of the Interior and with other agencies involved in overseeing energy development and managing public lands and associated natural resources.[91] According to the administration, these reforms have begun to reduce the number of leases that are being challenged. The White House reports that since the implementation of recent reforms, the number of protests has fallen 20 percent below FY2009 levels.[92]

Despite progress by the administration in reducing the number of protests and challenges, the results of a recent BPC survey of oil and gas developers suggest continued frustration among oil and gas producers about the efficiency of leasing and permitting processes for onshore development on federal lands.[93] Virtually all of those surveyed expressed concern about the lack of federal staff and resources, and noted that BLM does not have enough resources to effectively implement the job assigned by Congress and required by producers and stakeholders. There is also concern over inconsistency in interpretation and implementation of federal rules from one BLM office to another. The lack of BLM resources and inconsistency in the conduct of leasing and permitting decisions among BLM regional and field offices in particular can result in additional litigation and legal challenges from stakeholders who believe projects are receiving inadequate reviews. Litigation further compounds the workload of BLM.

In addition to a lack of resources and the ensuing problems with responsiveness at BLM, redundancies and inefficiencies in leasing and permitting processes combined with changing regulatory requirements have produced lengthy lead-times and substantial uncertainty. According to the survey findings, onshore, oil and gas producers of federal lands (regulated by BLM and U.S. Forest Service (USFS)) are reporting that the processes for obtaining permits to drill is taking longer and, in some cases, impacting the attractiveness and viability of oil and gas projects. This process, which now takes far more time to complete, includes: obtaining permits to drill, completions of environmental work as required under the NEPA [National Environmental Policy Act], issuances of seismic permits and approvals for rights of way (ROW).[94]

The survey findings also indicate that recent permitting reforms, albeit still relatively new, are having limited success in addressing industry's concerns—indeed some producers report that the leasing and permitting process has become, if anything, more complicated rather than less.[95] According to at least one survey respondent, his company is "de-emphasizing" operations on federal lands, because it has become too difficult and time-consuming to obtain permits. All of this suggests that inefficiencies in leasing and permitting, combined with the increasing commercial attractiveness of shale gas and oil opportunities on private lands elsewhere in the country, are playing a role in the recent decline of permit requests for new development on federal lands.

A set of specific policy recommendations aimed at improving the leasing and permitting process for onshore oil and natural gas development on federal and tribal lands follows.

Recommendations to Improve Permitting and Leasing for Onshore Oil and Gas Production on Federal Lands

1) **Adequate Resources –** Provide regulators at the federal and state level, particularly BLM, with sufficient funding to ensure adequate personnel, training, technical expertise, and effective enforcement to responsibly and efficiently provide oversight of industry activities. Resource allocation should be more correlated with activity level and flexible enough to respond to changing dynamics across the country's different regions.

2) **Consistent Requirements, Guidance, and Timelines –** Federal land managers should ensure that requirements for permits and approvals are consistent in field offices and across the agencies. Requests for information should be consistent, based on established criteria, understood by operators and leaseholders, clearly communicated early in the process, and based on guidance agreed upon by Washington, D.C. headquarters as to what is required by statute and under NEPA. Regulators (federal and state) should work with operators/lessees to identify duplicative processes and requirements with a view toward consolidating processes wherever possible.

   Similarly, clear and consistent protocols should be established for communications and timelines for coordination between land managers and operators/lessees. Applicants should be given a clear written understanding of what information is required of them and why; such information requests should be based upon consistent and supported guidance with inquiries from applicants being responded to promptly. Timelines for decisions should be established early in the process and agency personnel should aim to meet established deadlines and be accountable for doing so.

3) **Commission to Identify Opportunities for Regulatory Reforms –** The Department of the Interior should create a commission or task force to review the permitting and approval process and identify solutions. This commission should be composed of current or former federal and state agency personnel, energy producer and service company representatives, academic experts, and NGOs. The commission should review and assess the feasibility of various reforms and solutions such as those proposed in this report and develop implementation recommendations and strategies. Specifically, the commission should assess:

– Master Leasing Plans and other reforms that some believe have complicated the process.

– The number and requirements of permits and approvals needed from federal agencies, with a goal of creating a more efficient leasing and permitting process.

– How other countries, in particular Canada, issue and approve regulations and consult with stakeholders to address local concerns.

– Ways to improve communication among federal agencies and with producers, lessees, and operators, and how to establish and meet clear goals and timelines.

– Creating consistent guidance for reporting and information requirements.

– How planning can ensure adequate resources are provided to offices and options for more efficient sharing of resources and information.

– Opportunities to further reduce legal challenges to leasing and permitting decisions.

4) **Litigation Transparency –** Litigation of oil and gas leasing and permit decisions is common in the United States. Some of these actions lead to court-approved settlement agreements that federal agencies enter outside the normal open rule-making process. We recommend that processes be put in place to ensure public notice of such litigation is sufficient to allow other parties to comment and to participate in both the claims and proposed settlement actions. Settlements should encourage sound environmental protection policy while avoiding unreasonable restrictions to exploration and development.

5) **Statistics for Energy Projects on Federal Lands –** Interior should improve its systems for collecting, managing, and disseminating data relevant to energy projects located on federal lands. Specifically, Interior should maintain timely statistics for energy project leasing, permitting, and energy production on federal lands and on the OCS, and should make both current and historic data available to the public in user-friendly formats. Additionally, Interior should use similar definitions for each type of energy production (e.g., oil, natural gas, geothermal, solar, wind, etc.). Data for onshore and OCS energy projects should be provided in terms that are directly comparable.

Environmental Performance of Onshore Oil and Gas Development

Though the rapid expansion of domestic shale oil and gas development has been central to America's "good news" energy story, the industry faces a number of ongoing challenges—from concerns over the environmental impacts of hydraulic fracturing[96] to the need to meet growing infrastructure, water, and labor demands. Many of these issues are explored in our January 2012 report, *Shale Gas: New Opportunities, New Challenges,*[97] which identified the potential impacts of natural gas development on water supplies, wildlife habitat, air quality, and traffic along with management and disposal of wastewater, land-use tensions, and other cumulative effects on communities as some of the most important challenges for the industry.

Since the issuance of our shale gas report, a number of states have continued to work on strengthening and coordinating rules for unconventional oil and gas production. While many states have a long history of regulating oil and gas development, other states have found that new rules were needed to ensure proper oversight and are working to develop and implement them. These efforts are proceeding in parallel with a number of voluntary industry actions, as well as industry-stakeholder collaborations to address common concerns. The State Review of Oil & Natural Gas Regulations (STRONGER), a public, private, and government partnership, conducts reviews of state oil and natural gas regulations. To date, STRONGER has reviewed and advised on 22 state programs, representing over 94 percent of domestic onshore oil and gas production.[98] STRONGER review teams made recommendations for program improvements following each state review, and follow-up review teams documented that 76 percent of the recommendations from earlier reviews had been implemented.[99] Similarly, the Interstate Oil and Gas Compact Commission—a multi-state government agency—tracks, evaluates, and disseminates information on best practices at the state level.[100]

Other organizations—notably the Natural Gas Subcommittee of the Secretary of Energy Advisory Board (SEAB) and the National Petroleum Council (NPC)—have released their own recommendations to improve safety and mitigate community and environmental impacts from shale gas development, and significant progress has been made since these reports were released. Important efforts to develop best practices are either underway or have been recently completed by the American Petroleum Institute, the Marcellus Shale Coalition, and the Appalachian Shale Recommended Practices Group.

Though commendable, these particular industry-led efforts do not satisfy the SEAB or the NPC recommendations that the "board of directors" or "governance structures" of these best practices efforts include stakeholder participation from experts in "non-governmental organizations and academic institutions" or "other interested parties."[101]

Similarly, progress has been made on disclosure of the chemicals used in fracturing fluids through the Groundwater Protection Council's FracFocus database, which now contains data on more than 35,200 well sites.[102] But more work remains to be done in order to meet the SEAB and NPC report recommendations for universal disclosure, as some companies participating in the voluntary FracFocus program are not reporting data on all of their well sites.

Progress on air emissions associated with hydraulic fracturing also is evident. In April 2012, the Environmental Protection Agency (EPA) finalized emissions standards for new and re-fractured oil and gas wells to significantly reduce air emissions.[103] Similarly, an academia-NGO-industry collaboration to measure methane emissions from natural gas wells promises to provide sorely needed data.[104] The EPA has announced that it will develop a draft rule on hydraulic fracturing wastewater discharge that will help to protect groundwater supplies, and nine states currently require operators to test nearby water wells prior to drilling.[105] Appendix B provides a more detailed review of progress in fully implementing the SEAB and NPC recommendations.

Recommendation to Improve Environmental Performance of Onshore Oil & Gas Development

RECOMMENDATION: Implement the SEAB and NPC environmental performance recommendations.

We endorsed the SEAB and NPC recommendations in our January 2012 report, *Shale Gas: New Opportunities, New Challenges,* and we reiterate our support for their implementation. Efficient and environmentally responsible production of shale oil and gas resources has the potential

Hydraulic Fracturing on Federal Lands

Another major issue for federal land managers, for the oil and gas industry, and for environmental groups and other stakeholders is the regulation of hydraulic fracturing operations on federal lands. As BLM has pointed out, "current BLM regulations governing hydraulic fracturing operations on public lands are more than 30 years old and were not written to address modern hydraulic fracturing activities."[106]

In May 2012, the Department of the Interior released a draft rule that would establish new requirements for hydraulic fracturing on federal lands. The draft rule contains a number of changes that were recommended by SEAB.[107] Key provisions include a requirement that developers disclose which chemicals are used in the fracturing fluid; new minimum criteria for well-bore integrity, as well as new testing and monitoring requirements; and measures to address the management and disposal of wastewater from hydraulic fracturing operations on federal and tribal lands.[108] The comment period on Interior's draft rule closed in early September 2012.[109] In January 2013, BLM announced that in response to comments from stakeholders and the public, it has pulled back its proposed rule and will publish a new draft proposal in the first quarter of 2013.[110] One issue that BLM has sought particular input on is "how best to avoid duplication of requirements under this proposed rule with existing state requirements."[111] This is a significant concern for the industry as well, which has regarded the development of the BLM rule and with a number of separate EPA studies of hydraulic fracturing impacts[112] with some wariness. BLM, industry, and other stakeholders should work together to ensure the new rule does not simply duplicate existing state regulations and is sufficiently sensitive to differences in regional geology, while also implementing technical and reporting requirements as efficiently as possible.

to transform the nation's economic and energy security. While new shale oil and gas resources provide exceptional opportunities for the country, the environmental challenges are clear and need to be addressed. The recommendations made by the SEAB and the NPC lay out a clear path forward to improve safety and mitigate community and environmental impacts from shale gas development. Though we are encouraged by the progress made to date, significant work remains to be done.

Coal

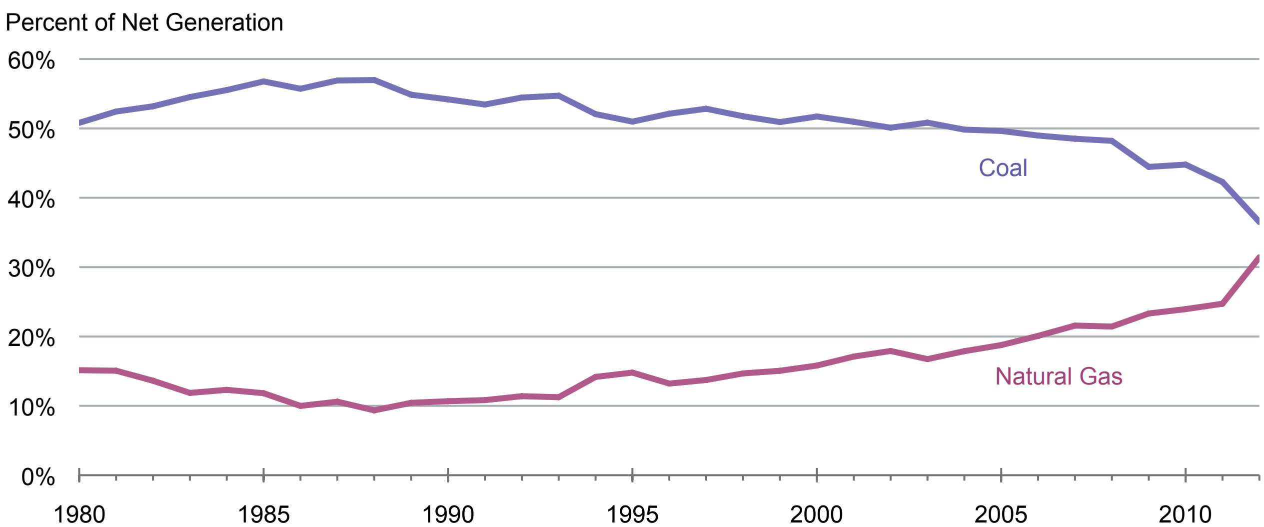
Coal has been an important energy source in the United States for well over a century, with the electric power sector becoming the dominant consumer of coal over the last 60 years. Today, electric power generation accounts for 91 percent of U.S. coal consumption (in 1950, the figure was 19 percent), and for decades nearly half the nation's electricity supply was generated using coal, although in the past few years this percentage has declined (Figure 2-10.)

In addition, coal is a major contributor of baseload power—plants that operate essentially all of the time at nearly constant output.[113]

From an energy security standpoint, coal is also important because it is America's most abundant fossil fuel resource. In fact, the United States is thought to have the largest recoverable reserves of coal in the world, with a demonstrated resource base totaling nearly 500 billion short tons[114] compared with current consumption of roughly one billion short tons per year.[115]

In recent years, however, falling natural gas prices and EPA regulations have prompted a shift away from coal and toward natural gas in the electric power sector. Increasingly, gas-fired generators—which used to operate primarily during peak demand periods—are being dispatched ahead of coal. At the same time, the number of announced coal plant retirements continues to mount as changing market dynamics and additional environmental regulations (see Table 2-1) put increasing pressure on the smaller, older,

Figure 2-10: U.S. Electricity Generation by Fuel, 1980-2012



Note: 2012 includes electricity net generation for January through September.
Source: U.S. Energy Information Administration, "Table 7.2a Electricity Net Generation: Total (All Sectors)," *Monthly Energy Review*, December 2012, http://www.eia.gov/totalenergy/data/monthly/pdf/sec7_5.pdf.

Table 2-1: Recent Power Sector Environmental Regulations

Authorizing Law	EPA Regulation	Status/Description
1990 Clean Air Act (CAA)	**GHG New Source Performance Standards (NSPS)** *Proposed Rule: March 2012* *(not yet final)*	First national GHG standards for new coal/oil power plants, not yet permitted or under construction. *Expected in future:* CAA tasks EPA with issuing guidance for state regulation of existing power plants, once NSPS has been issued for new plants.
	Mercury and Air Toxics Standards (MATS) *Final Rule: December 2011*	First national standards for hazardous air pollutants from new and existing coal/oil power plants.
	National Ambient Air Quality Standards (NAAQS) *2008 ozone standard* *2010 SO2 standards* *2012 particle pollution standards*	Since 1970, CAA has required EPA to set air quality standards and update every 5 years. States that exceed standards develop plans to reduce pollution. CAIR & MATS requirements help states meet air quality standards.
	Clean Air Interstate Rule (CAIR) *Final Rule: March 2005*	Reduces pollution that drifts across state lines and exceeds health/NAAQS standards in downwind eastern states. Overturned by court, but ordered to remain in effect after replacement rule was also overturned by court.
	Regional Haze *Final Rule: 1999* *BART Guidance: 2005*	In some areas not covered by CAIR, states require retrofits to reduce pollutants that impair visibility in national parks and wilderness areas.
1970s Clean Water Act	**Cooling Water Intake Structures** *Proposed March 2011 (not yet final)*	Regulates power plants that pull large amounts of water from oceans, lakes, and estuaries for cooling
1970–1984 Resource Conservation & Recovery Act (RCRA)	**Coal Combustion Residuals** *Proposed June 2010 (not yet final)*	Regulates disposal of coal ash after December 2008 spill in Tennessee

Sources: Clean Air Act Amendments of 1990, Pub. L. No. 101-549 (1990); U.S. Environmental Protection Agency, “Carbon Pollution Standard for New Power Plants,” May 25, 2012, http://www.epa.gov/carbonpollutionstandards/index.html; U.S. Environmental Protection Agency, “Mercury and Air Toxics Standards (MATS),” March 27, 2012, http://www.epa.gov/airquality/powerplanttoxics/; U.S. Environmental Protection Agency, Air and Radiation, “National Ambient Air Quality Standards (NAAQS),” December 14, 2012, http://www.epa.gov/air/criteria.html; U.S. Environmental Protection, Clean Air Markets, “Clean Air Interstate Rule (CAIR),” August 21, 2012, http://www.epa.gov/cair/; U.S. Environmental Protection Agency, “EPA’s Regional Haze Program,” May 31, 2012, http://www.epa.gov/visibility/program.html; Federal Water Pollution Control Amendments of 1972, Pub. L. No. 92-500 (1972); Clean Water Act of 1977, Pub. L. No. 95-217 (1977); Water Quality Act of 1987, Pub. L. No. 100-4 (1987); U.S. Environmental Protection Agency, “Cooling Water Intake Structures—CWA §316(b),” September 27, 2012, http://water.epa.gov/lawsregs/lawsguidance/cwa/316b/index.cfm; Resource Conservation and Recovery Act, Pub. L. No. 94-580 (1976); U.S. Environmental Protection Agency, Wastes - Non-Hazardous Waste - Industrial Waste, “Coal Combustion Residuals,” November 15, 2012, http://www.epa.gov/osw/nonhaz/industrial/special/fossil/coalashletter.htm.

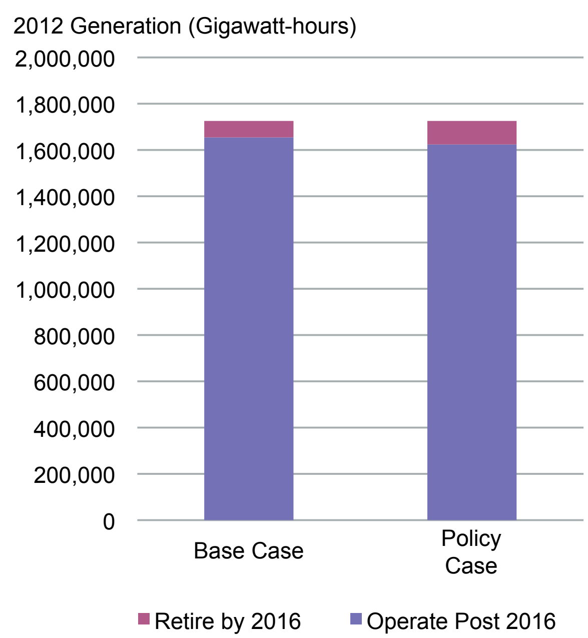
and less-efficient coal generators in the fleet. Many of these units are increasingly unable to compete economically with gas-fired generators in the short term and do not justify the investments in pollution control that would be needed to operate in the future.

According to a recent tally by the Brattle Group, companies have announced 30 gigawatts of coal-fired capacity slated for retirement by 2016.[116] The American Council for Clean Coal Electricity estimates that 31 gigawatts of coal capacity are scheduled for retirement or conversion to a different fuel. Additional retirement announcements are possible, particularly in regulated markets where such decisions may require a longer lead time. Meanwhile, the EIA is projecting that some 49 gigawatts of coal-fired capacity, representing roughly one-sixth of existing coal capacity, will be retired by 2020.[117] The most recent analysis by BPC staff projects that 426 coal-fired electric generating units with total capacity of 39 gigawatts will retire due to market conditions (reference case), and an additional 107 coal-fired generating units with total capacity of 16 gigawatts will retire due to air regulations by 2016 (policy case).[118] Figure 2-11 shows the share of electricity currently generated by the units that are projected to retire in the BPC analysis in both the reference and policy cases. In future years, the lost generation from retired units will be replaced by a combination of energy efficiency and demand response, existing generators, and a diverse portfolio of new capacity additions.

A clear shift toward natural gas is also evident in the pattern of planned capacity additions. Natural gas units accounted for 81 percent (nearly 237 gigawatts) of new capacity added to the overall U.S. electric system between 2000 and 2010 (excluding energy efficiency resource additions).[119] EIA's reference case estimates that 65 percent of capacity additions between 2011 and 2035 will be natural gas-fired.[120] In the near term, the construction of new coal units is unlikely given rising construction and financing costs for a new coal plant, as well as the consideration of fuel economics and environmental regulations and their compliance costs. These trends are reflected in the changing mix of generators used to meet the nation's electricity needs in recent years. According to EIA's Short-Term Energy Outlook for 2013, coal will be responsible for generating 38 percent of U.S. electricity in 2012 and natural gas will supply 30 percent.[121] However, the price of natural gas delivered to the electric sector is expected to increase by 30 percent in 2013. Because of this increase, coal is expected to supply 39 percent of U.S. electricity in 2013 and natural gas will supply 28 percent.[122]

Clearly, expectations of prolonged low gas prices, along with EPA regulations, will be the main drivers for near- and medium-term investment and retirement decisions in the electric power sector. Nonetheless, coal plays—and is widely expected to continue to play—a very large and vital role in providing reliable and affordable power to serve the U.S. market. Indeed, some analysts contend that more than three-quarters of the existing coal fleet is in a good position to weather changing market dynamics and comply with pending environmental regulations.[123] Longer-term, however, the key challenge for coal is likely to come from policy requirements to reduce greenhouse gas emissions. The industry is responding with deployment of first-of-a-kind coal-based generation technology with a CO_2 footprint comparable to that of natural gas.[124]

Figure 2-11: Share of Electricity Generated by Coal Units Slated to Retire



Source: Jennifer Macedonia and Colleen Kelly, *BPC Modeling Results: Projected Impact of Changing Conditions on the Power Sector*, July 2012, http://bipartisanpolicy.org/library/staff-paper/bpc-modeling-results-projected-impact-changing-conditions-power-sector.

Table 2-2: Estimates of Total Plant and Levelized Electricity Costs for New Coal-Fired Power Plants with and Without CCS Technology (2010 dollars)

With or Without CCS	Total Plant Construction Costs ($ per KW)		Levelized Cost of Electricity ($ per MWh)	
	Supercritical Pulverized Coal Plants	Subcritical Pulverized Coal Plants	Supercritical Pulverized Coal Plants	Subcritical Pulverized Coal Plants
Carnegie Mellon University				
Without CCS	1,788	1,710	55.9	56.0
With CCS	3,237	3,234	97.3	100.8
Premium for CCS	81%	89%	74%	80%
Electric Power Research Institute				
Without CCS	1,888	n/a	65.5	n/a
With CCS	3,138	n/a	111.5	n/a
Premium for CCS	66%	n/a	70%	n/a
Global Carbon Capture and Storage Institute				
Without CCS	1,919	n/a	57.4	n/a
With CCS	3,464	n/a	101.8	n/a
Premium for CCS	81%	n/a	77%	n/a
Massachusetts Institute of Technology				
Without CCS	1,734	1,669	53.1	54.6
With CCS	2,790	2,907	95.4	103.3
Premium for CCS	61%	74%	79%	89%
National Energy Technology Laboratory				
Without CCS	1,637	1,612	63.2	64.0
With CCS	2,895	2,924	107.7	111.3
Premium for CCS	77%	81%	71%	74%

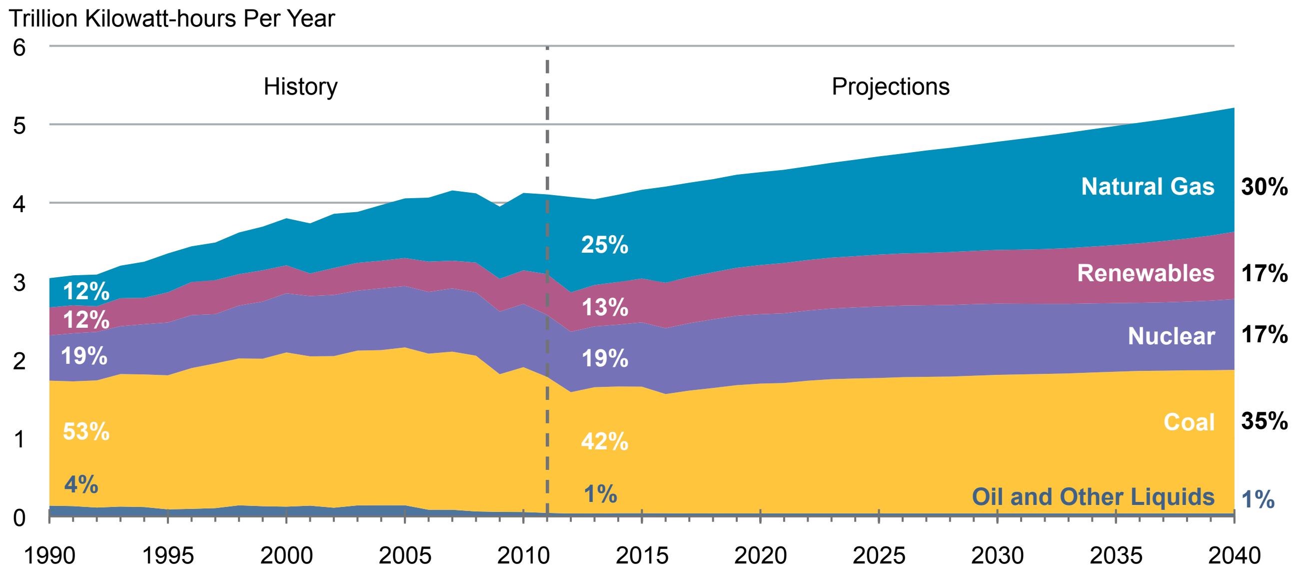
Source: Congressional Budget Office, Federal Efforts to Reduce the Cost of Capturing and Storing Carbon Dioxide, June 2012, 21, http://www.cbo.gov/sites/default/files/cbofiles/attachments/43357-06-28CarbonCapture.pdf.

Therefore, the recommendations for coal focus on further advancing carbon capture and storage (CCS) technology for combustion and gasification systems to enable coal to play a significant role given the potential for future carbon constraints. The development of robust strategies for utilization of this captured CO_2 should be supported in order to provide economic value to support the deployment of this technology.

Issues and Challenges for Carbon Capture and Storage (CCS) Technology

In light of the substantial coal reserves that exist in the United States and elsewhere, and given the widely held expectation that coal will continue to play a major role in the national and global energy mix for decades to come, successful development of a commercially viable technology

Figure 2-12: U.S. Electric Power Sector Generation Mix, 1990-2040



Source: U.S. Energy Information Administration, "Figure 12. Electricity generation by fuel, 1990-2040," *Annual Energy Outlook 2013 Early Release*, December 5, 2012, http://www.eia.gov/forecasts/aeo/er/early_elecgen.cfm.

for mitigating the carbon emissions associated with coal use is deemed by many to be essential.[125] The National Coal Council has emphasized that the use of captured carbon has tremendous potential economic value, and that future efforts should focus broadly on carbon capture, *utilization*, and storage ("CCUS").[126]

The Department of Energy (DOE) and the electric power industry have launched a combination of research and demonstration projects to advance CCS technology.[127] Many of the component technologies needed to implement CCS are mature and already in use in commercial applications. But integrated use of these components at the scale and level of complexity of a full-sized power plant has not yet been demonstrated, and significant technological and cost hurdles remain although several demonstration projects are underway,[128,129] (Table 2-2.)

For example, a major issue with existing technologies for carbon capture is the amount of energy they draw from the power plant in order to function. Reducing this additional energy load is critical to reducing the operating costs of CCS, which currently present a more fundamental hurdle than the technology's initial capital costs. Though additional demonstration projects could be expected to yield engineering improvements that would reduce the additional energy load and drive down costs, the potential for these cost reductions is currently unclear. According to a recent study by the Congressional Budget Office (CBO):

> DOE's CCS-related R&D activities have focused mainly on capturing and storing CO_2. The Department's analysts believe that the current technology for capturing CO_2 could never meet DOE's goal of reducing the cost of CCS-generated electricity. Consequently, DOE has been seeking to develop next-generation CCS equipment and processes that would capture CO_2 more quickly and more completely but use less energy than today's technology does. For example, some DOE-sponsored research involves basic and applied studies to better identify better

materials for absorbing CO_2, and reducing the amount of energy used by the process for capturing the gas.[130]

The challenges that must be overcome to implement the storage component of CCS on a large scale are different. As with the technologies currently available for capture, the component technologies needed to inject captured carbon dioxide into underground reservoirs are relatively well-understood and have been commercially demonstrated in the oil and gas industry. Indeed, enhanced oil recovery,[131] which is already economical, can act as a stepping stone toward the commercial demonstration of storage techniques in the near term. Moreover, storage capacity itself is not likely to present constraints: According to DOE and the International Energy Agency, the United States has enough potential geologic storage to sequester carbon dioxide from coal-fired plants for more than 1,000 years.[132] However, important technical, regulatory, legal, and environmental challenges remain related to large-scale, long-term CO_2 storage. These include issues of long-term reservoir management, mitigation of potential water-quality impacts, leakage/migration, and monitoring techniques. To date, the EPA has issued rules for CO_2 injection under both its Clean Air Act authority for monitoring and reporting fugitive CO_2 emissions and pursuant to the Underground Injection Control program established by the Safe Drinking Water Act. But in many cases regulatory oversight of injection into underground reservoirs is split between the federal government and the states; in addition, no comprehensive, integrated framework for long-term liability is currently in place for CO_2 storage sites.[133]

A longer-term challenge to the widespread deployment of CCS is the infrastructure investment needed to transport captured CO_2. Though pipeline technology is well-developed, issues remain in terms of optimizing the overall transport system, covering the high cost of pipeline materials and maintenance, and gaining public acceptance for siting CO_2 pipelines. This is a critical aspect of CCS because the location of generation may be far removed from the injection locations.

Also, there are many remaining issues related to long-term management and liability of CO_2 storage. A liability framework is needed to address a number of post-injection risks, such as harm to human health or the environment, as well as the potential for leakage of CO_2 and further climate impacts. Given the very long timeframes associated with storage, it will be necessary to eventually transfer some or all of the liability for storage sites from the owner/operator to the federal government. Although there is no comprehensive, integrated framework for long-term liability, several federal and state laws apply to long-term liability. EPA issued a final rule under its Safe Drinking Water Act Underground Injection Control program to require owners/operators to demonstrate financial responsibility through post-injection monitoring and site care.[134]

Recommendations for Advancing CCS Technology

RECOMMENDATION: Available resources for CCS-related RD&D should be balanced among basic research, product/process development, and demonstrations that fully integrate the technology.

We fully support continued investment in select CCS demonstration projects, both current and future. Demonstration efforts should be able to rely on sustained federal investment throughout the technology development cycle lest interruptions in funding dismantle or setback the effort. Priority should be given to investments in CCS demonstrations that are likely to substantially drive down capture costs or offer first-time, full-scale integration and long-term operation of the process. As such, we recommend directing DOE resources toward those technologies that (a) show promise for reducing the extra increment of energy and for achieving reasonable costs to capture carbon dioxide reliably on an ongoing basis, and/

or (b) can be applied to multiple types of fossil fuel–based electricity generation.

DOE's current RD&D program for CCS has two primary objectives: 1) to reduce the added cost of these capture systems no more than 35 percent compared with an identical plant without CCS, and 2) to increase the capture rate to 90 percent of CO_2 emissions.[135] The program received about $3.4 billion from the American Recovery and Reinvestment Act of 2009 and receives approximately $400 million in annual appropriations.[136] The Department's most promising efforts encompass pre-combustion capture, post-combustion capture, industrial carbon capture, and carbon storage/sequestration. DOE is also providing about $2.2 billion to partially fund five of the six CCS demonstration projects currently underway in the United States. (These projects are also receiving about $10 billion in private funding.)[137]

As noted in the foregoing discussion of technical challenges, however, an assessment by the CBO has found that substantial progress in reducing costs is needed to make CCS commercially viable, especially in a regulatory environment where CO_2 reductions are not mandated and thus have little if any market value.[138] While CBO has stated that shifting the focus of DOE's program to put greater emphasis on basic and applied research and development might better achieve the program's goals,[139] eliminating future demonstrations of likely successful CCS technologies would suspend the final step in the CCS RD&D process and thus slow commercialization of CCS technology. Further, without a robust demonstration program providing the large volumes of CO_2 necessary, the key challenges of storage cannot be addressed.

RECOMMENDATION: Working with states, industry, environmental organizations, and other stakeholders, EPA and DOE should take the lead to create a comprehensive, integrated legal framework specifically directed at defining and allocating long-term liability for carbon dioxide storage.

Energy Exports

Increased domestic energy production coupled with domestic energy demand reductions will result in decreased U.S. dependence on net imports of energy. With certain fuels, shifts in domestic supply and demand can result in new opportunities for net exports. In recent years, domestic production of natural gas has been increasing more rapidly than natural gas demand. Expectations of liquefied natural gas (LNG) imports have given way to discussions of LNG exports. In recent years, reduced domestic coal consumption and increased demand in developing international markets have resulted in higher exports of coal. Although the United States already exports many domestically produced fuels to some extent, the rapidly changing dynamics for some of these fuels have raised controversy over the potential for increasing energy exports. While controversy has surrounded other exports, primarily those with potential national security implications, the policy solution rarely has been to completely abandon the nation's traditional commitment to free trade. Given concerns about the persistent U.S. balance of payments deficit, restricting exports that would have the potential to reduce that deficit is particularly problematic.

RECOMMENDATION: Restricting international trade in fossil fuels is not an effective policy to reduce global greenhouse gas emission or to advance domestic economic interests, and we recommend against any such restrictions.

LNG Exports

The rapid advance in shale gas production over the past few years has transformed the outlook for the LNG market in the United States. Less than a decade ago, most market experts were anticipating significant increases in LNG *imports* as domestic natural gas production fell and prices rose. There were numerous proposals to expand existing LNG import facilities and build new import terminals—by 2006, the Federal Energy Regulatory Commission had received

43 such applications.[140] Today, the policy discussion surrounding LNG stands in stark contrast to those years and is instead almost entirely focused on the debate over whether to *export* LNG from the United States. DOE has already approved one permit application for a new export terminal—the Sabine Pass project in Louisiana—and 16 additional applications are under review.[141]

However, this new interest in exporting LNG has raised serious concerns among a number of analysts and policy makers who remember well the high natural gas prices of the 2000s and who worry that exports will drive up natural gas prices. A number of studies over the past few years have examined the impact of LNG exports on domestic natural gas prices. A recent report by the Brookings Energy Security Initiative provides a detailed review of these studies,[142] which found that the impact of LNG exports on natural gas prices ranges from a 2 percent to 11 percent increase compared with a baseline scenario that includes no LNG exports.[143]

In June 2012, Michael Levi of the Council on Foreign Relations released a wide-ranging discussion paper titled *A Strategy for Natural Gas Exports*.[144] His review provides an assessment of the potential benefits and costs of LNG exports that includes macroeconomic and distributional effects, climate change and local environmental impacts, and foreign policy consequences. With respect to the effect of LNG exports on domestic natural gas prices, he states:

> [T]o the extent that allowing exports leads to potentially worrisome rises in domestic natural gas prices, exports are likely to be self-limiting. … Strong increases in domestic prices will make exports less attractive overseas. Large export volumes would most likely close off additional exports before U.S. prices could rise too far.[145]

On balance, Levi concludes that the benefits of LNG exports outweigh the costs "assuming that proper steps are taken to protect the environment," and recommends that DOE should approve the export permit applications, noting that the government "should not encourage exports *per se;* it should simply allow them to occur if properly regulated markets steer the economy in that direction."[146] The Brookings report comes to a similar conclusion and states, "The study recommends that U.S. policy makers should refrain from introducing legislation or regulations that would either promote or limit additional exports of LNG from the United States."[147]

Similarly, a study by Dr. Kenneth Medlock III, of Rice University's James A. Baker III Institute for Public Policy, was unique in that it allowed for the interaction between the domestic and international market for LNG. The Medlock study concluded that "domestic market interactions with the market abroad will determine export volumes and therefore U.S. domestic prices" and that "LNG exports will not likely produce a large domestic price impact."[148]

DOE recently released a long-awaited study by NERA Economic Consulting that examined the macroeconomic impacts of LNG exports.[149] According to DOE, the NERA study is "part of a broader effort to further inform decisions related to LNG exports. … in order to gain a better understanding of how U.S. LNG exports could affect the public interest, with an emphasis on the energy and manufacturing sectors."[150]

The NERA report was positive on the prospects for U.S. exports of LNG. The study authors examined a wide range of U.S. natural gas supply, demand, and export levels, with a top line finding of "net economic benefits from allowing LNG exports" across all scenarios considered, with economic benefits increasing along with levels of LNG exports.[151] In addition, the study found that allowing exports would not affect overall U.S. employment levels and that domestic natural gas price impacts would be minimal across all scenarios considered because importers would not purchase U.S. LNG if wellhead prices rise above the cost of competing supplies.[152] However, the study also found that "impacts will not be positive for all groups in the economy" and that energy-intensive U.S. manufacturers subject to foreign competition may be subject to "[s]erious competitive impacts."[153]

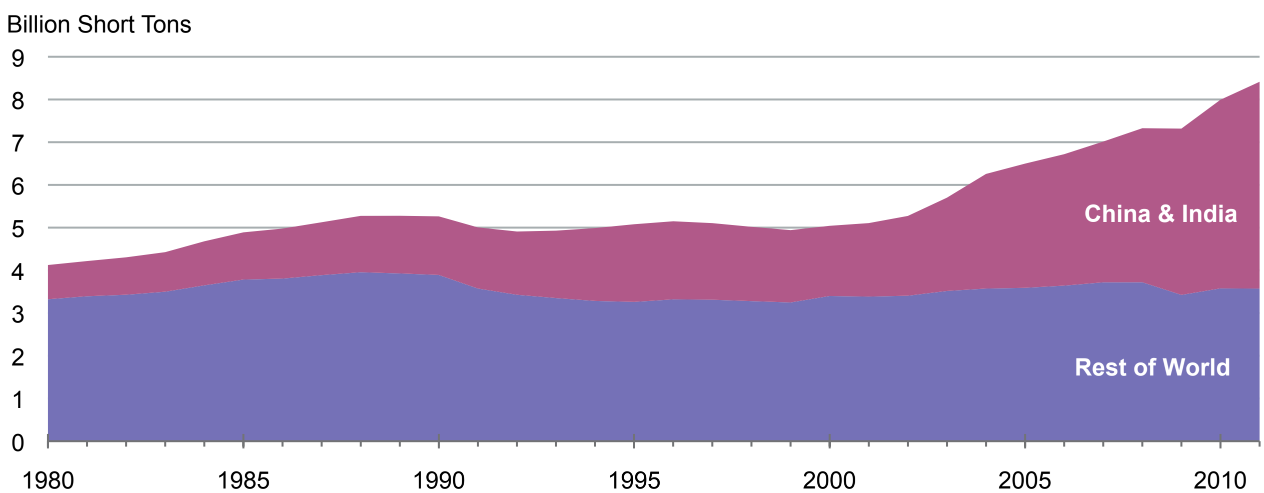
After reviewing these recent studies, we concluded that LNG exports are likely to have only modest impacts on domestic natural gas prices—LNG exports will adjust as domestic prices rise or fall. Moreover, abundant low-cost supplies abroad (particularly from Qatar) and the significant costs of liquefaction and transport from the United States will constrain U.S. export volumes. However, addressing the environmental impacts of shale gas production is a critical precursor to approval of export permits. Our previous report, *Shale Gas: New Opportunities, New Challenges,* outlined the environmental issues surrounding shale gas production, and other sections of this report provide recommendations to address these challenges. So long as state and federal regulators—along with both industry and stakeholders—continue to make strides to mitigate the environmental impacts of shale gas production, the federal government should approve permit applications.

Coal Exports

U.S. coal exports have risen sharply over the past several years—in fact, more than doubling since 2006—as a result of growing worldwide demand for coal.[154] While U.S. coal exports dipped in 2008, they continued to climb steeply from 2009 through 2011, with the largest increases in exports going to South Korea, Japan, the Netherlands, China, and the Ukraine.[155] While metallurgical coal drove much of the increase in total coal exports from 2009 to 2011, representing about two-thirds of exports in those years, steam coal has been driving much of the increase in total coal exports in 2012, accounting for 95 percent of the estimated annualized increase in 2012 coal exports.[156]

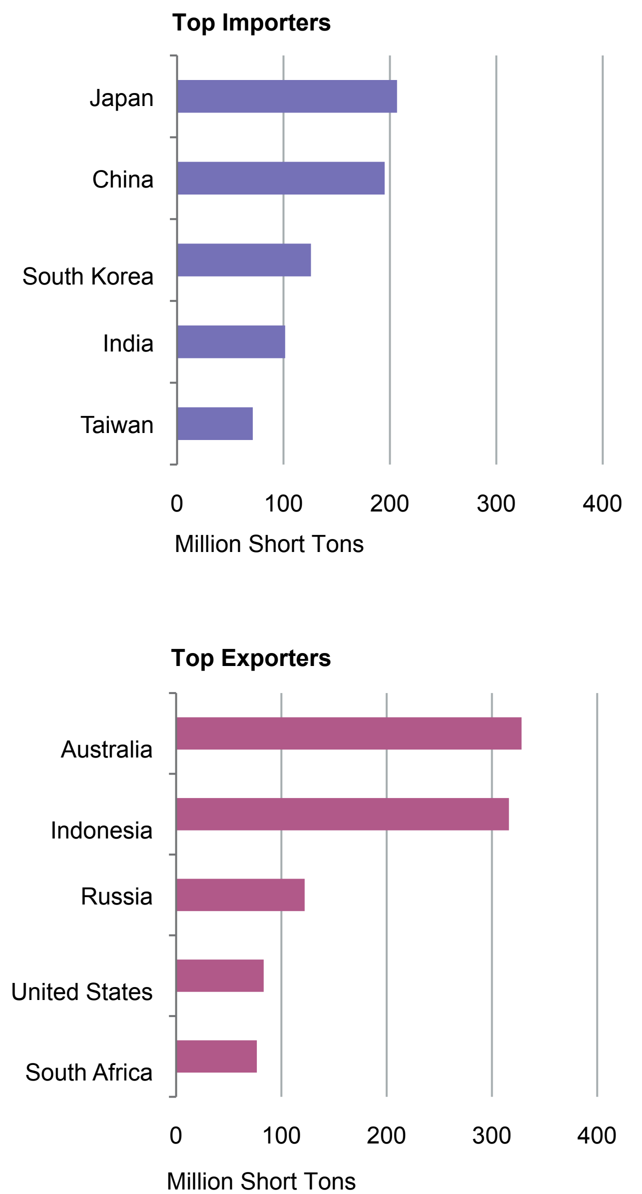
According to EIA, global energy consumption will increase by more than 50 percent by 2035, with the majority of this increase coming from countries that are not members of the Organisation for Economic Co-operation and Development (OECD).[157] Coal use during this timeframe is projected to increase in non-OECD countries by 76 percent.[158] Overall, U.S. coal exports are projected to increase by roughly 50 percent by 2035.[159]

Figure 2-13: Global Coal Consumption, 1980-2011



Source: U.S. Energy Information Administration, "Total Coal Consumption," *International Energy Statistics*, http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=1&pid=1&aid=2&cid=regions&syid=1980&eyid=2011&unit=TST, accessed on November 26, 2012.

Figure 2-14: Top Importers and Exporters of Coal, 2010



Source: U.S. Energy Information Administration, "Total Coal Imports," *International Energy Statistics*, http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=1&pid=1&aid=3, accessed on November 26, 2012; U.S. Energy Information Administration, "Total Coal Exports," *International Energy Statistics*, http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=1&pid=1&aid=4, accessed on November 26, 2012.

Coal is exported from numerous U.S. terminals—including those in Alabama, Alaska, Louisiana, Maryland, New York, and Virginia—to name a few.[160] However, export capacity on the West Coast is limited. Currently, most coal shipped from western mines (primarily the Powder River Basin in Montana and Wyoming) is transported via rail to one of three terminals in British Columbia for export. The strength of global demand would support an expansion of North American export capacity.

As a result of growing export demand, several proposals have been put forward to build new bulk export terminals in the Pacific Northwest (see Table 2-3). However, local community groups and national environmental organizations have opposed these new export terminals for a variety of reasons. Some of this opposition stems from concern over local impacts: increased rail traffic; related air-quality issues, including coal dust and increased diesel emissions from trains; and water-quality issues from increased port traffic, water pollution, and effects on marine wildlife. But opposition also stems from concerns over increased coal use in China and other growing markets driving potential increases in net global greenhouse gas emissions, as well as possible increases in mercury emissions emanating from coal-fired power plants in Asia that are transported long distances and impact western states.[162]

The question for discussion is whether the presence of more low-sulfur Powder River Basin coal on the world market will increase global emissions from coal combustion, primarily from Asia. On one hand, a recent study of world coal markets by the Energy Policy Research Foundation argues U.S. firms are essentially "price takers" in global coal markets, and that U.S. exports will have little to no impact on international prices:

> "The U.S. is an infra-marginal coal producer, but the world price is set by the marginal producer which is likely to remain between $90 and $110 per metric ton.[163] As a result, U.S. production will merely replace higher cost

production with minimal or no effect on world coal prices. Neither net world coal combustion or GHG emissions will change as a result of expansion of U.S. ports."[164]

A recent paper by Dr. Thomas Power at the University of Montana, on the other hand, argues that U.S. coal exports to China will lead to increases in Chinese coal consumption, primarily because the competition of additional U.S. coal in the world marketplace will reduce coal prices, incentivizing more use of coal.[165] "The lower prices and costs brought on by that competition will encourage a greater commitment to coal fired generation in Asia and will discourage the adoption of coal and electricity displacing improvements in technology."[166]

Given these competing analyses, the net effect of U.S. coal exports on international coal prices and global greenhouse gas emissions is unclear. To our knowledge, there does not appear to be a comprehensive, global analysis of international coal markets and the potential impact of increased U.S. coal exports on these markets. Indeed, international markets are evolving and changing rapidly, driven in large part by domestic Chinese coal production and consumption along with demand for imports.[167] While recognizing that existing analyses are limited, the vast amounts of global coal reserves relative to international demand suggest that U.S. coal exports may have only a minor influence on the global coal market, and that other countries will fill the gap if U.S. exports are limited.

As noted previously, restricting international trade in fossil fuels is not an effective policy to reduce global greenhouse gas emission. Instead, countries should pursue domestic policies to lower domestic greenhouse gas emissions, while continuing to engage in international negotiations aimed at global reductions. Such efforts will likely produce better outcomes than efforts to halt coal or other fossil fuel exports. And while concerns over rising Chinese investments in coal-fired power plants are understandable, it is also critical to note that the Chinese are making substantial investments both in renewable energy and in carbon capture and storage projects, including demonstration projects in the United States.[168]

Table 2-3: Proposed Bulk Export Terminals in the Pacific Northwest

Project	State	Developer	Export Capacity (million tons/year)
Cherry Point/ Gateway Pacific Terminal	WA	SSA Marine	48
Longview	WA	Millennium Bulk Terminals	44
Port of St. Helens	OR	Kinder Morgan	30
Port of Morrow	OR	Ambre Energy	8
Coos Bay	OR	Unnamed	10
		Total	**140**

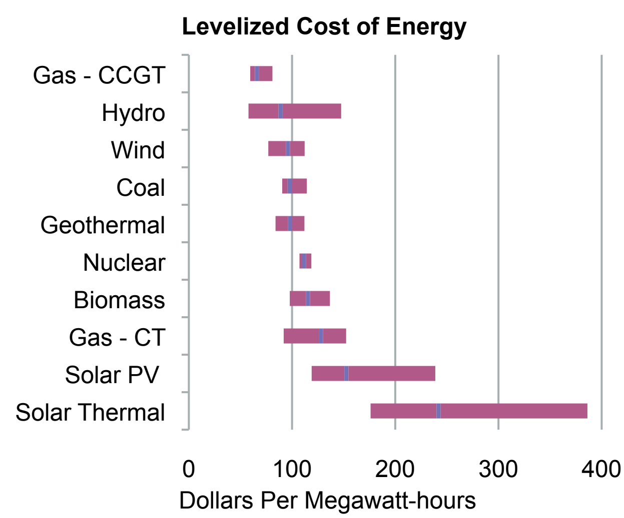
Source: Eric de Place, Sightline Institute, "Northwest Coal Exports: Some common questions about economics, health, and pollution," November 2012, http://www.sightline.org/wp-content/uploads/downloads/2012/11/coal-FAQ-November-12.pdf.

Renewable Electricity Production

The United States has substantial renewable energy resource potential. Lands available for wind power projects could accommodate 11,000 gigawatts of installed capacity, and offshore sites could accommodate 4,200 gigawatts of installed wind capacity; together, this amounts to roughly 50,000 terawatt-hours of generation potential, compared with total U.S. generation of roughly 4,100 terawatt-hours in 2011.[169] Land and rooftops suitable for solar power projects could accommodate over 150,000 gigawatts of installed PV capacity and 38,000 gigawatts of concentrated solar-thermal capacity; together, this amounts to just under 400,000 terawatt-hours of generation potential.[170] The United States also has the potential for over 4,000 gigawatts of enhanced geothermal power capacity,[171] which could generate over

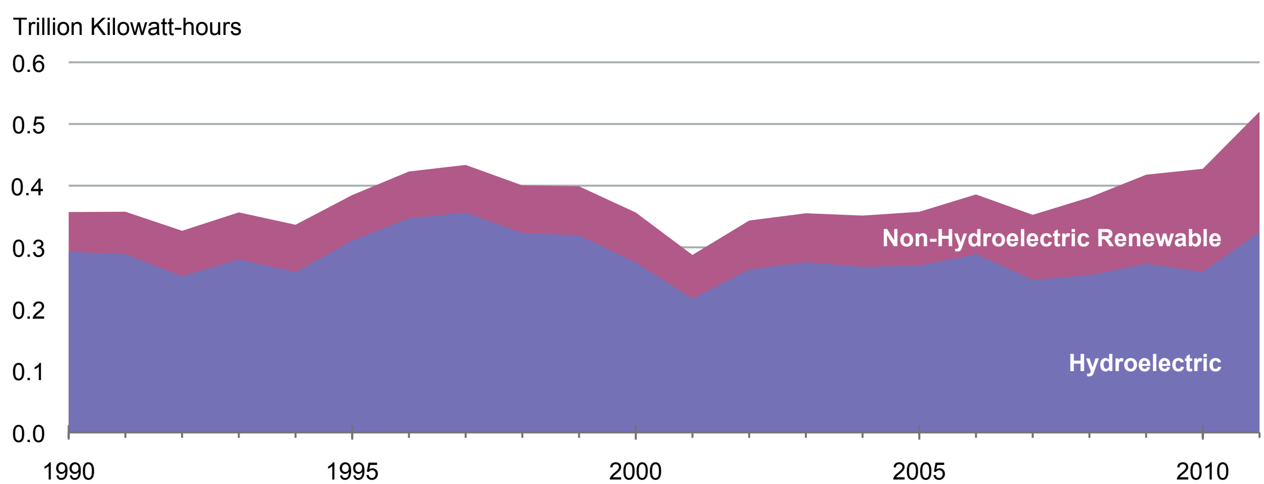
Figure 2-15: 2017 Levelized Costs of Energy, U.S. Energy Information Administration

Source	LCOE ($/MWh)		
	Low	Average	High
Gas - CCGT	$60	$66	$81
Hydro	$58	$89	$148
Wind	$77	$96	$112
Coal	$91	$98	$114
Geothermal	$84	$98	$112
Nuclear	$107	$111	$119
Biomass	$98	$115	$137
Gas - CT	$92	$128	$152
Solar PV	$119	$153	$239
Solar Thermal	$176	$242	$386



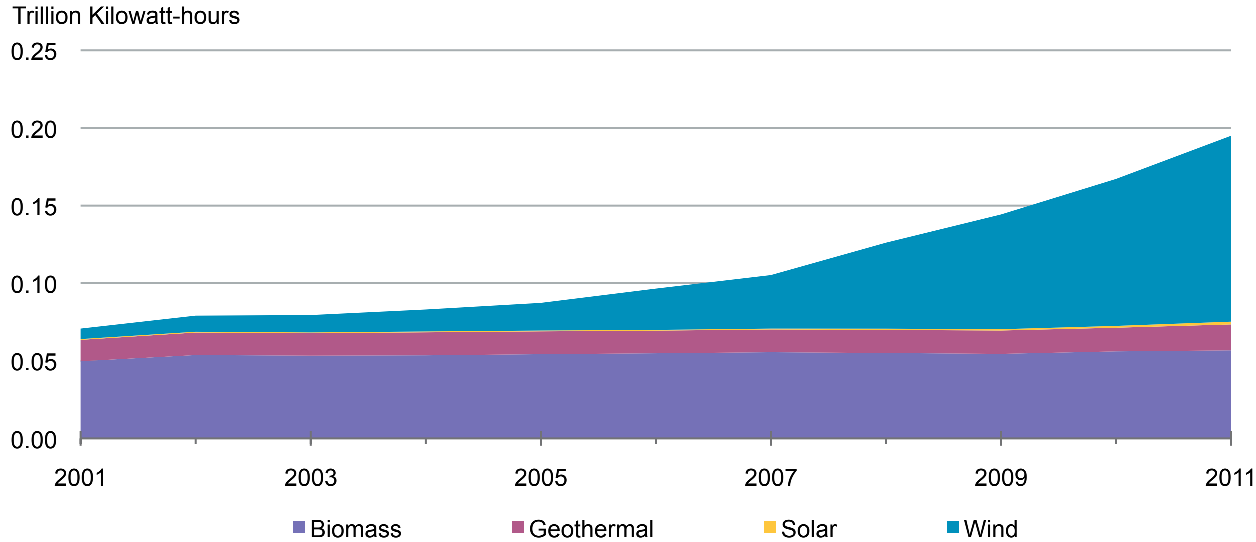
Source: U.S. Energy Information Administration, *Levelized Cost of New Generation Resources* in the *Annual Energy Outlook 2012*, July 20, 2012, http://www.eia.gov/forecasts/aeo/electricity_generation.cfm.

Figure 2-16: U.S. Net Electricity Generation from Renewable Sources, 1990-2011



Source: U.S. Energy Information Administration, "Table 8.2a. Electricity Net Generation: Total (All Sectors), 1949-2011," *Annual Energy Review 2011*, September 27, 2012, http://www.eia.gov/totalenergy/data/annual/#electricity.

Figure 2-17: U.S. Non-Hydroelectric Renewable Electricity Production, 2001-2011

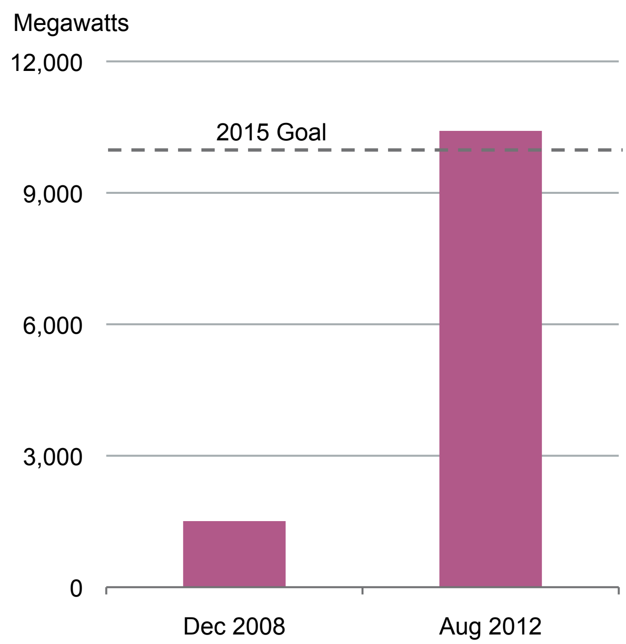


Source: U.S. Energy Information Administration, "Table 8.2a. Electricity Net Generation: Total (All Sectors), 1949-2011," *Annual Energy Review 2011*, September 27, 2012, http://www.eia.gov/totalenergy/data/annual/#electricity.

30,000 terawatt-hours of electricity.[172] Additionally, the United States has a theoretical tidal- and wave-generation potential of up 2,640 terawatt-hours.[173] These estimates reflect technical potential and do not take into account the various factors that make particular sites economical, such as access to transmission and project development costs.

Clean, renewable energy already plays an important role in the nation's energy supply, accounting for roughly 13 percent of U.S. electricity generation in 2011.[174] At present, hydroelectric plants continue to account for the largest share (62 percent) of renewable generation.[175] However, the contribution from other, non-hydroelectric renewable sources such as wind, solar, biomass, and geothermal has been increasing rapidly: non-hydro renewables accounted for nearly 5 percent of the nation's power generation in 2011, up from approximately 2 percent in 1990.[176] Non-hydro renewable electricity production has risen especially rapidly over the past few years—up nearly 85 percent from 2007 to 2011, and recent data indicate generation from these sources has grown an additional 13 percent in 2012.[177] The strongest growth has occurred in wind energy. Over the decade from 2001 to 2011, wind generation increased more than 17-fold, and in the single year between 2010 and 2011, wind energy output grew 27 percent despite an overall decline in national electricity consumption.[178] In recent years, we have seen significant growth in the deployment of solar energy (particularly in Europe but increasingly in the United States, as well as in China and elsewhere) as efficiency has improved and costs have come down sharply. Improvements in the materials used in the production of photovoltaic modules have improved their durability and longevity as well as their efficiency in converting sunlight into electricity. These improvements have lowered both installed costs and, more importantly, the levelized cost of electricity over the lifetime of the system. EIA estimates that costs for wind and solar photovoltaics could fall to $77 per megawatt-hour and $119

Figure 2-18: Megawatts of Approved Renewable Energy Projects on Federal Lands



Source: U.S. Department of the Interior, Bureau of Land Management, "Renewable Energy Projects Approved Since the Beginning of Calendar Year 2009," January 14, 2013, http://www.blm.gov/wo/st/en/prog/energy/renewable_energy/Renewable_Energy_Projects_Approved_to_Date.html.

per megawatt-hour respectively by 2017. Recent estimates by Bloomberg New Energy Finance for wind and solar suggest cost could be lower. (Appendix C provides a more detailed discussion of projected renewable energy costs.)

Distributed generation is also an increasingly significant resource in renewable energy generation. Distributed power generation refers to small-scale power-generation technology (usually less than 1 megawatt) that provides electric power at a site closer to customers than central station generation—for example, using rooftop solar photovoltaic installations. As of 2011, distributed generation from wind energy accounted for roughly 200 megawatts across 150,000 turbines nationally.[179] Distributed generation from grid-connected solar PV projects accounted for approximately 2.5 gigawatts across more than 200,000 projects nationally, well over half of the grid-connected solar PV capacity in the United States in 2011.[180] EIA estimated roughly 800 megawatts in off-grid solar PV installations nationally as of 2009.[181]

Throughout the past several years, the renewable energy industry has benefited from technology improvements, falling production costs, and supportive state and federal policies—notably state renewable portfolio standards, which typically require utilities to include a minimum percentage of renewable energy in their supply portfolio, state net metering programs, and federal production and investment tax credits.[182] Currently, 29 states and the District of Columbia have renewable or alternative energy portfolio standards, and many states as well as the federal government provide tax incentives for renewable energy development.[183] Nonetheless, technological, financing, siting, and environmental challenges remain. This section identifies the key challenges and recommends actions to promote continued investment in renewable technologies as part of a diverse and resilient electricity-supply portfolio and an important low-carbon option for the future. Since financial incentives and technology innovation are covered as cross-cutting issues in other chapters, the focus here is primarily on opportunities for expanding renewable electricity production on federal lands and on options for addressing infrastructure and grid-integration issues. (Recommendations regarding the renewable energy production tax credit are addressed in Chapter 5: Overhaul Federal Interventions in Energy Markets.)

Renewable Electricity Production on Federal Lands

Interest in siting renewable energy facilities on federal lands has increased dramatically in recent years. Prior to 2009, the federal government awarded right-of-ways on these lands for 1,508 megawatts of renewable generating capacity; since 2009, right-of-ways were granted to projects totaling more than 10,000 megawatts, and construction on these projects is proceeding.[184] At the current pace of project approvals and construction, the Department of the Interior is on pace to meet and exceed the goal in the Energy Policy Act of 2005 of hosting 10,000 megawatts of operating renewable energy projects on federal lands by 2015.[185]

BLM manages 20.6 million acres of public lands with wind potential.[186] Similarly, BLM manages more than 20 million acres of public lands with solar potential in six states: Arizona, California, Colorado, Nevada, New Mexico, and Utah.[187] Under current law, different forms of renewable energy production on federal land are treated differently. For example, the lease approach for geothermal projects is similar to that for oil and natural gas projects.[188] By contrast, wind and solar projects typically require a more limited authorization than an oil and gas lease, such as a right-of-way authorization under Title V of the Federal Land Policy and Management Act (FLPMA).[189] Any entity that obtains a right-of-way must comply with the terms and conditions of the grant and pay rental fees for use of the public lands.

Renewable energy development offshore has a relatively shorter history. The Energy Policy Act of 2005 appointed the Secretary of the Interior as the authority for issuing leases, easements, rights-of-way, and rights of use and easement for energy production, transportation, or transmission projects in the OCS from sources other than oil and gas, including wind, wave, and ocean current energy. The secretary delegated this responsibility to the new Bureau of Ocean Energy Management (BOEM). At present, offshore wind is thought to have the greatest near-term potential for renewable energy production; according to BOEM estimates, the wind resource potential off the shore of Atlantic states approaches 1,000 gigawatts.[190]

Since 2009, Interior has implemented numerous reforms to the siting and permitting processes for renewable energy on federal lands. In June 2011, BLM established the National Renewable Energy Coordination Office within the Minerals and Realty Management Directorate.[191] BLM has also worked with the Fish and Wildlife Service to draft voluntary guidelines for land-based wind energy projects that may affect wildlife and issued new instruction memoranda that provide guidance on improving NEPA documentation, streamlining the project application review and approval process, and strengthening Plans of Development and due diligence requirements.[192] BLM has also taken steps to reduce the permitting backlog for wind and solar projects. Under the American Recovery and Reinvestment Act of 2009, $41 million in funding was allocated for this purpose and, in FY2011, BLM began identifying priority projects that could be expedited through the permitting process.[193] To be deemed a priority project, developers must demonstrate that the project has progressed far enough to formally start the environmental review, as well as have the potential to be cleared for approval by the end of the calendar year. Typically such projects are identified as low-to-medium conflict in BLM's pre-application screening process.

Other recent efforts by Interior to promote renewable energy development on federal lands include the development of a programmatic environmental impact statement for solar energy and the "Smart from the Start" offshore wind initiative. Each is briefly described below.

Programmatic Environmental Impact Statement for Solar Energy Development: On July 24, 2012, Interior and DOE jointly published a programmatic environmental impact statement for solar energy development in six southwestern states—Arizona, California, Colorado, Nevada, New Mexico, and Utah.[194] It is intended to speed the permitting of utility-scale solar energy facilities on public lands by identifying and comprehensively analyzing the most promising areas for development based on access to existing or planned transmission, potential for resource conflicts, and availability of incentives. Overall, the programmatic statement identifies 17 "Solar Energy Zones," totaling about 285,000 acres of public lands and estimates that these zones could support 23,700 megawatts of solar energy development.[195]

"Smart from the Start" Initiative for Offshore Wind Development: In November 2010, Secretary Salazar launched the "Smart from the Start" initiative to facilitate new wind energy development offshore in Atlantic states.[196] Launched shortly after Secretary Salazar approved the Cape Wind Project in Massachusetts, the initiative aims to facilitate siting, leasing, and construction. (The siting and permitting process for Cape Wind project spanned nine years and involved 17 federal and state agencies.) The "Smart from the Start" initiative is modeled after the solar programmatic review process described above. Like that process, it incorporates numerous regulatory reforms aimed at expediting approvals and reducing duplication. In February 2012, Interior announced the completion of environmental assessments for proposed wind energy areas off the coasts of New Jersey, Delaware, Maryland, and Virginia. The environmental assessments, which found no significant adverse environmental or socioeconomic impacts from wind development in these areas, identified locations "most suitable" for wind energy development and cleared the way for site- and project-specific lease proposals.[197] Developers will still need appropriate and comprehensive site-specific NEPA review of individual projects as well as state permits, which could have longer lead times when compared with federal permitting. To date, BOEM has announced "Calls for Information" for lease nominations off the coasts of Maryland[198] and Virginia, and, in October 2012, BOEM reached its first commercial wind energy development lease agreement under the program for 96,430 acres off the coast of Delaware.[199,200] Meanwhile, a parallel process is currently underway to facilitate siting for the transmission infrastructure needed to bring offshore wind power ashore.

Recommendations for Renewable Energy Production on Federal Lands

RECOMMENDATION: Interior and other federal agencies should continue to fully fund and implement these important reforms, initiated over the past few years, for approving renewable energy projects on federal lands as expeditiously as possible.

We applaud Interior for surpassing the Energy Policy Act of 2005 goal of approving 10,000 megawatts of renewable energy projects on federal lands by 2015, ahead of schedule.[201] Similarly, we support the reforms implemented by Interior and DOE to date, notably the "Smart from the Start" initiative for offshore wind developments, the completion of the Programmatic Impact Statement for Solar Energy Development, and the creation of the Renewable Energy Coordination Office. These efforts, along with many others too numerous to mention here, are the latest results from the sea change that has occurred in renewable energy development on federal lands since 2005. Today the country is just beginning to see the results of these reforms.

Renewable Energy Production and the Department of Defense

Accounting for over half of the federal government's electricity consumption, the Department of Defense (DOD) plays a particularly significant role in federal policy on renewable energy.[202] The National Defense Authorization Act of 2007 codified DOD's voluntary goal to produce or procure 25 percent of its total facility energy use from renewable sources beginning in 2025.[203] DOD additionally pursues its own voluntary target of 1 gigawatt of installed renewable capacity for Army, Navy, and Air Force each by that time.[204] Most of the electricity will be used to power DOD's 500 installations worldwide, constituting over half a million buildings covering over two billion square feet.[205] DOD spending on renewable energy generation is forecast to rise to $1.8 billion annually in 2025, up from a base of

$163 million in 2013.[206]

DOD sees renewable energy generation as a strategic asset for several reasons. First, renewable energy generation is part of DOD efforts to increase the self-sufficiency of military facilities, improving service reliability and reducing vulnerability to external disruptions. Second, with a $4 billion annual utility bill for its installations,[207] DOD is pursuing renewable energy production to manage its risks. In an operational context, renewable energy production will contribute to DOD efforts to manage increasing energy demands from battery-powered equipment and vehicles, to enhance military capability, improve force protection, and reduce the vulnerability of logistics supply chains for liquid fuels in conflict zones. Additionally, DOD also must comply with Executive Order 13514, issued in 2009, which requires DOD to set a percentage reduction target for greenhouse gas emissions for FY2020. DOD has set as its goal reducing greenhouse gas emissions 34 percent from FY2008 levels by FY2020, in part through increasing use of renewable energy.[208]

DOD has worked with both DOE and Interior to implement its renewable energy strategy. In 2010, DOD and DOE signed a memorandum of understanding to facilitate cooperation to accelerate the research, development, and deployment of energy efficiency and renewable energy technologies.[209] In particular, DOE and DOD are working together on development and demonstration of numerous battery and microgrid technologies, which will allow for better renewable energy integration as part of efforts to increase self-sufficiency at installations. In 2012, DOD and Interior signed a memorandum of understanding to promote renewable energy generation on federal lands restricted for military uses and offshore locations near military installations.[210] DOD installations account for 28 million acres in the United States, and it is estimated that 13 million acres contain high-quality wind, solar, or geothermal resources.[211] In 2012, the U.S. Army Corps of Engineers announced its intention to procure $7 billion of renewable energy contracts, which are expected to provide at least 2.1 million megawatt-hours annually.[212]

Additionally, each service pursues its own strategies and targets beyond specific DOD mandates. The Army and the Navy have both set targets for net-zero energy. A net-zero installation produces as much energy onsite as it uses; the military is pursuing net-zero goals through a mix of efficiency measures and renewable energy development. The 2009 Army Energy Security Implementation Strategy sets as a goal that five installations meet net-zero energy goals by 2020, and an additional 25 achieve net-zero energy by 2030.[213] The Navy sets as a goal that half of all installations meet net-zero energy goals by 2020.[214]

Recommendations for Increasing Renewable Generation by the Department of Defense

RECOMMENDATION: The Department of Defense should continue efforts and initiatives to achieve greater energy efficiency and harness renewable and alternative energy investments in direct support of its national security mission.

DOD should be commended for the considerable progress it has made toward realizing its long-term goals for renewable power generation and energy efficiency. We firmly believe that the military stands to reap significant benefits from these actions, including more self-reliant installations that are less vulnerable to possible energy disruptions. In addition, we also recognize the tremendous value in using the purchasing power of the largest energy user in the federal government to lead emerging technologies along the path of commercialization, in a way that is fiscally responsible and advances the DOD's core mission of national defense.

Addressing Grid Integration, Infrastructure, and Other Challenges for Renewable Electricity

Although the renewable electricity industry has made significant strides in reducing costs and expanding its commercial footprint, renewable options still face challenges. These include the need for new transmission infrastructure to cost-effectively connect promising renewable energy sites with population centers, technology improvements to address grid cost and integration issues, improved grid management techniques, and better energy storage and other integration options so that renewable power can be used to meet demand during all hours of the day. As more renewable generators come on line, infrastructure and grid-integration challenges will become more significant as they have the potential to constrain the industry's future growth unless adequately addressed.

Intermittent generating technologies, such as wind and solar, provide operational challenges for management of the grid. Electricity generation from wind and solar resources varies according to weather; for example, solar power is not available at night and is affected by cloud cover. Wind power can fluctuate throughout the course of a day, ramping up and down over relatively short time periods. Moreover, geographically clustered wind or solar resources are vulnerable to the same perturbations at the same time, increasing the magnitude of localized variability in their output. Integrating these variable energy resources into the power grid requires geographical diversification of sites and/or the use of other resources or processes, such as load balancing, ancillary services, forecasting, back-up generation, storage, and demand response, in order to maintain system reliability. These operational considerations need to be addressed in order to cost-effectively scale up renewable energy resources. Market and regulatory authorities are responding to provide or develop cost-effective and workable technical and operational solutions.

In many regions, wind generation is not as high on average during peak periods when electricity demand is highest (as compared with baseload periods at night, when electricity demand is at its lowest level). As a result, wind resources can sometimes be heavily discounted when calculating reserve margins used to assess reliability in meeting peak demand, which can result in the need for additional investments in non-intermittent capacity or back-up generation to support renewables. Better storage options and grid management along with increased deployment of distributed generation could help to reduce the need for additional back-up power.

Building additional transmission lines in some regions will require increased cooperation among utilities, regional transmission organizations, states, and the federal government, both to ensure that costs are allocated equitably among beneficiaries and to obtain needed rights-of-way. As MIT's recent study, *The Future of the Electric Grid,* notes, if renewable energy resources are to be developed in an efficient manner, "an increasing fraction of transmission lines will cross state borders, independent system operator (ISO) regions, and land managed by federal agencies such as the U.S. Forest Service."[215] Beyond expanding access to renewable resource opportunities, transmission investments can have important benefits for the grid as whole, enhancing overall system reliability, resiliency, diversity (in the sense that more generators can access potential markets), and efficiency.

Grid integration has become an issue because of the variable, intermittent nature of renewable resources like wind and solar. Yet, the specific nature of the challenge depends on the region and market structure in which renewable generators operate. For example, the Pacific Northwest's challenges relate to the deployment of wind resources in combination with operational constraints on the hydropower that dominates the region's power-generation mix. The Southwest is focused on how to deploy solar resources. Smaller balancing authorities (entities responsible for balancing electricity supply and demand in real time over a defined area) in this region and elsewhere increase the challenge of reliably integrating intermittent generation. In regions with regional transmission organizations (RTOs) or independent system operators (ISOs), the resource base tends to be larger and more varied (primarily because the geographic area covered is usually larger), which in turn mitigates the impact of intermittent generation. Different RTOs and ISOs are in various stages of incorporating renewable generation and are using different approaches to address these issues.[216]

New grid technologies and improvements, often grouped under the general term "smart grid," can also help to address some of these integration needs and, as with transmission investments, offer potentially significant benefits for the electric power system as a whole. For example, smart grid technologies[217] can support the increased use of distributed generation resources, allow for the broader penetration of demand response programs,

Energy Sector Workforce Needs

All key energy sectors and their stakeholders, including the oil and gas industry, the electric power sector, and the renewable energy and energy efficiency industries, require a highly skilled, well-trained workforce in order to deliver clean, reliable, and affordable energy to the U.S. economy. Many sectors will face significant workforce challenges due to a rapidly aging employee pool and high future demand for qualified workers. The electric power sector, for example, directly employs about 400,000 people, 30 to 40 percent of whom will be eligible for retirement or are expected to leave the industry for other reasons within the next five years.[219] Compounding this demographic shift, many workers appear to be delaying retirement due to the economic downturn, and this could create a larger disconnect if workers retire en masse when economic conditions improve.

In addition to replacing retiring workers, the industry will need an unprecedented number of skilled workers to design, construct, and operate the next generation of energy-sector infrastructure. For example, employment in the oil and gas industry is expected to grow at a rate of 6.9 percent per year through 2015 and will need to recruit and train a skilled workforce to meet its needs.[220] Achieving future public policy goals with the respect to energy, the economy, and the environment will present an opportunity to create new high-skill, high-paying jobs in the energy sector.

Congress, the executive branch, and stakeholders in industry and academia should cooperate to ensure that these workforce challenges are met and that the proper institutions and systems are put in place. Several specific steps should be taken to prepare for future workforce needs in the U.S. energy sector, including:[221]

- **Congress should direct DOE and the Department of Labor to work with states to evaluate regional and state training needs and to facilitate multi-stakeholder energy-sector training programs across the country. Congress should appropriate funds to Labor and DOE in order to establish these initiatives.**
- **Congress should provide funds for and direct DOE, Labor, and the Department of Education to improve existing systems for collecting, managing, and disseminating workforce and educational data relevant to the energy sector.**
- **Congress should provide funds for and direct the Department of Labor, in consultation with industry, labor, and education stakeholders, including the Department of Education and DOE, to identify training standards and best practices for energy-sector jobs.**
- **Congress should provide support for individuals who seek relevant technical training and experience through existing funding mechanisms, such as indexing Pell Grants and Perkins Act funding to inflation.**
- **Congress should reauthorize the America COMPETES Act, which provides critical support for investments in science, technology, engineering, and mathematics. These investments are needed in order to continue the progress that has been made to revitalize math and science education in the nation's schools and to provide career counseling and other support to individuals who have the interest and skills to work in the energy sector.**

help system operators coordinate variable generation output with demand-side resources, facilitate the deployment and management of energy-storage resources, and improve the overall efficiency and resiliency of transmission and distribution systems. These improvements in turn will enable greater penetration of clean energy resources and, in some circumstances, help mitigate or avoid expensive capital investments by making optimal use of existing infrastructure. Despite these benefits and considerable progress in the deployment of certain technologies, such as advanced metering and the implementation of additional smart grid improvements, progress continues to be slowed by cost constraints, technology hurdles, and lack of familiarity among customers, regulators, and utilities themselves.

Recommendations for Addressing Grid Integration and Renewable Energy Production

RECOMMENDATION: Identify and implement strategies to modernize the grid and enable investment in necessary transmission and non-wires solutions in order to more efficiently integrate renewables into the electric power system.

Specific policy priorities should be: (1) the construction—where cost-effective—of long-distance transmission to connect remotely located renewables to load; (2) market access for cost-effective, non-wires alternatives, such as demand response and distributed generation; (3) research and development targeted at reducing the costs of energy storage technologies; and (4) improved planning and coordination processes within and across jurisdictions.

A separate project from BPC recently released a comprehensive report, *Capitalizing on the Evolving Power Sector: Policies for a Modern and Reliable Electric Grid,* specifically addressing the grid-integration and reliability issues described above.[218] The report provides a fuller discussion of this topic than we were able to accommodate in this report and provides a number of recommendations to address electric system reliability challenges arising from increased deployment of intermittent resources and other factors. Though we do not necessarily endorse each of the specific recommendations in the report, we support its overall conclusion that there are a number of cost-effective approaches that have multiple benefits, including improving overall system reliability and facilitating the integration of intermittent renewable resources. We urge policy makers at the state, regional, and federal levels to continue work on these solutions.

Nuclear Power

Nuclear power has been part of the U.S. electricity mix since the 1970s; today, it supplies nearly one-fifth of the nation's overall electricity needs.[222] Over the last two decades, the nation's fleet of 104 existing reactors has compiled an impressive track record of reliable, economic, and safe operations. But the current fleet is aging—in fact, 73 units are already operating on license extensions that allow them to run beyond their original 40-year license periods.[223] With only four units currently under construction at two plant sites and others planned but not moving forward, in addition to at least some inevitable plant retirements on the horizon, it seems likely that the nuclear contribution to America's electricity portfolio will level off within the next decade or two and then begin to decline.[225]

This picture of the industry facing static or diminishing prospects is in sharp contrast to the outlook just a few years ago, when nuclear energy in the United States was widely thought to be on the verge of a renaissance driven by rising demand for electricity and mounting concern about climate change and other environmental impacts of fossil fuel-based electricity generation. This, however, was before evidence accumulated indicating a long-term trend of slowing electricity demand growth and before rapidly falling natural gas prices substantially shifted the economics of the electric power sector. Today, the question for policy makers is whether the long-term benefits of retaining nuclear energy as a viable, non-carbon component of a diversified energy supply portfolio justify the investments needed to continue to move the technology forward while also addressing long-standing challenges related to waste management, safety regulation, national security, and nonproliferation.

A strong case for America's national interest in maintaining a leadership role in the evolution and management of nuclear energy technology is articulated in another recent BPC report titled *Maintaining U.S. Leadership in Global Nuclear Energy*.[226] Released in September 2012, this report was co-chaired by former Senator Pete Domenici and former DOE Assistant Secretary for Nuclear Energy Pete Miller. The discussion of issues and challenges for nuclear energy in the next section draws on this earlier BPC effort. We broadly endorse the findings and recommendations of the Blue Ribbon Commission on America's Nuclear Future, which issued a report to the Secretary of Energy in January 2012 concerning a strategy for getting the nation's nuclear waste-management program back on track.[227]

Overcoming Challenges for Nuclear Energy in the United States

Nuclear energy has long enjoyed bipartisan support at the highest levels of U.S. government because it is seen as

Recommendations of the Blue Ribbon Commission on America's Nuclear Future

As noted previously, we broadly support the recommendations of the Blue Ribbon Commission on America's Energy Future (BRC) concerning a new direction for the nation's nuclear waste-management program. The BRC's recommendations were the result of an intensive two-year process that took into consideration a wide range of inputs and stakeholder perspectives; key elements of the BRC approach are summarized below. Two additional points about the BRC's recommendations are worth highlighting. First, we urge policy makers and stakeholders not to underestimate the real-world difficulty of implementing certain aspects of the BRC's approach—including, notably, the recommendation to implement a new, consent-based approach to future siting decisions—in light of the intractability of the problems encountered in the U.S. waste-management program over the past 30 years since the passage of the Nuclear Waste Policy Act. It is also important to point out that nothing in the BRC's recommended approach precludes further consideration of Yucca Mountain as a potential repository site—on the contrary, the BRC explicitly states that its approach is intended to provide a basis for continued progress whether Yucca remains part of the nation's waste-management plan or not. With these two additional observations in mind, the strategy set forth in the BRC's report offers the best available avenue for moving toward a successful resolution of the waste issue.

Key elements of the BRC report include the following:

- A new, consent-based approach to siting future nuclear waste-management facilities.
- Creation of a new self-sustaining, quasi-governmental federal corporation outside of DOE dedicated to managing safe storage and disposal of spent fuel and high-level wastes.
- Access to the Nuclear Waste Fund and fees nuclear utility customers are providing for the purpose of nuclear waste-management, to be implemented through immediate policy changes to (1) ensure full access to future waste fee revenues for waste management purposes, subject to the appropriations process but independent of competition with other funding needs, and (2) eventual legislative changes by Congress to transfer waste fee funds, including the unspent balance in the Nuclear Waste Fund, to the new federal corporation.
- Prompt efforts to develop one or more geologic disposal facilities.
- Prompt efforts to develop one or more consolidated, interim storage facilities, following adoption of appropriate regulatory standards.
- Early preparation for the eventual large-scale transport of spent nuclear fuel and high-level waste to consolidated storage and disposal facilities.
- Support for continued U.S. innovation in nuclear energy technology and for workforce development.
- U.S. leadership to promote international efforts to address safety, waste management, nonproliferation, and security.

advancing several of the nation's core energy policy goals. Among the interests historically cited in favor of preserving a substantial role for nuclear technology are energy security, fuel diversity, reliability and affordability of energy supplies, local and regional job creation, environmental performance, climate change mitigation, and U.S. technology leadership in a global export market.

Despite this support, however, the U.S. nuclear energy industry is also increasingly seen as standing at a crossroads, with commercial prospects for the near- and medium-term future uncertain at best. Supporters and critics of nuclear energy alike point to at least four key challenges for the domestic industry going forward:

- **Cost and Financing:** The high capital costs of new nuclear power plants—estimates of which include the $14 billion PSC-approved budget for two 1,100 megawatt units now under construction in Georgia and the projected $22.5 billion in 2022 for a comparably sized plant not yet under construction[228]—are a formidable hurdle to new nuclear investments, particularly in a market environment driven by low natural gas prices. Today, few utility companies are in a position to consider investments on the scale needed to build new reactors, and few state regulatory authorities would likely approve the cost-recovery guarantees needed to undertake these investments. The industry's cost and financing hurdles are exacerbated by long timeframes for licensing and construction and substantial regulatory and political uncertainty with respect to future safety and waste-management requirements. Simply put, at today's natural gas prices new nuclear is not competitive with other electricity-generation options, and the government incentives that are currently in place—notably loan guarantees and standby insurance—have had only limited success in spurring new plant investments.
- **Waste Management:** This is a longstanding issue that remains unresolved despite decades of effort by the federal government to move forward with one or more permanent geologic disposal facilities for spent nuclear fuel and high-level radioactive waste. The waste-management program reached its most recent impasse in 2009, when the Obama administration suspended work on Nevada's Yucca Mountain site. Today, spent nuclear fuel is being stored on an ad hoc basis at existing reactor sites, and the U.S. government has been sued for, and required to refund, millions of dollars from the Nuclear Waste Trust Fund as damages from its failure to deliver on a disposal solution. A number of states have banned the construction of new plants until the waste issue is resolved. To add further complexity, the NRC must resolve its position on nuclear waste confidence to clarify future reactor licensing actions. As a result of recent court decisions, the NRC must draft a new waste confidence environmental impact statement and rule, and a final decision is not expected until September 2014. More broadly, this situation has further undermined public confidence in nuclear energy as a viable energy source for the future.
- **Safety, Security, and Nonproliferation:** These concerns demand continuing improvements in nuclear reactor and fuel-cycle technologies, along with continued regulatory vigilance and effective international cooperation. The United States, which led the way in commercializing civilian uses of nuclear energy and in developing the current international nonproliferation regime, has long played a leadership role. Today, U.S. regulatory institutions and U.S. models for industry self-regulation, such as the Institute for Nuclear Power Operations (INPO), are still looked to internationally as the best models for assuring safe and secure nuclear operations and robust emergency planning and response. However, U.S. technological dominance on nuclear power has slipped as the focus of new nuclear investment and export activity shifts to countries like China, India, Russia, and South Korea. Some have questioned whether the U.S. government's ability to exercise strong leadership

on international questions of nuclear security and nonproliferation will inevitably be weakened if the United States lacks a vibrant commercial industry at home.

- **Public Acceptance:** Another perennial issue for the nuclear energy industry, one that is inextricably linked to successfully addressing all of the foregoing challenges, is the public's view of nuclear power. In the United States, public opinion polls showed gradually increasing support for nuclear power in the late 1990s and early 2000s until the Fukushima accident led to a resurgence of public concern about safety. In the near term, the accident might again increase opposition—especially at the local and regional levels—to proposals to build new nuclear plants or in some cases to extend the operating life of existing ones. Despite the drop in favorable public opinion regarding nuclear power following the Fukushima accident, a recent poll indicates that Americans who favor nuclear energy (41 percent) outnumber those who do not (20 percent).[229]

Recommendations to Advance Nuclear Energy in the United States

RECOMMENDATION: Broadly speaking, we endorse the key strategic goals set out in the September 2012 Domenici and Miller report and in the report of the Blue Ribbon Commission on America's Nuclear Future to guide policy makers on this issue. These goals are summarized below with our specific additions and caveats in italicized text.

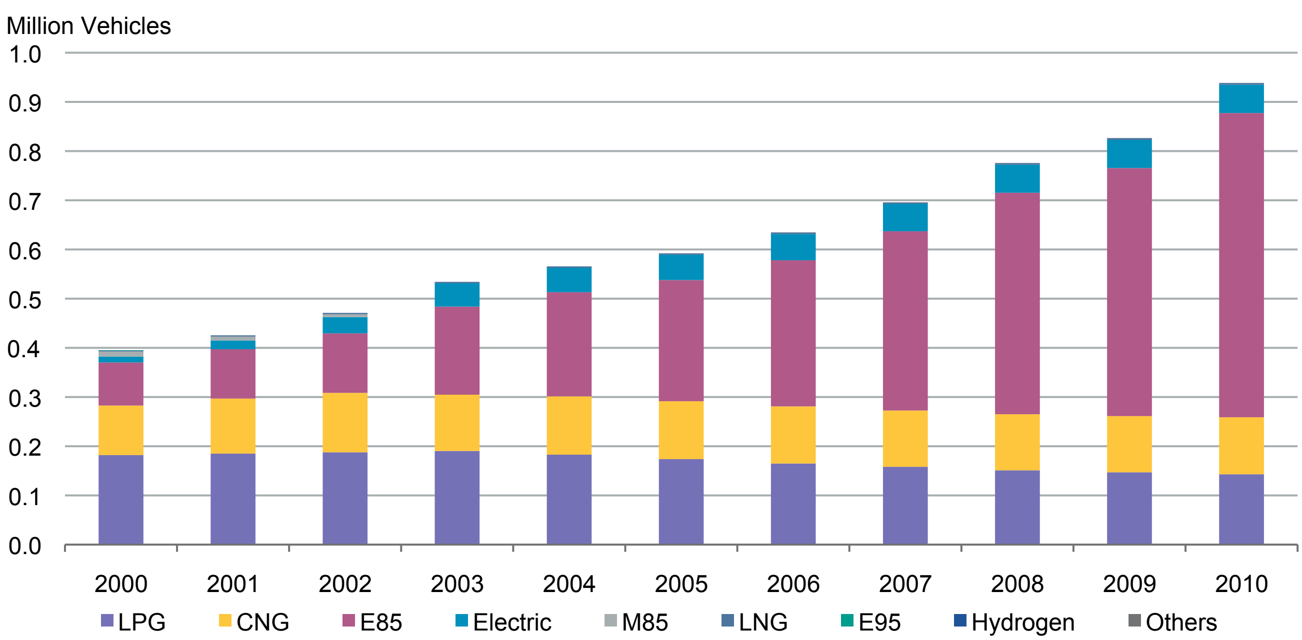
- Ensuring a strong U.S. nuclear energy sector should be a high priority for federal energy and national security policy. Nuclear energy is critical to maintaining a reliable, affordable, and clean electric power sector, and a strong domestic nuclear industry strengthens America's position in international nonproliferation matters.
- To maintain U.S. leadership in nuclear safety and security, the industry and the U.S. Nuclear Regulatory Commission should continue efforts to strengthen nuclear plant safety and security, *and provide the industry with regulatory certainty and uniform standards,* particularly in light of lessons learned from Fukushima.
- A key factor in terms of the outlook for a robust domestic nuclear industry and continued safety performance is progress on the management and disposal of spent nuclear fuel. The administration and Congress should act quickly to implement the recommendations of the Blue Ribbon Commission on America's Nuclear Future (see text box) and adopt an effective, long-term strategy for managing and disposing of the nation's spent nuclear fuel and high-level radioactive waste. *As a first step, S. 3469, introduced in the 112th Congress by then-Senator Jeff Bingaman, should be reintroduced and passed.*
- Continued strong U.S. leadership in global nuclear security matters is central to protecting national security interests. In particular, U.S. leadership in nuclear technology and operations can strengthen U.S. influence with respect to other countries' nuclear programs and the evolution of the international nonproliferation regime while also supporting U.S. competitiveness in a major export market.
- Historically, the United States has been a leader in nuclear technology research and commercialization. To extend this tradition and assure further innovation, the United States must continue to support research and development efforts within the nuclear industry, the national labs, and U.S. universities. *Specifically, we recommend focusing future federal RD&D efforts on two core areas: reactor safety and small-scale reactors that may be better-suited to the diversity of electricity markets and regulatory structures that currently exists in the United States. These small-scale reactors potentially could serve installations, complexes, campuses, and other institutional aggregations on a cost-effective basis.*

Alternative Transportation Fuels

Oil plays a critical role in our energy portfolio and in the broader economy, and oil has been at the center of America's energy security concerns for nearly a half-century.[230] The U.S. transportation sector remains overwhelmingly dependent on oil. In 2011, petroleum-based fuels accounted for more than 93 percent of primary energy consumption in the sector.[231] Biofuels and natural gas accounted for the remaining 4 percent and 3 percent, respectively. This lack of fuel diversity in a critical sector of the U.S. economy means that American consumers and businesses remain exposed to the fluctuations of the world oil market—*regardless* of how much oil the United States is producing domestically. A large share of global oil supplies comes from regions or countries that are unstable and/or conflict-prone—indeed, a considerable amount of world oil is controlled by national oil companies subject to political and geostrategic interests and motivations. The level of domestic oil production has at most a small effect on world oil prices, which are driven by global trends in supply and demand. In other words, even if the United States produced enough oil to meet 100 percent of domestic demand, American consumers would still pay the world oil market price. In this context, the most direct way to insulate the U.S. economy from oil price shocks is to reduce overall oil demand through efforts that include greater fuel diversity, improved fuel economy, and improvements to the efficiency of our nation's transportation system.

As discussed in Chapter 3, vehicle efficiency improvements required by fuel economy and greenhouse gas tailpipe standards are slated to have a dramatic impact on the demand for transportation fuel. In addition, diverse efforts to improve the efficiency of our nation's transportation system—including limitations on traffic congestion and engine idling, as well as a reduction in the number of vehicle miles traveled—help to reduce oil use and limit our

Figure 2-19: Estimated Number of Alternative-Fueled Vehicles in Use, 2000-2010



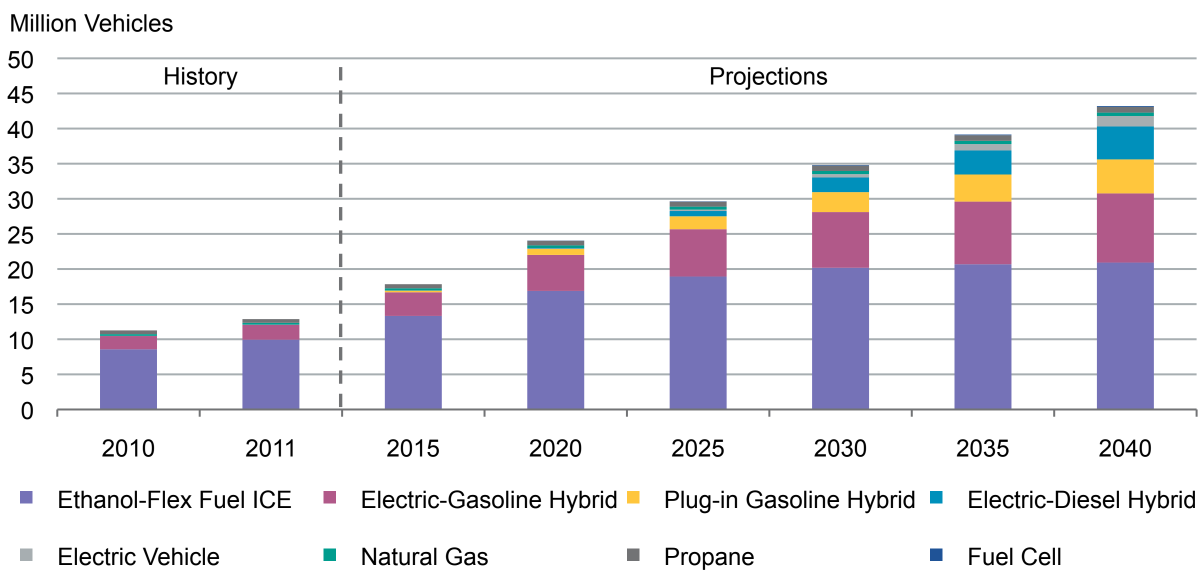
Source: U.S. Energy Information Administration, "Table 10.5 - Estimated Number of Alternative-Fueled Vehicles in Use and Fuel Consumption, 1992–2010," *Annual Energy Review 2011*, September 27, 2012, http://www.eia.gov/totalenergy/data/annual/.

exposure to oil price shocks, greenhouse gas emissions, and other environmental consequences.

The development of alternative transportation fuels has long been seen as an important complement to make the United States more energy secure and less reliant on foreign sources of oil while also reducing pollution. With these benefits in mind, the U.S. government introduced, with limited success, a variety of initiatives aimed at spurring the development and commercialization of alternative transportation fuels over the last four decades. The synthetic fuels (synfuels) program of the 1970s and early 1980s, in particular, is widely viewed as a failure. More recent efforts to develop biofuels and electric vehicle technologies, by contrast, have produced more tangible results. Biomass-based fuels have grown from 0.5 percent in 2000 to more than 4 percent of primary energy consumption in the transportation sector in 2011.[232] In addition, recent progress in the development of all-electric and hybrid-electric vehicle technologies offers promise. Nonetheless, alternatives to conventional, liquid-fueled internal-combustion engine vehicles still account for only a small share of the overall vehicle market.

A recent study of the future of transportation fuels by the National Petroleum Council (NPC) concluded that a number of remaining technology hurdles and infrastructure challenges would need to be overcome in order to enable the wide-scale commercialization of advanced fuel-vehicle systems by 2050.[233] Noting that there was still a great deal of uncertainty about which individual fuel-vehicle systems are most likely to overcome these hurdles and become economically and environmentally attractive over the next several decades, the NPC study also identified several areas of R&D that should continue to receive private and federal funding, either because progress in these areas is needed to address a priority technical issue or because it could lead to innovations that would allow for game-changing improvements in vehicle and fuel technology.

Figure 2-20: Projected Number of Alternative-Fueled, Light-Duty Vehicles, 2010-2040



Source: U.S. Energy Information Administration, "Light-Duty Vehicle Stock by Technology Type, Reference case," *Annual Energy Outlook 2013 Early Release*, December 5, 2012, http://www.eia.gov/oiaf/aeo/tablebrowser/#release=AEO2013ER&subject=15-AEO2013ER&table=49-AEO2013ER&region=0-0&cases=early2013-d102312a.

In addition to other challenges, alternative fuels generally face economic and logistical challenges associated with deploying fuel-dispensing infrastructure in a timely manner to facilitate the growth of alternative vehicle demand. This so-called "chicken and egg" issue arises from the difficulty of managing infrastructure costs while matching supply and demand during the transition to wide-scale use. Policy makers should consider how to encourage early multimodal alternative fuel infrastructure investments before economies of scale can be realized. In addition, the transitional infrastructure issues associated with alternative fuel-vehicle pathways warrant coordination between fuel retailers and fuel users during infrastructure growth, as well as policy coordination between fuel, vehicle, and infrastructure programs to maximize their effectiveness.

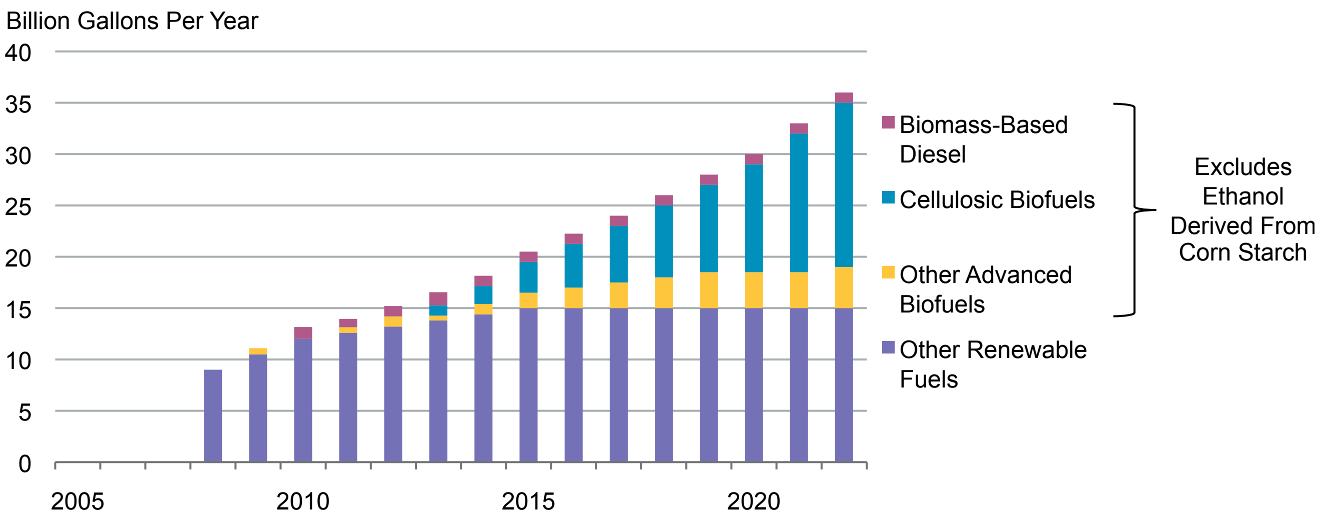
The remainder of this section reviews the status of alternative transportation fuels and identifies key issues for further development and deployment. Although subject to significant uncertainty, Figure 2-20 shows the latest baseline projection from the EIA on expected alternative vehicle growth in the light-duty fleet.

Biofuels

Since the late 1970s, states and the federal government have introduced a variety of incentives, regulations, and programs to encourage the production and use of biomass-based fuels (renewable fuels) to reduce our nation's dependence on foreign oil and to improve air quality. Examples include minimum renewable fuel-use requirements, blending and production tax credits, an import tariff, loans and loan guarantees, and research grants. Many of these provisions have expired, including the largest tax expenditure, the grain ethanol blender's credit.

The most significant federal program for biomass-based fuels is the Renewable Fuels Standard (RFS), which was first introduced with bipartisan support as part of the Energy

Figure 2-21: Renewable Fuel Standard (RFS2) Volume Requirements



Source: Randy Schnepf and Brent D. Yacobucci, Congressional Research Service, *Renewable Fuel Standard (RFS): Overview and Issues*, January 2012, R40155, 3, http://www.fas.org/sgp/crs/misc/R40155.pdf.

Policy Act of 2005. In its first phase, the RFS mandated the use of at least four billion gallons of renewable fuel in the U.S. gasoline supply by 2006 and increased to 7.5 billion gallons in 2012.[234] The Energy Independence and Security Act of 2007 expanded on these requirements with bipartisan support, increasing the minimum quantity of biofuels to 15 billion gallons in 2015 and an additional 21 billion gallons of advanced biofuels by 2022.[235] In addition, the renewable fuel volume requirements were divided into four separate but nested categories: total renewable fuels, advanced renewable fuels, biomass-based diesel, and cellulosic biofuels. To qualify in each of these categories, biofuels are required to meet a minimum lifecycle greenhouse gas threshold and use renewable biomass that complies with certain land use restrictions.

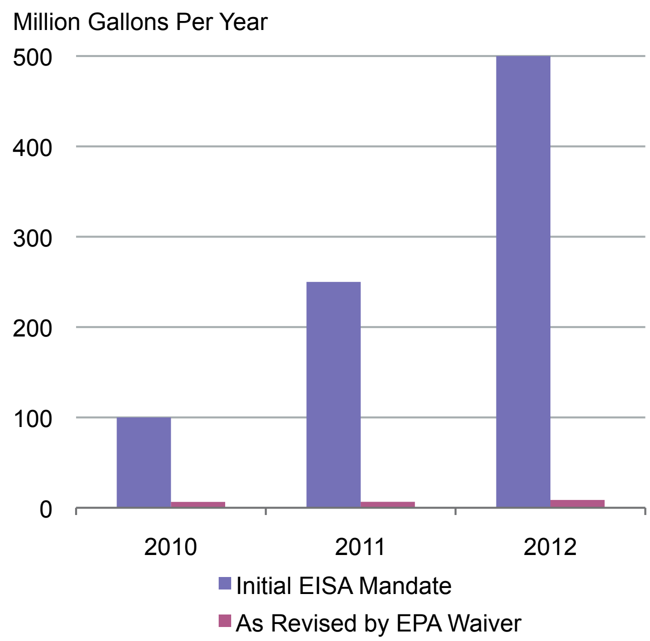
The first generation ethanol production has met and exceeded the volume goals outlined in the 2007 Act. Domestic production of fuel ethanol increased from 83 million gallons in 1981 to nearly 14 billion gallons in 2011.[236] Currently, grain-based ethanol production capacity is nearly at the 15-billion-gallon, fully phased-in RFS level for non-advanced biofuels.[237] Further, the industry continues to make efficiency gains as water use continues to decline[238] and net energy (currently 2.3 BTUs of ethanol for each BTU of energy used) continues to increase.[239] In recent years, ethanol has been more expensive than conventional gasoline on an energy-equivalent basis. Nonetheless, ethanol has valuable blending qualities to help meet octane and other fuel-specification requirements.[240]

The progress in building infrastructure and manufacturing capability for first-generation biofuels has set the stage for the development and commercialization of the next-generation advanced biofuels. While the National Research Council report[241] cites uncertainties regarding the impacts of biofuels, those uncertainties will be reduced with the growth and commercialization of advanced biofuel technologies and use of cellulosic (woody or fibrous) feedstock. The availability of biomass resources for the production of second-generation fuels exists in every state in the nation, and the investments from the production of second-generation biofuels will be spread widely across the United States.

The advanced biofuel categories of the RFS, which are slated to grow each year through 2022, exclude ethanol derived from corn starch. Because the United States has nearly reached sufficient production capacity for the portion of the renewable fuels target that is not limited to advanced biofuels, further growth in biofuels volumes under the RFS will be in fuels such as ethanol made from cellulosic feedstock, and drop-in[242] fuels such as biobutanol. Second-generation biofuels offer advantages compared with first-generation biofuels (including corn-based ethanol), because they generally use non-edible biomass (including algae), have significantly lower lifecycle greenhouse gas emissions, and may be "drop-in" replacements that can be used with existing tanks, pipelines, and pumps without costly modifications.[243] As is almost always the case with new technology, initial costs for the first advanced biofuels will be higher but are expected to come down with increasing production volumes.

This next generation of biofuels is now beginning to show progress. Biodiesel production expanded from nine million gallons in 2001 to more than 900 million gallons in 2011.[244] New cellulosic ethanol facilities are coming on line. However, cellulosic production has been lagging the RFS, partly because the 2007 RFS mandate was signed into law in late 2007, just prior to the start of the deepest recession in 70 years. That halted new investment, not just in advanced biofuels, but throughout the rest of the economy as well. In addition, the blend wall that has limited the amount of ethanol that can be blended with gasoline to 10 percent for most vehicles has sent a negative signal to investors and the next generation of biofuels that the market is not available.

Figure 2-22: Cellulosic Biofuel Volumes Mandated Under EISA and EPA Revision



Source: Randy Schnepf and Brent D. Yacobucci, Congressional Research Service, *Renewable Fuel Standard (RFS): Overview and Issues*, January 2012, R40155, 3, http://www.fas.org/sgp/crs/misc/R40155.pdf.

Ethanol today accounts for 10 percent of the gasoline used in the United States.[245] It is generally mixed with petroleum-based fuel in blends of up to 10 percent ethanol (E10) and is widely used in conventional vehicles across the country. Although there are no major technological barriers to expanding the use of ethanol, infrastructure and vehicle compatibility issues begin to arise as blend ratios (the proportion of ethanol mixed with conventional gasoline) exceed 10 percent. To meet future RFS mandates, current projections of fuel demand imply that higher ethanol blends will be required, which in turn is expected to necessitate changes to vehicles and separate fueling pumps. Although most older cars in the existing vehicle fleet were not designed to run at higher ethanol contents, new cars are typically compatible with a 15 percent ethanol blend (E15),[246] and approximately ten million flex-fuel vehicles on the road today were designed to accommodate blends up to 85 percent ethanol (E85).[247] Furthermore, as automakers seek to meet new fuel economy and GHG tailpipe standards, engines optimized for ethanol blends above 10 percent offer potential because of ethanol's high-octane value and the benefits of octane in smaller high-compression engines.[248,249] However, there has been insufficient incentive to date for fuel retailers in most areas to invest in the infrastructure needed to dispense ethanol blends above 10 percent, such as E15 and E85. It will take both time and money for the proper infrastructure and certifications to allow wide-scale fueling of vehicles with higher ethanol blends.

The 2007 authorizing law, which directs EPA to implement the RFS program, provides a series of off-ramps and reviews of the required biofuels mandates,[250] recognizing that technologies, such as cellulosic biofuels, did not exist at the law's passage and would require time to develop and commercialize. Based on the flexibility built into the law, EPA adjusted the annual blending requirements with waivers for cellulosic biofuels in 2010–2012 (the first three years of the cellulosic biofuel blending requirement) (Figure 2-22) but left the overall advanced renewable fuels levels unchanged, allowing other advanced biofuels, such as sugarcane-derived ethanol and drop-in renewable fuels, to fill the gap. Under the 2007 law, future year cellulosic targets from 2016 through 2022 will be reviewed through a public notice and comment process triggered by the EPA waivers. The authorizing law also provides a cost "circuit-breaker" in the form of a compliance credit that blenders can purchase in lieu of blending actual gallons of renewable fuel, whenever a waiver is issued for cellulosic biofuels. These credits cap the per-gallon cost of cellulosic biofuels to blenders, and the credit price was set at $1.56, $1.13, and $0.78 in 2010, 2011, and 2012, respectively. In 2010 and 2011, EPA sold cellulosic biofuel waiver credits to industry for a total of $5 million.[251]

The current high cost of second-generation biofuels is the key challenge in advancing them to a point where they are competitive with conventional fuels on a basis that values their inherent health, environmental, and energy security benefits. As the technology matures, the production cost of cellulosic and other advanced biofuels is expected to decline, as it did with grain ethanol; however, it is anticipated that at least initially, advanced biofuels will increase the cost of gasoline. Thus, a key aspect of the success of future biofuels will be early operating experience and R&D to reduce their cost.

Significant private-sector investment in commercial-scale cellulosic biofuel facilities is beginning to occur. Construction is currently underway in building America's first six cellulosic biofuel refineries[252] (Table 2-4), and more than 165 companies[253] are involved in biofuel production in the United States and Canada. With the first commercial-scale refineries coming on line, cellulosic biofuel production is expected to increase almost 20-fold in 2013, signaling a shift from an experimental fuel into commercial development.[254]

DOD, which pursues advanced biofuels for their strategic value in supporting the military's mission,[255] continues to play an important role in driving advanced biofuels. DOD procurement policies provide market demand at a critical stage of development for renewable fuels, which has helped to bring down their costs.[256] DOD is currently limited to entering into procurement contracts of five years (with the option to extend in one-year increments, up to an additional five years).[257] Longer-term contracting for biofuels would allow the DOD to establish price certainty for alternatives and provide greater market stability. In turn, this stability would stimulate greater private investment, expediting the commercialization of alternative fuels.

Natural Gas as a Vehicle Fuel

Recent trends in domestic natural gas production could support the increased use of natural gas as a cost-competitive alternative to petroleum fuels in transportation applications. Natural gas, either in liquefied or compressed form, can fuel light-duty vehicles, trucks, or even trains and airplanes. In recent years, the retail fuel prices for compressed natural gas (CNG) and liquefied natural gas (LNG) have been lower than retail prices for gasoline and diesel fuel on an energy-equivalence basis.[258] However, even with potentially lower-cost fuel, the added costs for vehicles and fueling infrastructure may make the use of natural gas vehicles more expensive and less attractive to consumers. LNG is particularly suited for the long-haul

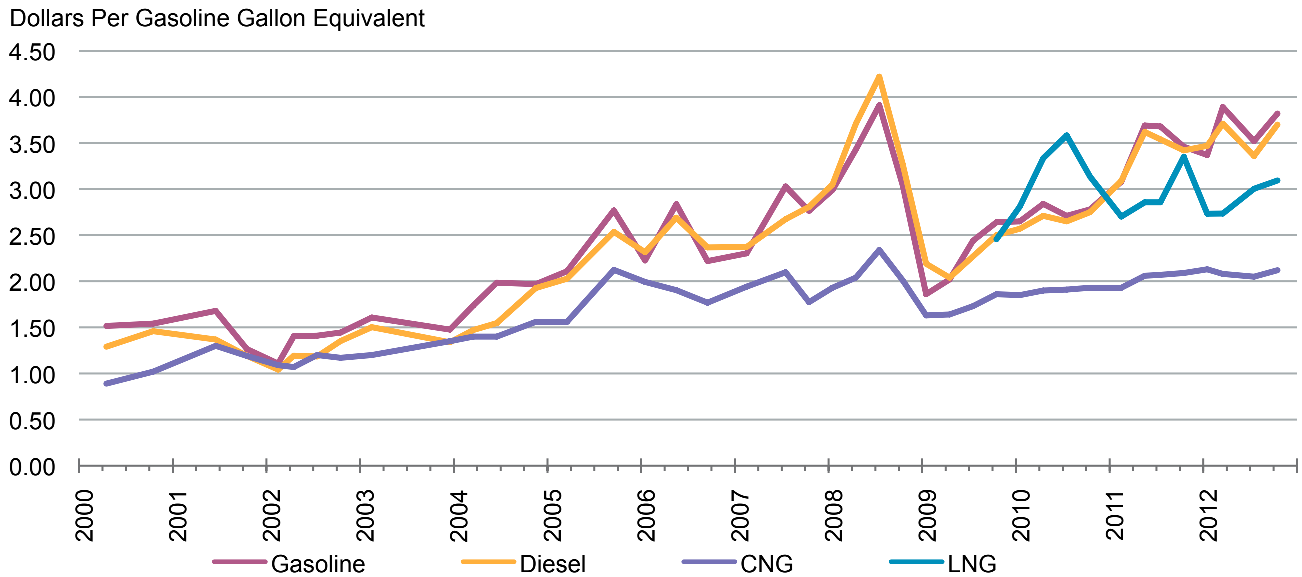
Table 2-4: Commercial Cellulosic Biofuel Projects Underway

Company	Location	Nameplate Capacity (million gallons per year)	Year of Expected Start-up
KiOR	Columbus, MS	11	2012/13
INEOS Bio	Vero Beach, FL	8	2012/13
Abengoa Bioenergy	Hugoton, KS	23	2013
POET	Emmetsburg, IA	25	2013
Fiberight	Blairstown, IA	4	2013
DuPont	Nevada, IA	30	2014

Note: The table includes cellulosic biofuel projects currently projected to produce commercial volumes during 2012 or 2013, as of September 18, 2012 according to US EIA and Dupont's commercial cellulosic ethanol facility that just commenced construction.

Source: DuPont Industrial Biosciences, "Dupont Advances Commercialization of Cellulosic Ethanol with Iowa Biorefinery Groundbreaking; Once Completed, Plant to Supply 30 Million Gallons of Renewable Fuel to the United States," November 30, 2012, http://biosciences.dupont.com/media/news-archive/news/2012/dupont-advances-commercialization-of-cellulosic-ethanol-with-iowa-biorefinery-groundbreaking/; U.S. Energy Information Administration, "Table 5. Cellulosic biofuels projects currently projected to produce commercial volumes during 2012 and 2013," *Biofuels Issues and Trends*, October 2012, 22, http://www.eia.gov/biofuels/issuestrends/

Figure 2-23: Average U.S. Retail Transportation Fuel Prices, April 2000 – October 2012



Source: U.S. Department of Energy, Alternative Fuels Data Center, *Clean Cities Alternative Fuel Price Report*, http://www.afdc.energy.gov/fuels/prices.html.

trucking industry, and potentially the railroad industry, because of the positive economics of natural gas compared with diesel fuel. Truckers and railroads travel on established routes, which would make it easier to establish corridors of LNG fueling stations.[259] Natural gas vehicles also offer an opportunity for high-mileage fleets—such as taxi, bus, and delivery vehicles—that are centrally fueled and/or operate within limited areas.

However, significant barriers to widespread use of natural gas as a vehicle fuel remain. They include substantial price premiums for vehicles that can run on natural gas and the need to greatly expand refueling infrastructure. On average, a light-duty vehicle designed to operate on compressed natural gas (CNG) costs $5,500 more than a conventional gasoline vehicle, while a LNG-equipped heavy-duty truck costs $70,000 more than a conventional diesel truck.[260] Natural gas vehicles (both CNG and LNG) have to refuel more often than conventional vehicles and take about twice as long to fill up as gasoline vehicles. Finally, CNG and LNG fueling stations require major capital investments and are more expensive to build than regular gasoline and diesel fueling stations.[261]

Although natural gas vehicle and infrastructure deployment has been limited, multiple LNG and CNG projects are currently underway across the country, led and funded by different industry players including natural gas producers, utilities, city-owned fleets, private-industry medium-duty trucking delivery or service companies, and equipment manufacturers, among others. For example, Clean Energy, a natural gas transportation fuel provider, is building a network of LNG fueling station corridors on the interstate highway system to serve long-haul truckers.[262] State and local governments are also offering technical support, grants, credits, loans, or other benefits to entities that purchase natural gas vehicles or build out the fueling infrastructure.

In addition, a strategically promising prospect for the transportation sector (surface, aviation, and maritime) is the conversion of natural gas to synthetic diesel. Advances in the conversion process that result in lower costs, reduced energy inputs, and improved efficiency would enable the United States to harness its natural gas supplies to further diversify the U.S. transportation energy mix and foster greater self-sufficiency. Importantly, synthetic diesel produced from natural gas could utilize existing infrastructure.

Electric Vehicles

Electric vehicles have the potential to play an important role in our nation’s transportation and offer several advantages: they are significantly more efficient than their conventional counterparts,[263] they require less maintenance than conventional gasoline vehicles, they emit no tailpipe pollutants, and under most vehicle and power-sector assumptions have lower greenhouse gas emissions on a full fuel-cycle basis.[264] Plug-in Hybrid Electric Vehicles (PHEVs) share many of the advantages of all-electric vehicles and have the added flexibility to operate on both electricity and conventional fuel, which expands their driving range and diminishes the infrastructure limitations faced by purely electric vehicles. Experts predict the potential for significant growth in the use of PHEVs, as well as electric vehicles, if a series of hurdles can be addressed.

Necessary cost and technology improvements have yet to be fully realized, including issues of battery cost and weight, recharging time, driving range, and energy density. In addition, the infrastructure for charging electric vehicles is limited and unevenly distributed.[265] Plug-in hybrid and electric vehicles also pose a unique challenge for the grid, as they may contribute a significant new load with unusual and potentially disruptive impacts on current distribution systems, particularly if they are recharged during times of already high electricity demand in the late afternoon and early evening.

Efficiently deploying and accommodating an expanded electricity-based vehicle fleet will likely require some combination of real-time pricing and centralized management of vehicle charging, advanced communication and control equipment, build-out of recharging infrastructure, and improvements in vehicle technology. A number of policies and programs have been introduced to overcome these technical and operational challenges with federal laws and incentives that promote R&D, manufacture, and use of these vehicles, including 21 for electric vehicles and 9 for PHEVs.[266] For example, DOE’s ARPA-E program funds research projects on relevant electric vehicle (EV) technologies including next-generation storage.[267] The Plug-In Electric Drive Motor Vehicle Tax Credit is a federal tax credit available to purchasers of a new, qualified plug-in electric motor vehicle.[268] However, additional investments in R&D and infrastructure will be needed to further reduce costs and increase EV penetration.

Hydrogen Fuel Cells

Fuel-cell electric vehicles powered by hydrogen continue to receive attention and investment from government and industry. With no tailpipe emissions other than water and with the potential to produce hydrogen from a variety of sources, hydrogen vehicles have substantial potential energy security, greenhouse gas, and air-quality benefits. However, significant cost and technical challenges remain, particularly related to vehicle and infrastructure requirements.[269]

Recommendations for Alternative Transportation Fuels

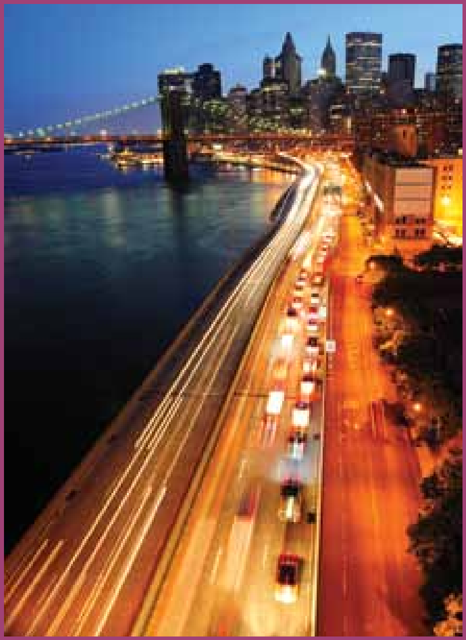
RECOMMENDATION: The Federal government, by itself or in combination with industry, should pursue sustained investment in research and development for transportation fuels, vehicles, and infrastructure to advance more efficient and cleaner energy consumption in the transportation sector. Efforts should focus on advanced biofuels production and multimodal fueling infrastructure (particularly for enhancing the cost-competitiveness of renewable fuels, and expanding infrastructure for higher ethanol blends), developing fuels compatible with the existing motor vehicle fueling infrastructure, vehicle light-weighting, vehicle battery technology, and other areas associated with the potential to contribute to game-changing innovations.

RECOMMENDATION: Local, state, and federal governments should continue and expand efforts to encourage early infrastructure investments for those alternative fuel-vehicle systems that offer a path to long-term viability, considering their lifecycle costs and long-term benefits. Given the "chicken and egg" infrastructure challenges of early deployment for alternative multimodal fuel infrastructure, as well as the long-term societal benefits in terms of energy, economic, and environmental security, targeted government support could facilitate permitting, provide technical assistance and aid coordination of fuel retailers and fuel users, leverage private-sector financing, and synchronize alternative fuel, vehicle, and infrastructure policies to maximize their effectiveness.

RECOMMENDATION: While we have diverse views regarding the Renewable Fuel Standard (RFS) provisions for conventional renewable fuels, we uniformly believe the nation should continue to develop advanced renewable fuels, and we support the role that the RFS can play in promoting these fuels. Some subcategories of advanced biofuels, such as cellulosic biofuels, have developed more slowly than anticipated, but significant expansion of cellulosic biofuel capacity is now occurring as a result of the RFS. We recognize that, in the short term, the RFS allows the nation to gain experience with commercial production of advanced biofuels and an opportunity to bring down their costs. However, a review of the RFS may be warranted after allowing some time to gain operating experience from the advanced biofuels refineries that have recently begun or are close to beginning production. In any case, the provisions of the Energy Independence and Security Act of 2007 allow for annual waivers and have already triggered a process to reevaluate the cellulosic biofuels targets for the years 2016–2022.

RECOMMENDATION: We support longer-term DOD procurement contracts, consistent with the fulfillment of its national security mission, for advanced biofuels and urge the Congress to authorize extended procurement contracts. DOD has pursued advanced biofuels for their strategic value in supporting the military's mission. DOD is currently limited to entering into procurement contracts of only five years. Longer-term contracting for biofuels would allow the DOD to establish price certainty for alternatives and provide greater market stability to support expediting the commercialization of alternative fuels.

Energy & Infrastructure Program
Energy Project



Chapter 3: Improve the Energy Productivity of the Economy

Energy Productivity and the U.S. Economy

Energy productivity is a measure of the useful output achieved for a given amount of energy used.[270] Output can be a quantity of something produced, such as a ton of steel, or output can be measured in terms of a service rendered, such as heating or lighting provided. Energy productivity improvements deliver multiple benefits in terms of cost savings, enhanced competitiveness, and pollution reductions. This chapter assesses recent U.S. experience with improving energy productivity in the commercial, residential, industrial, transportation, and electric power sectors. It also explores the prospects for further progress and provides recommendations on policies and approaches that would increase energy productivity in these sectors. Several key themes inform the overall discussion and are worth highlighting at the outset:

- Cost-effective energy efficiency is a resource that can and should compete with energy-supply alternatives on a life-cycle basis. In many situations, the cheapest and cleanest energy source is the energy we don't have to use.
- Energy efficiency has a 30-year track record of making it possible to provide more cost-effective energy services while reducing the need for additional supply. There are examples of and opportunities for cost-effective improvements in energy productivity in every sector, and these improvements can help fuel economic growth across the economy.
- Procurement of cost-effective energy efficiency resources by electric and gas utility companies will be a critical driver of energy productivity improvements across the residential, commercial, industrial, and electricity supply sectors. Though a number of states have developed successful regulatory structures to encourage such activity, many states still need to remove barriers to and create incentives for cost-effective utility investments in energy efficiency.
- Only in situations where clear market failures have been identified should government policies be used to address these failures. Such policies include a combination of performance-based efficiency codes and standards, labels, and targeted financial incentives, as well as measures that leverage private-sector finance. These tools are most effective when they are applied in an integrated fashion, carefully targeted to overcome identified barriers, and designed to ensure sustained improvement across the spectrum of appliances, lighting, equipment, and buildings.
- As the U.S. economy recovers from the recent recession, it is critical that the next major tranche of industrial and utility investment maximizes efficient and cost-effective use of energy resources.

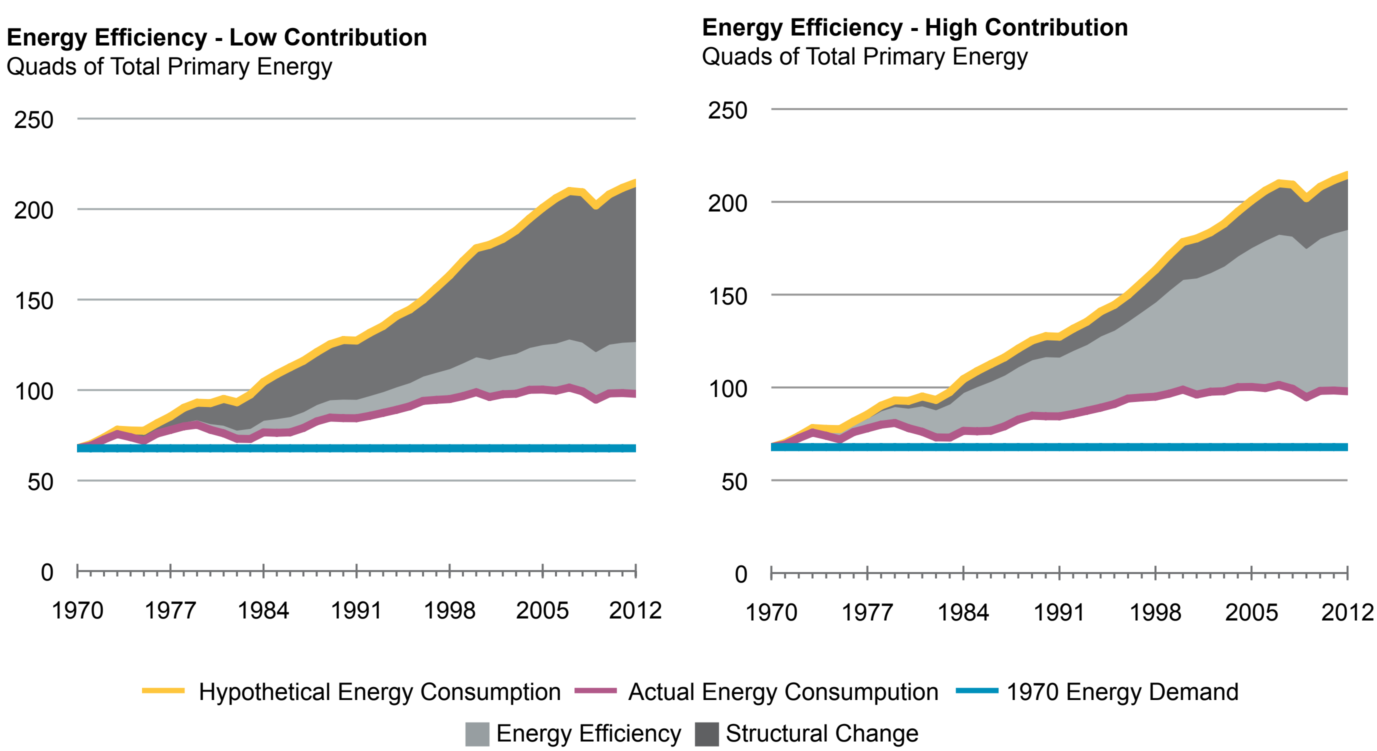
A Generation of Improvement in U.S. Energy Productivity

Energy productivity has improved over the last 40 years, as efficiency gains have made it possible to fuel more economic activity using less energy. Since 1970, overall U.S. economic output has more than tripled, while energy usage increased by only 43 percent.[271] These remarkable gains in energy productivity can be attributed to two main drivers. The first involves structural changes in the U.S. economy, including the shift from more energy-intensive manufacturing industries to less energy-intensive service industries. The second major driver has been investments in developing and deploying energy-efficient technologies and processes.

Figure 3-1 depicts a simplified way to think about the significant improvement in energy productivity that occurred in the United States over the past few decades. The "Hypothetical Energy Consumption" line represents the energy consumption levels that would have occurred between 1970 and 2012 if energy consumption per unit of economic activity had stayed constant at 1970 levels. *In other words, it illustrates how much energy would have been required to fuel the actual economic growth during this period if there had been no improvement in energy productivity after 1970.* Using this assumption, total U.S. energy demand would have increased by 147 quads between 1970 and 2012. By comparison, *actual U.S. energy consumption in 2012* was only 30 quads higher than in 1970. Thus, the graph shows that energy productivity improvements made up nearly 117 quads, or 79 percent of the hypothetical increase in energy demand that would otherwise have been necessary since 1970 to support current levels of economic activity.[272]

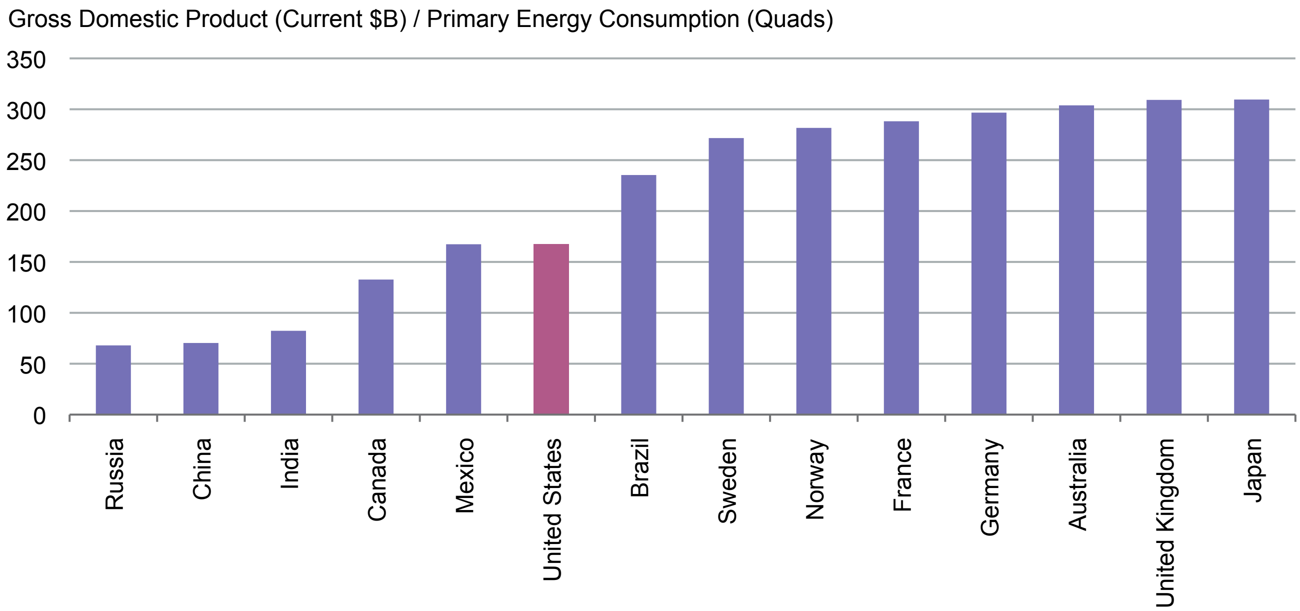
Numerous studies have looked at the relative importance of structural changes compared to efficiency investments in terms of explaining the energy productivity gains that occurred over the last generation. Separating and quantifying the impacts of these two drivers is challenging, but,

Figure 3-1: Energy Demand and Supply 1970-2012; Range of Energy Efficiency Contribution



Source: U.S. Energy Information Administration, "Annual Energy Outlook 2010 with Projections to 2035," April 2010, 30-32, http://www.eia.gov/oiaf/aeo/pdf/0383%282010%29.pdf; Gilbert E. Metcalf, "An Empirical Analysis of Energy Intensity and Its Determinants at the State Level," *The Energy Journal*, January 2008, http://globalchange.mit.edu/files/document/MITJPSPGC_Reprint08-8.pdf; St. Louis Federal Reserve, "Real Gross Domestic Product," accessed August 16, 2012, http://research.stlouisfed.org/fred2/series/GDPC1. U.S. Energy Information Administration, "Energy Consumption Estimates by Sector 1949-2011," September 27, 2012, http://www.eia.gov/totalenergy/data/annual/showtext.cfm?t=ptb0201a. John A. "Skip" Laitner et al., American Council for an Energy-Efficient Economy, "The Long-Term Energy Efficiency Potential: What the Evidence Suggest," January 2012, http://aceee.org/research-report/e121.

Figure 3-2: Energy Productivity by Country, 2011



Note: In this graph, energy productivity is calculated as gross domestic product divided by primary energy consumption.
Source: International Monetary Fund, "Gross Domestic Product, Current Prices in U.S. Dollars," *World Economic and Financial Surveys: World Economic Outlook Database*, October 2012, http://www.imf.org/external/pubs/ft/weo/2012/02/weodata/index.aspx; BP Global, "Primary Energy: Consumption Mtoe (from 1965)," *BP Statistical Review of World Energy*, June 2012, http://www.bp.com/extendedsectiongenericarticle.do?categoryId=9041234&contentId=7075077.

overall, the literature that exists on this topic indicates that efficiency investments have accounted for anywhere from one-quarter to three-quarters (i.e., 25–75 percent) of the improvement in energy productivity achieved over the last three decades.[273,274,275,276] As Figure 3-1 illustrates, if not for improved energy efficiency, the increase in U.S. energy consumption would have at least doubled and perhaps quadrupled between 1970 and today.

The Potential for Further Improvements in Energy Productivity

Despite the impressive record of progress documented in the last section, the United States is not close to exhausting opportunities to save energy at a lower cost than it can be produced. This point is well-documented by recent studies from the American Physical Society[277] and National Academy of Sciences (NAS),[278] which find that cost-effective energy savings in the buildings sector alone over the next 20–25 years could completely offset the projected increase in energy consumption in this sector over the same period if business as usual continued. According to a 2008 Brattle Group study, realistically achievable energy efficiency and demand response[279] could reduce the need for new electric generating capacity by as much as 38 percent through 2030.[280] Moreover, the NAS report also notes that because of energy losses in the generation, transmission, and distribution of electricity, the amount of electricity entering a building or facility represents only 30 percent or less of the original energy content of the fuel. Therefore, reducing energy use at the end-use level translates into a three-to-one savings at the generation level.[281]

It is also instructive to compare energy productivity across a variety of countries (Figure 3-2). Although energy productivity in the United States is less than in some other industrialized countries, it is important to note that some of this variation can be attributed to structural economic differences (e.g., the levels and types of manufacturing activity), variations in domestic energy resources, and other factors such as population density. Nevertheless, this comparison with other nations highlights the potential for improvement in U.S. energy productivity.

To achieve additional gains in energy productivity, a variety of disincentives and barriers must be addressed. For example, although efficiency investments offer savings in energy costs, the potential beneficiary of an energy efficiency investment is not always the party in a position to make improvements (e.g., renters in multi-family apartment buildings). In other cases, information barriers may stand in the way of cost-effective efficiency investments.[282] Utility programs can help overcome these barriers, but for reasons discussed in the next section, many states' ratemaking structures create potent disincentives to utility-led investment in cost-effective, customer-side efficiency programs.[283] Practical solutions to this problem are well-understood but have been slow to emerge in many states. A final market failure arises from the fact that some of the external costs of energy use, including certain adverse public health, environmental, and national security impacts, are not fully reflected in the delivered price of energy and therefore into investment decisions. Quantitative assessments of the costs of these externalities are complex, controversial, and imperfect. Nevertheless, most analysts would agree that these costs are "greater than zero" and that some energy efficiency standards and programs have implicitly or explicitly included these costs when setting levels of stringency.[284]

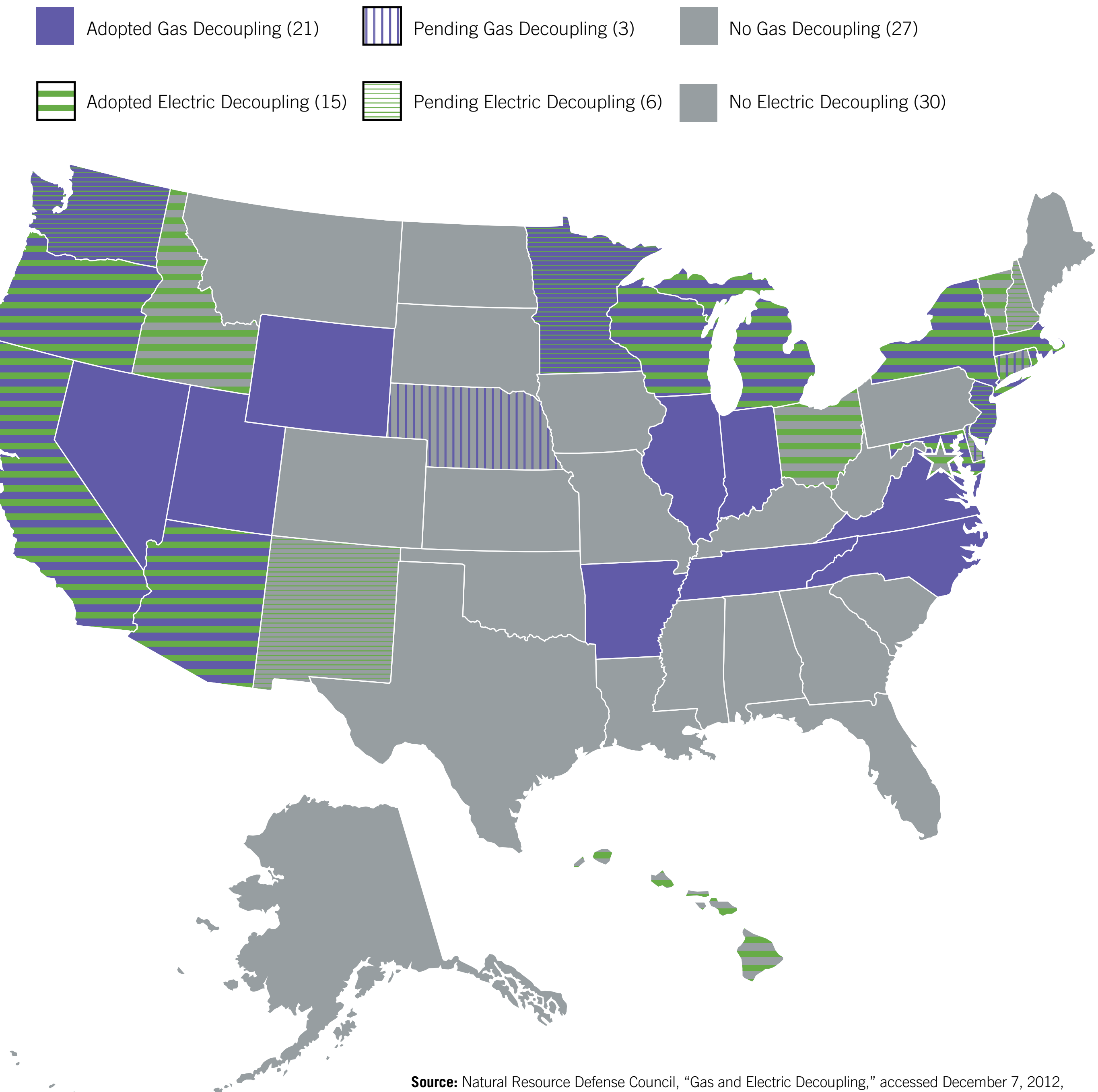
Fortunately, there are effective policies and practices that can address these barriers to cost-effective energy efficiency at the federal, state, local, and corporate levels. The following sections describe how these approaches can be applied to spur cost-effective energy productivity investments in major sectors of the economy. Each of these sector discussions concludes with specific recommendations to policy makers at different levels of government.

The Role of Utilities in Driving Energy Productivity Improvements Throughout the Economy

Utilities are well-situated to spur the implementation of cost-effective energy efficiency measures, given their access to customers and consumption data, and an announced capital budget of up to $2 trillion (for electric utilities alone) over the next two decades.[285] Electric and gas utilities have access to capital, as well as the skills to make sound resource choices tailored to local conditions. However, they typically lack proper incentives to view energy efficiency as a resource. In most states, the utility business model, which rewards increased retail sales and not energy savings, creates a financial disincentive for utility investments in customer-side efficiency improvements. So long as their financial health is directly tied to sales, utilities in these states (whether public or investor-owned) incur automatic harm when electricity or gas use declines as a consequence of cost-effective efficiency investments.

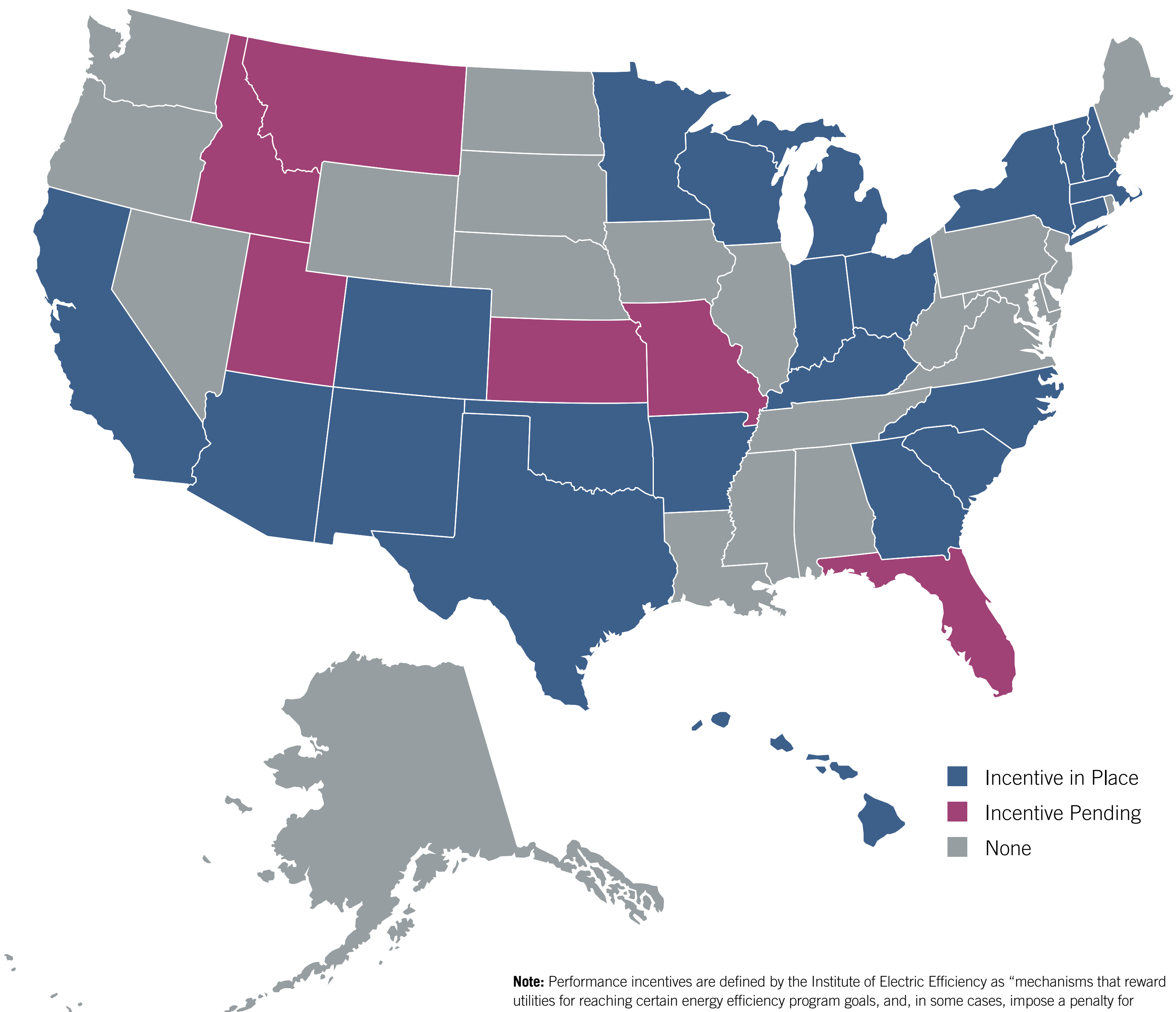
A number of states have adopted policies to address this disincentive to utility support for customer-side efficiency improvements. One approach, sometimes called "decoupling," uses small, regular rate adjustments to ensure that changes in customer sales do not result in the over- or under-recovery of authorized costs (Figure 3-3). Decoupling effectively removes the financial disincentive for utility investment in efficiency; it does not, however, create positive incentives for such investments. To be fully motivated to undertake efficiency programs, utilities must see an earnings opportunity. Some states have addressed this issue by

Figure 3-3: Electric and Gas Utility Decoupling Mechanisms by State, as of January 2012



Source: Natural Resource Defense Council, "Gas and Electric Decoupling," accessed December 7, 2012, http://www.nrdc.org/energy/decoupling/.

Figure 3-4: Utility Performance Incentives for Electric Efficiency by State, as of July 2012

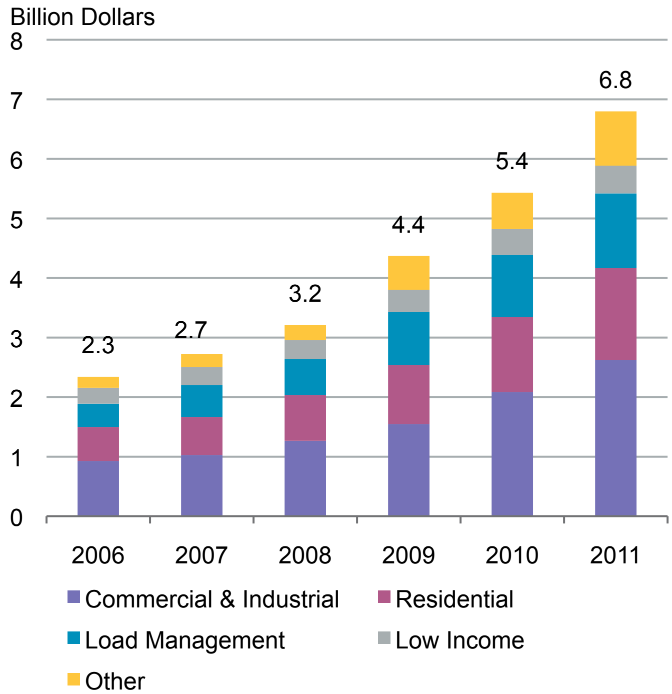


Note: Performance incentives are defined by the Institute of Electric Efficiency as "mechanisms that reward utilities for reaching certain energy efficiency program goals, and, in some cases, impose a penalty for performance below the agreed-upon goals. Performance incentives allow for utilities to earn a return on their investment in energy efficiency, typically similar to the return on supply-side investments."
Source: IEE, *State Electric Efficiency Regulatory Frameworks*, July 2012, 2, http://www1.eere.energy.gov/buildings/betterbuildings/neighborhoods/pdfs/iee_state_reg_frame.pdf.

providing financial incentives for efficiency programs (Figure 3-4)—for example, by linking utility incentives to verified performance in delivering cost-effective, customer-side energy savings.[286]

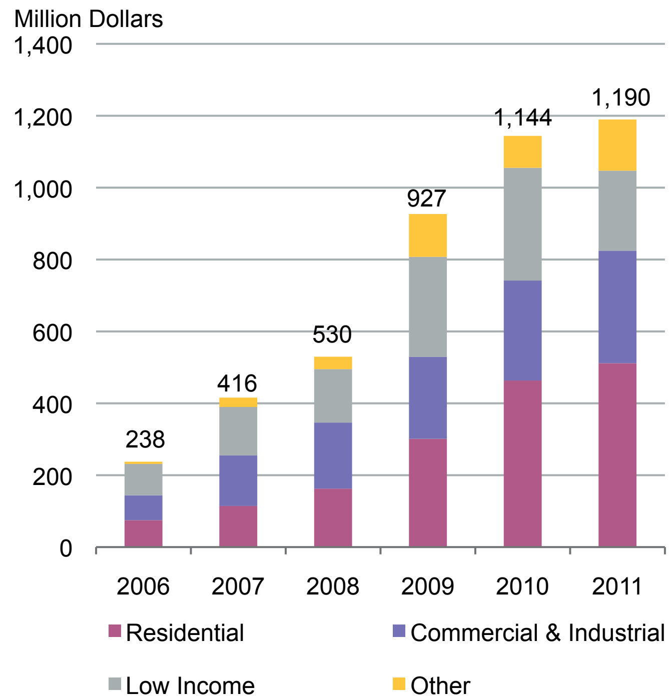
State policies such as revenue decoupling, performance incentives, and savings goals have given some utilities incentives to overcome barriers to implementing efficiency programs. For example, some states have adopted an Energy Efficiency Resource Standard, which requires utilities to either (a) achieve a certain percentage reduction in energy use through efficiency measures, or (b) ensure that they have captured all cost-effective demand-side efficiency opportunities. As of September 2012, 24 states had adopted Energy Efficiency Resource Standards.[287] Figures 3-5 and 3-6 illustrate the results of a survey done by the Consortium for Energy Efficiency on U.S. electric and gas utility budgets for customer-side efficiency programs.[288] The electric and gas program administrators included in the survey allocated $8 billion for energy efficiency programs in 2011. This was more than double what they budgeted in 2007.[289,290]

Figure 3-5: Energy Efficiency Program Budgets for U.S. Electric Utilities, 2006-2011



Note: Actual expenditures could vary from the budget numbers.
Source: Patrick Wallace and Hilary Jane Forster, Consortium for Energy Efficiency, *State of the Efficiency Program Industry: Budgets, Expenditures, and Impacts 2011*, March 14, 2012, http://library.cee1.org/sites/default/files/library/8000/2011_CEE_Annual_Industry_Report_0.pdf.

Figure 3-6: Energy Efficiency Program Budgets for Gas Utilities, 2006-2011



Note: Actual expenditures could vary from the budget numbers.
Source: Patrick Wallace and Hilary Jane Forster, Consortium for Energy Efficiency, *State of the Efficiency Program Industry: Budgets, Expenditures, and Impacts 2011*, March 14, 2012, http://library.cee1.org/sites/default/files/library/8000/2011_CEE_Annual_Industry_Report_0.pdf.

There are numerous examples of utility programs designed to help customers adopt cost-effective efficiency technologies. For example, PG&E's Energy Partners Program, which began in 1983, offers energy audits, weatherization upgrades, and energy-efficient appliances to qualifying low-income households. By 2008, more than one million households had participated in this program, and PG&E had trained more than 1,500 energy specialists to conduct the audits. In 2008, the program achieved an estimated 26 million kilowatt-hours of electricity savings, and natural gas savings of approximately 1 million therms (or roughly 100,000 MMBtus). The average participating household achieved annual energy cost savings of roughly $600.[291] Energy Partners was named an exemplary low-income energy efficiency program by the American Council for an Energy Efficient Economy.

Utilities are also well-positioned to deploy the next generation of demand response technologies. (The term *demand response* includes technologies that both shift load and save energy.) Traditionally, demand response programs have enabled electric utilities to manage short-term peaks in energy use for residential, commercial, and industrial customers through load-control devices and smart thermostats that cycle heating and cooling equipment on and off or adjust temperature settings in the home to reduce consumption and minimize electricity price spikes. A new generation of automated demand response technologies, or auto DR, broadens the pool of potential participants by giving commercial and industrial consumers the ability to automatically respond to demand and price signals from utilities. Participants receive an automated signal from the utility that triggers short-term changes in building systems—such as turning off banks of lights, elevators, or cycling equipment—subject to parameters set in advance by the customer. The ability to customize load-shedding strategies is critical to enlisting commercial and industrial customers in demand response programs because these customers' energy needs vary widely, and because energy is often critical to their day-to-day operations.

By using auto demand response to connect with commercial and industrial customers, utilities can respond more effectively to reduce load when electricity demand peaks, thereby bringing greater stability to the power grid. In this way, auto demand response also helps electric utilities integrate renewable energy sources, such as wind and solar, into the electrical grid, using demand management as a valuable tool for continuously balancing power generation and demand.

Demand response programs are often done in tandem with dynamic pricing of electricity. Under dynamic pricing, retail electricity prices vary over short intervals, such as by the hour, based on the actual cost of providing electricity at that time. Dynamic pricing creates more accurate price incentives for electricity consumers and offers an effective opportunity to make the demand side of the electricity equation more responsive to supply constraints. The cost-effectiveness of dynamic pricing has been shown predominantly with large industrial and commercial customers.[292] These classes of customers are often more educated about their electricity usage and also use enough energy that a dynamic pricing mechanism has the potential to translate into significant savings. Studies on the use of dynamic pricing for residential customers have shown more mixed results. In the coming years, with the increased penetration of smart meters in the residential sector, there should be better data about customer behavior in response to dynamic electricity price signals, as well as further development of technologies to enable customer response to be automated. This experience will shed additional light on the benefits of dynamic pricing in the residential sector.

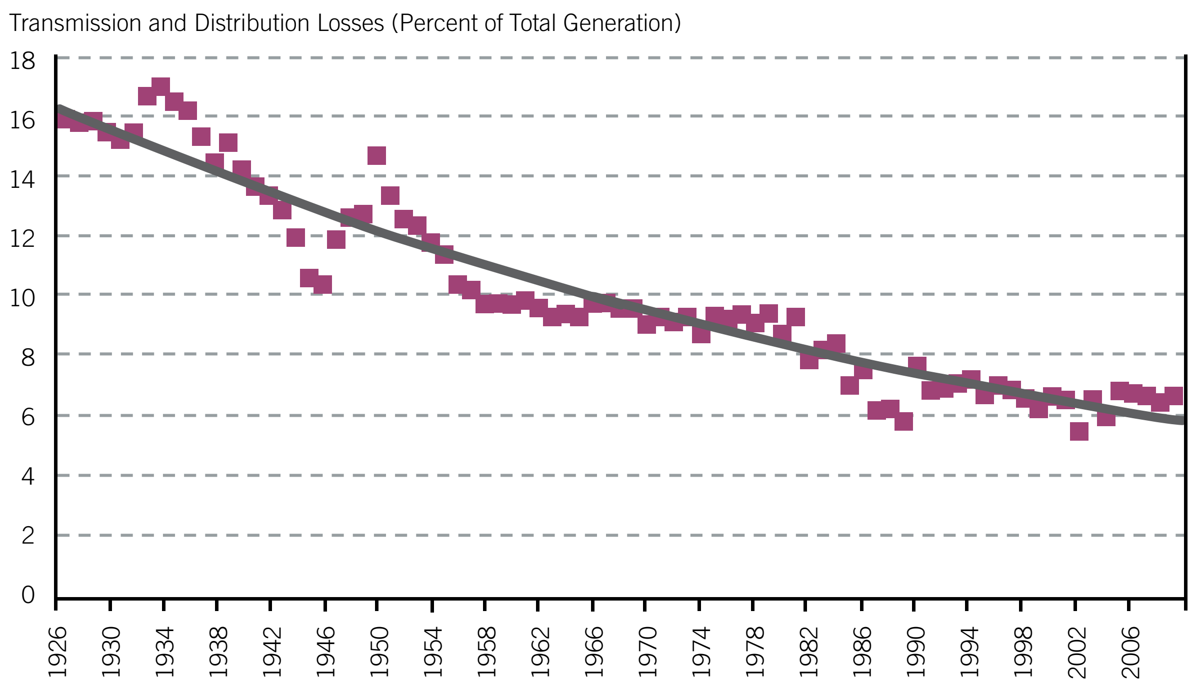
Potential for Electricity Supply-Side Efficiency Improvements

In addition to driving improvements in energy efficiency through investment in technologies on the customer side of the meter, some utilities also have improved efficiency on the supply-side. In the case of electric utilities, this includes improvements in generation, transmission, and distribution system efficiency.[293] The average overall efficiency of fossil fuel-fired electric power generation in the United States has increased over time and is expected to continue to increase as a result of several factors. First, there has been a growing role for natural gas combined cycle turbines, which have displaced less efficient generation. Second, there continues to be improvement in generation efficiencies of coal technologies. For example, AEP's J.W. Turk Plant, a 600 megawatt, ultra-supercritical pulverized coal generator, uses 180,000 fewer tons of coal per year of normal baseload operations and significantly less water than a same size unit using subcritical pulverized coal technology, while reducing coal ash, flue-gas desulfurization waste, SO_2, and NO_x.[294]

Finally, as discussed later in the industrial efficiency section, there is the potential for significant efficiency gains from combined heat and power (CHP) projects, which can reach total system efficiencies of 70–85 percent by recovering waste heat for additional power generation, heating, ventilation, and air conditioning (HVAC) uses, or useful industrial process applications.[295]

The policy design, accounting provisions, and/or structure of environmental regulations often influences whether various efficiency improvements are counted toward meeting emission-reduction obligations and may even provide an unintended disincentive for energy efficiency gains. For example, output-based performance standards allow facilities to count supply-side efficiency improvements toward their

Figure 3-7: U.S. Transmission and Distribution Losses, 1926-2009



Note: 1926-1950 data from Edison Electric Institute and 1951-2009 data from the Energy Information Administration.
Source: MIT Energy Initiative, "The Future of the Electric Grid," *Massachusetts Institute of Technology Energy Initiative*, December 5, 2011, 8, http://mitei.mit.edu/publications/reports-studies/future-electric-grid.

emission obligations and also better reflect the efficiency gains at cogeneration facilities by including all useful thermal outputs (e.g., electricity and industrial steam). Where possible, Congress and implementing agencies should be encouraged to seek environmental program designs that promote energy productivity.

The electric power industry has also achieved overall reductions in the amount of electricity lost in transmission and distribution (T&D) systems (Figure 3-7). Estimates of current losses range between 6 and 8 percent.[296] This improvement in the loss rate can be attributed to a number of factors, including more efficient transformers and new, higher-voltage transmission lines, and is likely to continue as the electric grid is upgraded over time. Recently, DOE proposed a rule, effective in 2016, to increase transformer efficiency by 10 percent over current levels. DOE estimates that this change will save 1.58 quads over a 30-year period, which is enough to displace approximately 2.4 gigawatts of generating capacity.[297] Moreover, some companies have shown that installing transformers with efficiencies higher than the new DOE standard is cost-effective and desirable.[298]

Despite significant progress in improving T&D efficiency, barriers remain. For example, projects to upgrade transmission infrastructure sometimes raise jurisdictional issues between state and federal authorities, and projects involving multiple states encounter related problems. Transmission improvements can be expensive and there is often controversy over the cost-allocation methodologies used to determine who should pay for new or upgraded transmission.

Informational barriers may also prevent investment in cost-effective technologies, including emerging smart grid technologies. In some cases, utilities may be reluctant to invest because of questions over effectiveness and economics. Similarly, it may be challenging to justify distribution system improvements using unfamiliar technologies to state utility regulators, despite the potential efficiency gains. Regulators may be hesitant to approve the higher electricity rates needed to recover the costs of these investments, and without reasonable assurance of cost recovery and an earnings opportunity, utilities are understandably reluctant to pursue such efficiency upgrades.

At the federal level, recent bipartisan legislation has addressed transmission and distribution efficiency through several provisions. For example, the Energy Independence and Security Act of 2007[299] directed the National Institute of Standards and Technology (NIST) to establish standards for the use of smart grid equipment and systems to ensure compatibility across the grid. The 2009 American Recovery and Reinvestment Act granted billions for upgrades to transmission lines and electric grid modernization, with $11 billion for smart grid technologies.[300] In an effort to encourage sharing of best practices, the federal government has also established websites to disseminate information on new technologies and on the outcomes of relevant demonstration projects.

Finally, note that a companion report by BPC, *Capitalizing on the Evolving Power Sector: Policies for a Modern and Reliable Electric Grid*, addresses electric system T&D issues, including system reliability and the deployment of new technologies, in more detail. The premise of the report is that the changing electric power sector will require significant investment in transmission and distribution infrastructure over the next decade. In some regions, additional transmission facilities, including more efficient lines spanning state boundaries and federal lands, may be needed. The construction of such projects brings with it complex decisions over siting and allocation of costs. With respect to distribution, upgrades to distribution systems that incorporate smart grid technologies and add capacity will be essential to allow non-transmission alternatives—such as certain forms of energy storage, distributed generation, energy efficiency, or demand response—to reach their full potential. BPC's grid report provides a menu of specific recommendations for state, regional, and federal authorities.

Recommendations on the Role of Utilities

RECOMMENDATION: Establish utility ratemaking policies that reward investments in cost-effective customer energy efficiency as a distributed resource and remove disincentives to these investments. Utilities will continue to be crucial investors in cost-effective energy efficiency resources. State ratemaking structures and policies such as decoupling, performance incentives, and savings goals will be critical to insure that utilities continue to make these beneficial investments.

RECOMMENDATION: Encourage cost-effective energy efficiency through Energy Efficiency Resource Standards, incentive programs, and/or resource procurement planning and measure the effectiveness of these policies. In addition to ratemaking policies, there are a variety of policies and programs with a strong track record for encouraging cost-effective energy efficiency. Utilities, states, and local utility boards should continue to consider and adopt these policies and should measure the effectiveness of different approaches.

RECOMMENDATION: Encourage the adoption of dynamic retail pricing of electricity and continue to evaluate the use of this option in the residential sector. Utilities and state public utility commissions (PUCs) can create more accurate price incentives for customers through dynamic pricing, a mechanism designed to shift load and decrease peak energy demand, by making electricity rates vary over certain time intervals. These rate structures are particularly effective when coupled with cost-effective programs such as automated demand response measures in the industrial and commercial sectors. Research and experimentation should continue on the use of dynamic pricing in the residential sector.

RECOMMENDATION: Design environmental programs that encourage efficiency improvements. EPA should consider policy designs and accounting provisions for environmental regulations that provide incentives and avoid disincentives for energy efficiency. For example, output-based emissions standards that account for both electricity and steam output can better reflect the energy productivity benefits of industrial cogeneration.

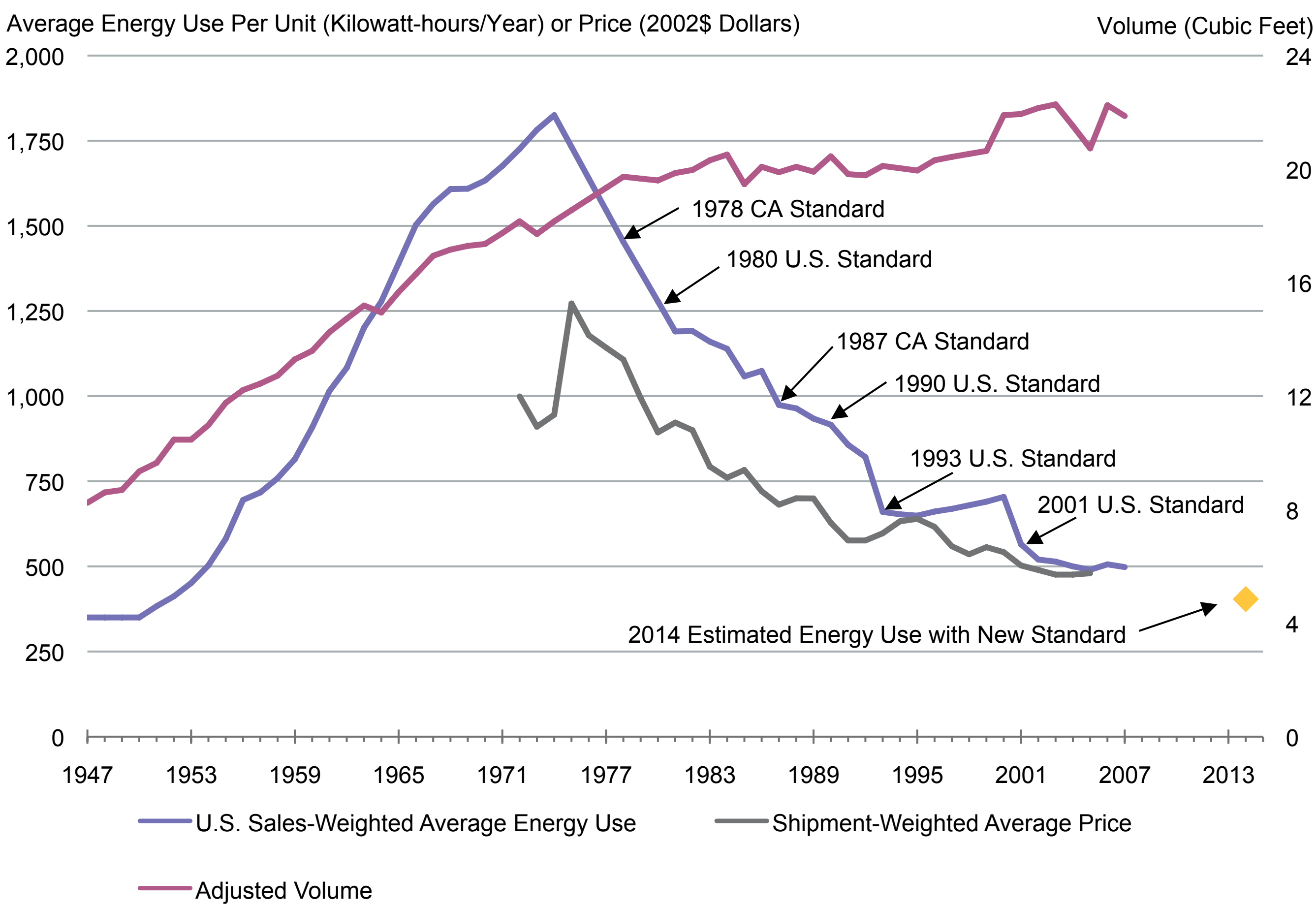
RECOMMENDATION: Encourage investment in new, more efficient transmission and distribution infrastructure. Some technologies and measures associated with new transmission and distribution infrastructure improve efficiency and have additional important benefits including improved system reliability. Policy makers at the state and federal levels—including state PUCs, local utility boards, and FERC—should encourage these types of investments where they are cost-effective.

Energy Productivity in the Residential and Commercial Sectors

The residential and commercial sectors account for more than 40 percent of total U.S. energy consumption and offer significant opportunities to improve efficiency.[301] Recent decades have seen a shift in residential energy use: The number of homes, the average size of homes, and the number of appliances and electronic devices in homes have increased, while the number of occupants per home has decreased. Yet improvements in construction and in the efficiency of end-use appliances and devices have offset these increases. Residential energy consumption per household (i.e., electricity, natural gas, and fuel oil consumption) is lower today than 30 years ago.[302]

Between 1970 and today, for example, the efficiency of refrigerators improved dramatically. Figure 3-8 shows how energy use for this major household appliance dropped (blue line) even as the size of refrigerators increased (red line), thanks to technology improvements spurred by the coordinated applications of efficiency incentives and standards. Importantly, this increase in size and efficiency did not lead to a corresponding increase in price; indeed, the cost of the average refrigerator (gray line) largely fell over

Figure 3-8: U.S. Refrigerator Energy Use vs. Time with Real Price, 1947-2014



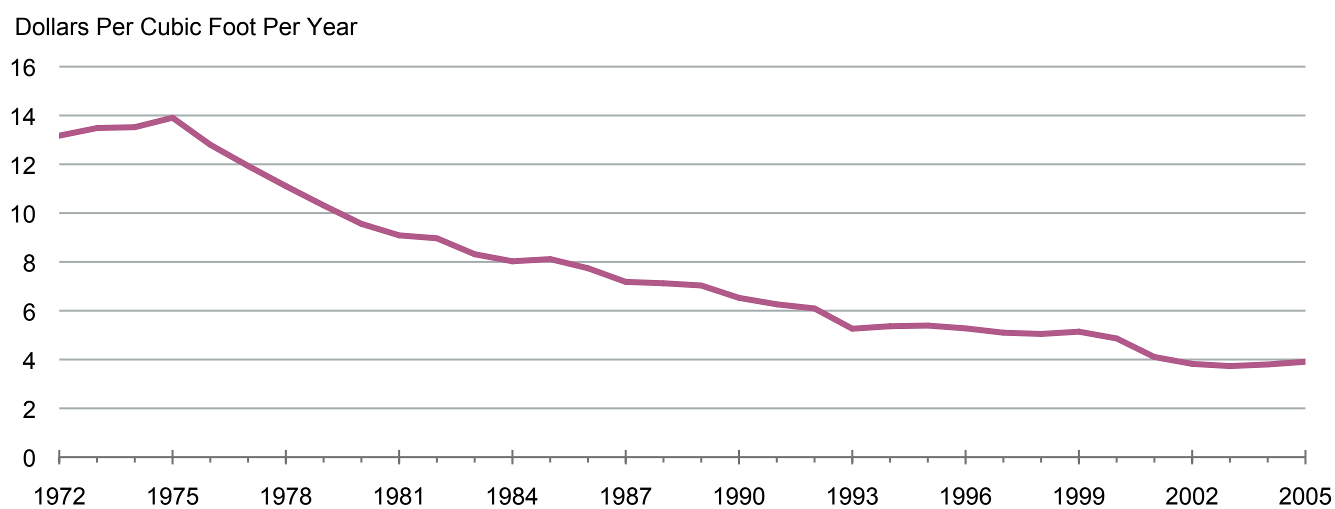
Note: Energy consumption and volume data is from the Association of Home Appliance Manufacturers and price data is from the U.S. Census Bureau. The data includes standard size and compact refrigerators. Energy consumption and volume reflect the DOE test procedure published in 2010. Volume is adjusted volume, which is equal to fresh food volume + 1.76 * freezer volume. Prices represent the manufacturer selling price (e.g., excluding retailer mark-ups) and reflect products manufactured in the U.S. Data supplied to BPC by NRDC.
Source: Amanda Lowenberger, et al., Appliance Standard Awareness Project, *The Efficiency Boom: Cashing in on the Savings from Appliance Standards*, March 2012, 66, http://www.appliance-standards.org/sites/default/files/The%20Efficiency%20Boom.pdf.

this time period. Figure 3-9 highlights the declining cost of refrigeration as an energy service. The refrigerator case is one where industry and government worked together to cut consumers' energy bills while simultaneously slashing a major source of electricity demand. New federal standards for refrigerators and freezers will take effect in 2014 and will limit electricity consumption for these appliances to between 404 and 624 kilowatt-hour/yr, depending on the model type. The new standards also will require a further 20–30 percent reduction in energy use.[303]

The commercial sector also has seen major gains in energy productivity. From 1980 to 2009, energy consumption per unit of commercial floor space decreased by roughly 20 percent as a result of efficiency improvements in HVAC systems, as well as appliances, insulation, lighting, windows, roofing, and other technologies.[304]

Despite the considerable progress achieved to date, pervasive barriers continue to slow the adoption of many cost-effective energy efficiency technologies. Many consumers and business owners are unaware of the availability and benefits of these technologies and may not experience directly positive health and environmental effects. In some cases, residential or commercial consumers or builders are reluctant to pay higher upfront capital costs for more efficient products, especially when retrofitting older buildings. In addition, misaligned incentives may inhibit investment in energy-efficient products. For example, an owner or renter may not make efficiency upgrades because he or she expects to leave before those investments pay back in energy savings, and builders may not prioritize efficient design or equipment because they will not pay the building's future operating costs. Furthermore, as discussed above, traditional ratemaking structures can discourage electric utility investment in programs aimed at reducing consumer energy use.

Figure 3-9: Declining Cost of Refrigeration, 1972-2005



Note: For each model year, the calculation includes the average retail price for a new refrigerator amortized over the life of the refrigerator plus the average annual electricity cost of operating a new refrigerator in that year. The lifetime of the refrigerator and the price of electricity are assumed to be constant in real terms from 1972 to 2005. Data supplied to BPC by NRDC.

Source: U.S. Energy Information Administration, "Average Retail Price of Electricity to Ultimate Customers: by End-Use Sector." Electric Power Monthly, September 24, 2012, http://www.eia.gov/electricity/data.cfm#sales; Amanda Lowenberger, et al., Appliance Standard Awareness Project, *The Efficiency Boom: Cashing in on the Savings from Appliance Standards*, March 2012, 66, http://www.appliance-standards.org/sites/default/files/The%20Efficiency%20Boom.pdf.

Given these barriers, federal, state, and local governments have enacted a variety of policies to improve the efficiency of the residential and commercial sectors, including appliance standards, product labeling and other information programs, building codes, tax credits and other subsidies, and performance contracts for government buildings. In addition, the federal government has supported R&D efforts to advance the next generation of efficient technologies—these programs are discussed in Chapter 4 of this report, which discusses technology innovation. A number of states have also adopted ratemaking reforms and other policies to remove disincentives to utility investment in demand-side efficiency and to ensure that energy efficiency is treated as a resource comparable to new generation in utility planning processes.

Federal Appliance and Building Standards

DOE's appliance standards program, which was first authorized by the Energy Policy and Conservation Act in 1975,[305] sets energy efficiency requirements for a variety of residential and commercial products that use electricity or natural gas.[306] In general, the standards are required by law to achieve the maximum energy efficiency improvement in a product that can be shown to be "technologically feasible and economically justified." Congress codified industry consensus standards for additional appliances with some opposition as part of broader energy legislation passed in 1987, 1992, 2005, and 2007. DOE is required to consider updating these standards every six years and also has the authority to set standards for additional products. In 2007, DOE gained new authority to promulgate regional standards for furnaces, heat pumps, and air conditioners. DOE was also given the authority to expedite rulemaking through the use of a Direct Final Rule upon receipt of a consensus petition from stakeholders.[307]

According to the Appliance Standards Awareness Project, the federal standards that are already in place will reduce electricity use by 14 percent and avoid the need to build 118 large (~570 megawatts) power plants nationally by 2035, while saving consumers a net of $1.1 trillion. For natural gas, the savings through 2035 will total 950 trillion BTUs, or enough to heat 32 percent of all natural gas–heated homes in the United States. The additional savings that could be achieved as a result of new standards issued between 2012 and 2015 could avert the need for another 49 power plants.[308]

Despite this success, some experts see opportunities to expand or improve the current standard-setting process. For example, one recent analysis recommended that the federal standards program be modified to accommodate "smart grid" enhancing capabilities in new appliances. The analysis also recommended streamlining the process for developing new test procedures for appliances if there is consensus from stakeholders.[309]

In addition to appliance standards, the federal government has contributed to the development of model-building standards since 1977. These model codes are updated every three years by two independent organizations: the International Code Council (ICC) and the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE). DOE offers technical support in this process and evaluates new standards for energy savings.[310] The Energy Policy Act of 1992 stipulates that states must consider the adoption of these model codes for new commercial and residential buildings. The fact that states have the autonomy to set their own standards, however, has created a patchwork of codes (Figures 3-10 and 3-11).[311] While significant energy savings have been realized from the codes already in place, there are opportunities for further energy savings, both through the adoption and full implementation of existing codes and from improvement to the codes themselves.

Local governments are often tasked with code enforcement, but inadequate funding can limit effectiveness. Some utilities have helped facilitate the implementation of building efficiency standards. For example, Southern Company's subsidiaries promote the EarthCents Home Program, a residential energy efficiency program, through incentives, rebates, audits, and guidance. These homes, with features such as high efficiency cooling, heating, and ventilation, must exceed building codes by 15 to 25 percent. Pacific Gas & Electric and Southern California Edison have incentive programs in California that reward architects, builders, and building owners for constructing buildings that exceed codes by 10–20 percent. Utilities can also reward the building owner monetarily if the energy usage is as low as predicted.[312]

The idea of linking performance to incentives has also been used in federal grant programs. For example, the American Recovery and Reinvestment Act of 2009 required states to commit to adopt and improve compliance with the 2007 ASHRAE Standard and 2009 International Energy Conservation Code (IECC) as a condition to receive their share of State Energy Program grants.[313] Governors in all 50 states agreed to adopt and achieve 90 percent compliance with the latest editions of the code. While this drove significant code adoption in many states, there is currently no penalty or continued incentive for governors to follow through on these commitments, and a few states have rolled back their codes as a result.

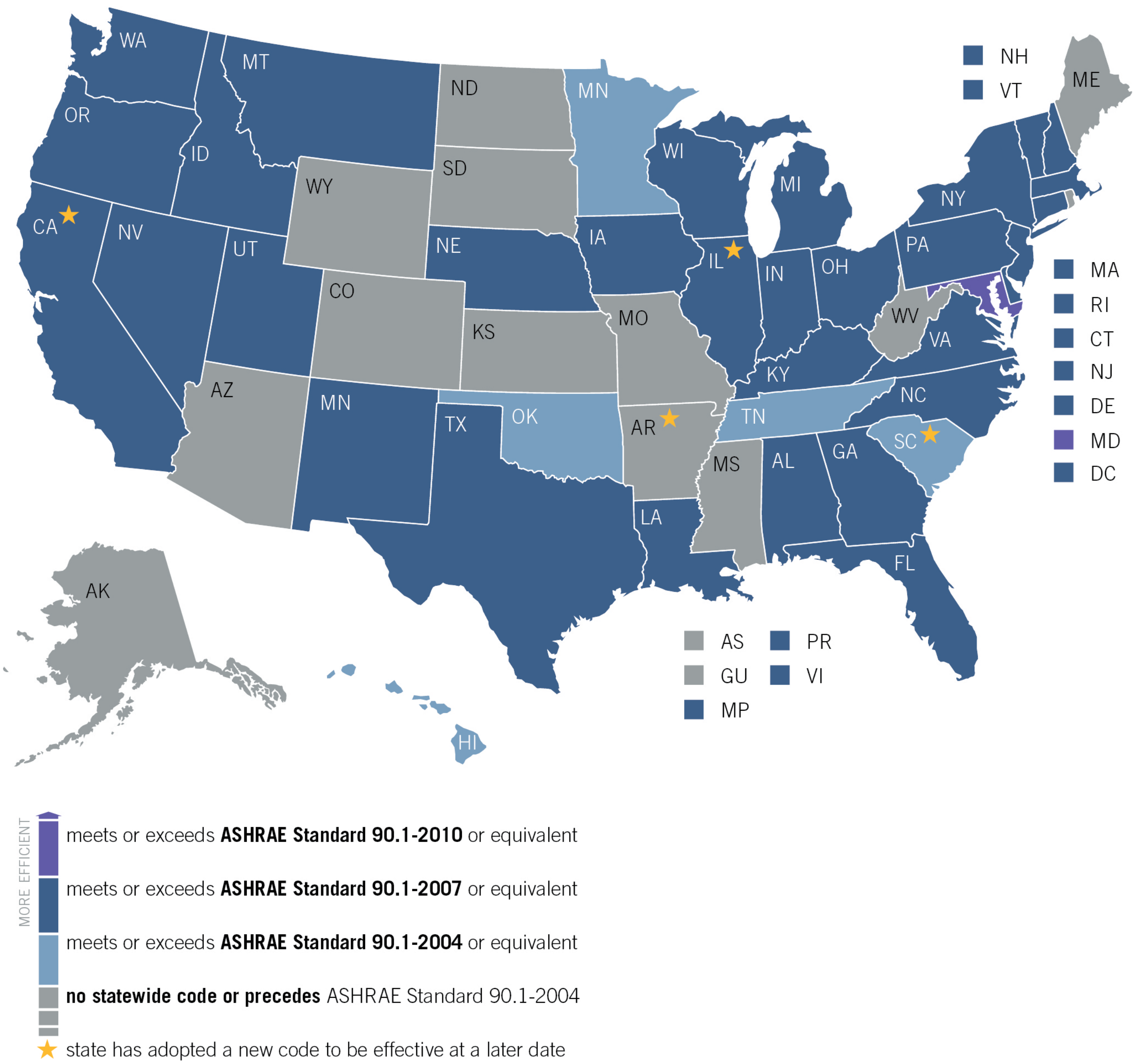
Leveraging Private and Public Finance

There are also options to leverage private financing for money-saving efficiency improvements. Energy service companies (ESCOs) aim to identify and arrange financing for such improvements. The federal government has used Energy Savings Performance Contracts (ESPCs) to finance energy retrofit projects, including the 2009 DOE-awarded umbrella ESPCs for energy efficiency, renewable energy, and water conservation projects at federally owned buildings and facilities. In December 2011, President Obama issued a memo committing federal agencies to enter into at least $2 billion in contracts over the next two years to improve the energy efficiency of federal buildings.[314] Under such a contract, the ESCO guarantees the financial and operational performance of an energy retrofit. After a comprehensive energy audit identifies cost-effective energy-saving opportunities, the ESCO helps to arrange project financing, often with long-term debt. The ESCO ensures that savings from the project will be adequate to cover borrowing costs for the work. The ESCO typically assumes responsibility for the design, installation, and savings performance of the project and may assume the credit risk as well.

Another financing mechanism for energy efficiency projects is an Energy Service Agreements (ESA), which is an alternative to using equity or a traditional loan to retrofit a building. An ESA is a contract that permits energy efficiency to be packaged as a service that building owners pay for over time. The ESA provider performs an analysis to determine and propose cost-effective efficiency improvements. Generally, an ESA requires no or a minimal upfront cost or debt to the owner as the ESA supplier provides the capital and the service is paid for over time.[315]

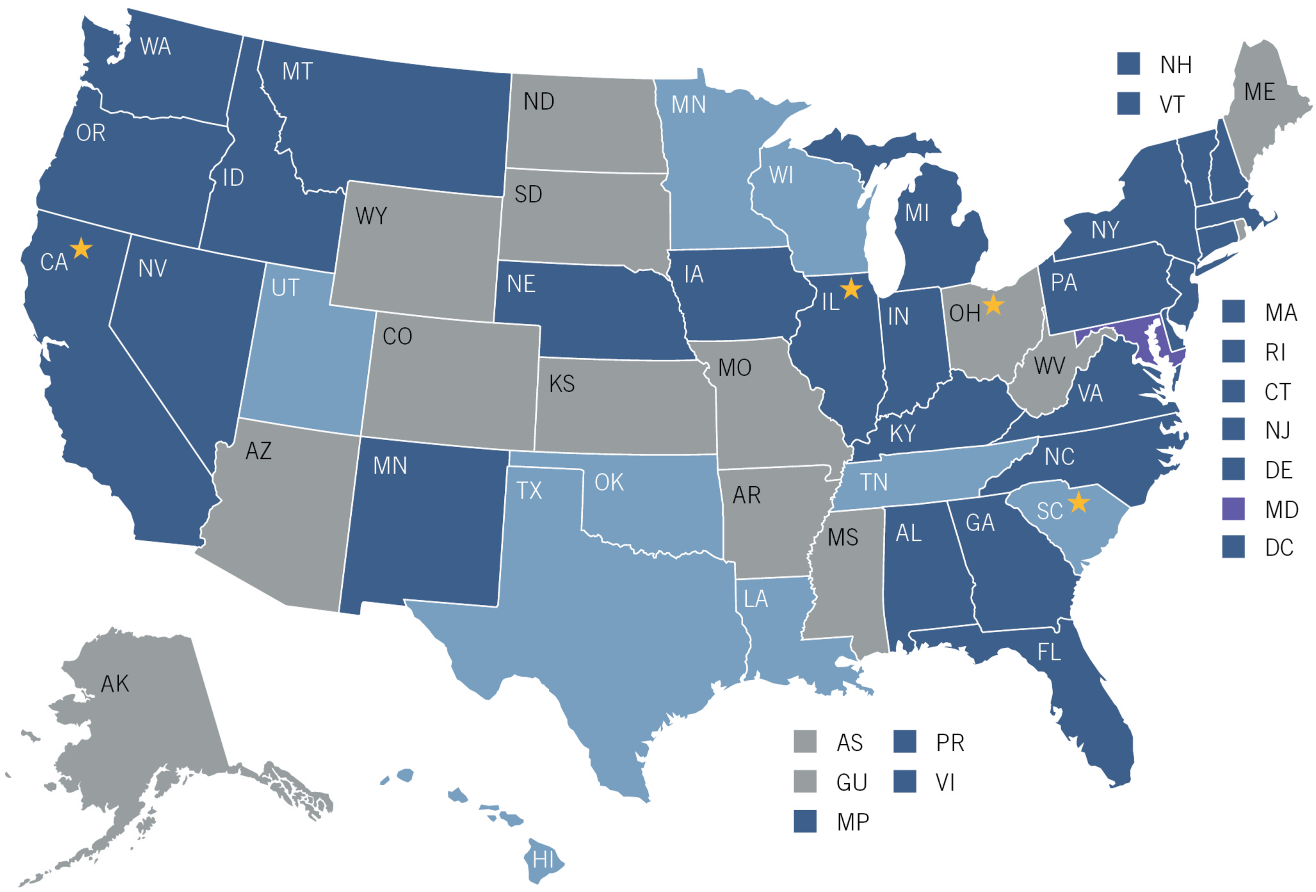
There are also innovative public-financing mechanisms for energy efficiency. For example, property-assessed clean energy (PACE) financing has been used as an alternative to loans for energy efficiency technologies for the residential, commercial, and industrial sectors. PACE financing allows states and local governments to raise money through bonds or other sources to pay for energy efficiency projects, thus minimizing the high upfront cost. The borrowed amount is usually paid back by the building owner through a special assessment on property taxes or other locally levied taxes or bills.[316] This arrangement has a number of potential benefits, including long-term, fixed-cost financing, loans tied to the property as opposed to the owner, and the potential to deduct the repayment from federal taxes. However, federal bank regulators have effectively halted PACE programs due to concerns over legality, lender risk, and altered valuations for mortgage-backed securities. Some supporters of PACE financing are calling for federal legislation to resolve these issues, but currently the status of PACE financing remains in flux.

Figure 3-10: Commercial State Energy Code Status, as of July 2012



Source: The Building Codes Assistance Project, "Code Status: Commercial," October 1, 2012, http://energycodesocean.org/code-status-commercial.

Figure 3-11: Residential State Energy Code Status, as of July 2012



meets or exceeds the **2012 IECC** or equivalent

meets or exceeds the **2009 IECC** or equivalent

meets or exceeds the **2006 IECC** or equivalent

no statewide code or precedes the 2006 IECC

★ state has adopted a new code to be effective at a later date

Source: The Building Codes Assistance Project, "Code Status: Residential," October 1, 2012, http://energycodesocean.org/code-status-residential.

To better leverage private resources, a coordinating group—such as a trade association or aggregating entity—could partner with utility and industrial funders and help to ensure a predictable funding stream for targeted efficiency investments.

Labeling and Information Programs

The United States has had a voluntary labeling program for office equipment and other products since 1992, when the Energy Star program was established by EPA. In 1996, EPA joined with DOE to provide labeling for particular product categories. The Energy Star label is now on major appliances, office equipment, lighting, home electronics, and more. In 1999, EPA also extended Energy Star to cover the energy efficiency performance of new homes and commercial and industrial buildings. By the end of 2011, there were almost 16,500 Energy Star buildings in the United States, generating annual savings of approximately $2.3 billion in utility bills.[317]

In addition to the Energy Star program, the Federal Trade Commission (FTC) manages the Energy Guide labeling program, which displays estimated yearly electricity use and cost, or similar information, for certain consumer products. Energy Guide labels also compare the energy performance of the appliance compared with other appliances in the same product class. They generally display the Energy Star logo if the product meets Energy Star criteria.

EPA/DOE's Energy Star and FTC's Energy Guide have played important roles in improving the energy efficiency and performance of the appliances and electronics in millions of U.S. households and businesses. However, because of the overlap, there is redundancy and the potential for consumer confusion. The Energy Star program could be further improved by providing a more differentiated system that allows a product to be compared with others in its product category. For example, labeling products with one to four stars or a letter grade to denote varying degrees of efficiency, similar to the differentiated energy rating systems employed by a number of other countries (e.g., Japan and the European Union) would provide additional information to consumers. Congress could also consider whether an improved Energy Star label would obviate the need for the FTC Energy Guide and whether energy labeling authority should be consolidated under DOE and EPA.

Outside the federal government, there are other standards and labeling programs. For example, there are voluntary standard-setting activities led by industry groups, including the U.S. Green Building Council (USGBC) and the National Electrical Manufacturers Association (NEMA). USGBC's Leadership in Energy and Environmental Design (LEED) is an internationally recognized certification program for green building design. To become LEED certified, buildings must satisfy prerequisites in a number of different categories, including better building energy performance. Although voluntary, this consensus-based, market-driven program has had a significant impact on design.[318] In addition, the standards set by NEMA work to help improve the safety and economics of electrical equipment. These voluntary standards can also influence the setting of mandatory federal standards.[319] For example, DOE employs the EnergySmart Homes Scale (E-Scale) as a residential label for the Builders' Challenge, a national voluntary building efficiency program. E-Scale is based on the Home Energy Rating System (HERS) index, which is an index to calculate a home's energy performance and measure home energy efficiency. The index and was initiated by the Residential Energy Services Network (RESNET), an independent nonprofit organization. EPA also utilizes the HERS index for a home's Energy Star rating, and the Internal Revenue Service uses the HERS index for compliance with the Section 45L new homes tax incentive.[320,321]

Future U.S. labeling and information programs can benefit from a growing body of experience abroad. For example, Australia has instituted a system that provides extensive information about the efficiency of commercial buildings (known as the Commercial Buildings Disclosure Scheme). Under this system, building owners or property managers must disclose an energy efficiency rating (on a 1–5 scale) to prospective buyers or tenants. The labeling approach is designed to enhance the property value of buildings that are more efficient and to make efficient buildings more desirable to owners and renters. This will give owners of inefficient buildings an incentive to improve the energy performance of their properties and thus boost the overall efficiency of the building stock.[322] Building on this national rating system, the government of New South Wales now requires office buildings that are larger than 1,000 square meters (10,763 square feet) and that are owned or rented by the government to maintain a rating of 4.5.[323]

Meanwhile, utilities and others have begun making greater use of social and behavioral science to encourage customer implementation of cost-effective energy efficiency measures. Research in the fields of psychology and behavioral economics indicates that, in some cases, non-price interventions can be just as influential as price interventions for altering consumer behavior.[324] Non-price interventions can take many forms (e.g., appeals to social norms, labeling, etc.). For example, Opower's Home Energy Report (HER) program employs social normative messaging to motivate homeowners to implement efficiency measures. Customers get personalized analyses in their monthly energy bills that shows how their household energy use compares, both to the average for their area and to their most efficient neighbors. According to Opower, this neighbor comparison analysis has proved more effective than appeals based on environmental, social, or financial benefits.[325]

University-Based Energy Efficiency Centers

University-based centers have a track record of driving innovation through manpower training and technology research. Such centers were used decades ago to promote nuclear energy technology; today, the nuclear industry still benefits from more than 30 university-based centers around the country and from the strong public and private support and engagement they provide. This concept has only recently been applied to energy efficiency, and the first university center dedicated to energy efficiency was created in 2006 at the University of California at Davis. Today, there are still only five such centers, with three of them in California and the other two in Idaho and Missouri. The UC-Davis Energy Efficiency Center offers a compelling example of a public-private partnership, having attracted strong engagement from utilities, businesses, and government at both state and federal levels. The Davis center's lighting and cooling laboratories already have a track record of innovation and have successfully primed new technologies for commercial application including Light Emitting Diode (LED) downlights; its advisory board includes representatives of the California Public Utilities Commission, DOE, Chevron, Walmart, Microsoft, Wells Fargo, PG&E, Edison International, Sempra, Los Angeles Department of Water and Power, Sacramento Municipal Utility District, and the California Clean Energy Fund.[326]

Recommendations for Improving Energy Productivity in the Residential and Commercial Sectors

The following recommendations are aimed at overcoming barriers to cost-effective residential and commercial-sector efficiency improvements.

RECOMMENDATION: Continue to assign high priority to the timely issuance of and upgrades to all its statutorily authorized performance-based efficiency standards for appliances, lighting, and equipment. DOE's current efficiency standards cover a wide range of appliances, lighting, and equipment and have translated into substantial energy savings since their inception. Continuing to update the standards in a timely way as technology and processes improve will only increase the energy savings potential.

RECOMMENDATION: Continually upgrade state building standards for new buildings and major renovations, and model

federal standards, based on life-cycle cost-effectiveness. Implementation of building codes and standards continues to be inconsistent across states. State legislatures should continue to consider and adopt improved building codes and standards.

RECOMMENDATION: Promote demand-side efficiency with improved customer information (e.g., smart meters, dynamic pricing) and other innovative uses of customer information (e.g., comparing energy usage among peers).[327] Enhanced and innovative forms of information on energy usage and pricing can be used to motivate customers to implement energy efficiency and load shifting measures. Utilities, state public utility commissions, and local utility boards play a critical role in advancing these programs.

RECOMMENDATION: Support state agencies and contractors that administer building codes and standards through encouragement of partnerships with utilities. Utilities have demonstrated their capacity to help support the implementation of efficiency standards at the state level through providing training, technical expertise, and financial support. State public utility commissions and local utility boards should encourage these types of cooperative approaches between industry and state and local authorities.

RECOMMENDATION: Support the creation of university-based energy efficiency centers. University-based centers, such as the one at the University of California-Davis, can drive innovation through training and research. State public utility commissions, local utility boards, utilities, and Congress can be instrumental in ensuring that the number and size of these programs grow.

RECOMMENDATION: Promote energy performance labeling in both new and existing buildings through voluntary programs and/or by utilizing labels as a compliance mechanism for incentive programs. Energy performance building labeling programs increase renter/buyer knowledge and encourage building owners to improve efficiency. Congress, executive branch agencies, state public utility commissions, states, and local utility boards should consider ways to expand upon these approaches.

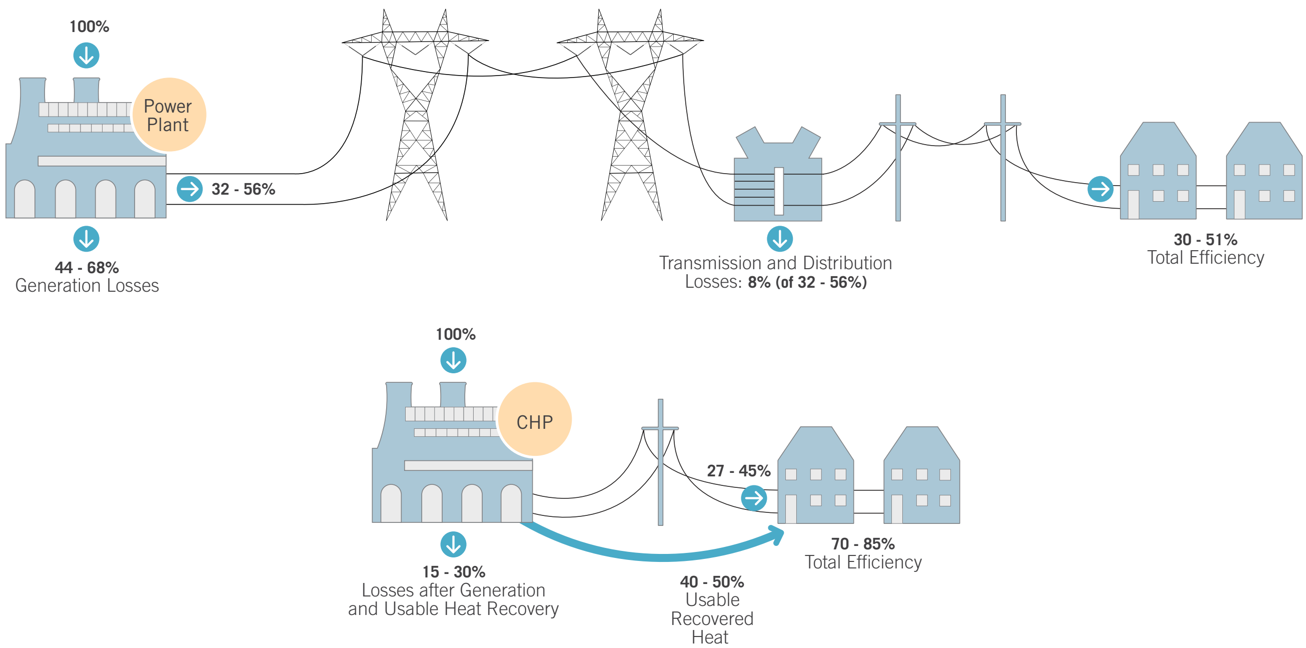
RECOMMENDATION: Improve and harmonize federal energy efficiency programs including DOE appliance standards, DOE and EPA's ENERGY STAR program, and the FTC's Energy Guide Program. Energy efficiency standards and labeling programs for office equipment, appliances, and other products should be harmonized to improve information and avoid redundancy. In particular, the FTC's Energy Guide could be consolidated with the DOE and EPA ENERGY STAR program.

Energy Productivity in the Industrial Sector

The industrial sector spans a large variety of entities that have diverse energy needs. According to EIA's 2013 Annual Energy Outlook Early Release, the industrial sector accounted for just under one-third of total U.S. energy consumption (31.3 quadrillion British thermal units) in 2011. EIA estimates that industrial energy use will grow by about 14 percent to 35.3 quads in 2035.[328] Manufacturing accounts for the largest share of energy consumption within this sector, and motor-driven equipment accounts for more than half of manufacturing electricity use.[329] Taken together, the energy-intensive manufacturing industries—bulk chemicals, refining, paper products, iron and steel, aluminum, food, glass, and cement—account for nearly two-thirds of industrial delivered energy consumption.[330]

Given fierce global competition in manufacturing, the industrial sector has historically worked diligently to keep costs down. Continued technology advances and industrial process improvement, particularly during periods of high energy prices and/or strong economic conditions, have resulted in significant energy productivity gains over time. In addition, EIA projections suggest that an ongoing shift toward non-energy intensive manufacturing in the coming decades will further reduce the overall energy intensity of the U.S. industrial sector.

Figure 3-12: Total System Efficiency for Conventional Power Plant vs. CHP



Source: U.S. Department of Energy, Energy Efficiency and Renewable Energy, "Combined Heat and Power Basics," accessed December 7, 2012, http://www1.eere.energy.gov/femp/technologies/derchp_chpbasics.html.

Nonetheless, cost-effective opportunities to further increase energy productivity remain widely untapped in a number of specific industries. Promising technologies include more efficient motors, pumps and other equipment, process optimization, waste heat recovery, and demand management. Significant gains could be achieved by replacing inefficient boilers that generate industrial steam with natural gas turbines that co-generate electricity and steam in a combined heat and power (CHP) system. As noted in Figure 3-12, CHP systems can attain significant overall efficiencies compared with conventional power plants.[331] CHP is a proven commercial technology with 82 gigawatts of installed capacity at over 3,700 industrial and commercial sites in the United States today.[332] However, this option remains under-utilized given that the technical potential for CHP has been estimated at 130 gigawatts in U.S. commercial and industrial applications.[333,334] Higher capital costs to incorporate CHP often presents a hurdle for the utilization of CHP.

Additional industrial efficiencies can also be realized through operational improvements. Sub-metering at industrial facilities is a tool that can help to identify energy-saving opportunities and plant inefficiencies by providing better energy data to facility operators.

Multiple barriers stand in the way of energy efficiency investments in the industrial sector. As in other sectors, there are informational barriers. Some companies do not have reliable access to information about the potential savings and return on investment available from some efficiency measures and CHP. Often, tight budgets and the desire to keep short-term costs low prevents investment in beneficial energy efficiency measures. Industrial companies generally

SEE Action Recommendations

In their March 2011 blueprint for industrial efficiency and CHP, the State Energy Efficiency (SEE) Action Network identified the following key solutions and actions:

Drive demand for industrial EE and CHP

1. State, local, and utility programs for industry
2. State policy models
3. National energy efficiency policy
4. Education and outreach

Build workforce

5. Education and workforce development
6. Develop training and academic curricula
7. Licensing & certification protocols

Promote efficient operations & investment

8. Financing innovation
9. Financial incentives
10. Technical solutions
11. Energy management programs/continuous energy improvement

Move market toward adoption of CHP

12. Technology demonstration
13. Regulatory recommendations to support CHP
14. Reduce uncertainty related to state interconnection [for CHP]
15. Financing reform (i.e., depreciation rules and Sarbanes-Oxley Act)

Source: SEE Action Network, Industrial Energy Efficiency & Combined Heat and Power Working Group Blueprint. March 2011. http://www1.eere.energy.gov/seeaction/pdfs/industrial_efficiency_chp_blueprint.pdf

operate under a two-year (or shorter) payback period for energy efficiency improvements. This creates a high hurdle rate (i.e., minimum return in a given period of time required to justify an investment) for energy efficiency and CHP investment.

Because utilities typically operate under a payback period measured in decades rather than years, utility involvement holds promise for improving industrial efficiency while reducing customer costs. Numerous companies have successfully partnered with utilities, and this list continues to grow. Some notable examples include: Puget Sound Energy with Boeing; PG&E with Safeway and Sybase; Southern California Edison with Allergan and Mission Foods; Rocky Mountain Power with Albertsons and Varian Medical Systems; Connecticut Light and Power with A&P Food Market and Ford Motor Company; National Grid with Boston Scientific, Garelick Farms and Rockport.

In some cases, these cooperative efforts are part of a broader utility program to promote cost-effective industrial energy efficiency. For example, Alabama Power and Georgia Power, subsidiaries of Southern Company, operate Technology Application Centers (TACs) located in Birmingham, Alabama, and Atlanta, Georgia, as demonstration facilities to help industrial customers reduce production costs, improve energy efficiency, increase productivity, improve product quality, and address environmental concerns. The TACs focus on a variety of technologies and demonstrate the application of these technologies to such processes as curing, drying operations, energy cost reduction, and many others. The TACs assist customers with problem solving and demonstrate manufacturing applications using customers' parts and products. They also provide technical assistance, manufacturing process evaluations, and material analyses to help improve production processes.[335]

However, complex technical and contractual arrangements, regulatory and institutional barriers, and electricity rate policies in some states have also slowed the pace and spread of economically beneficial utility-industry partnerships (including industrial energy efficiency investments, shared savings arrangements, and utility involvement in industrial co-generation and transmission to the grid). To address these barriers, state PUCs and local utility boards should continue to look for ways to incentivize industrial CHP, waste heat recovery, and other efficiency investments. More streamlined permitting for units of a certain size and/or for units that comply with certain emission limits could also help projects proceed more quickly and efficiently.

Federal efforts to promote industrial-sector efficiency have been diverse and have included incentives, technical aid, and R&D, among other approaches to accommodate different types of industrial facilities. For example, the Energy Independence and Security Act of 2007 authorized DOE funding for RD&D to develop new processes and technologies for energy-intensive industries. In addition, this legislation tasked EPA with assessing the potential for economically feasible waste energy recovery. Subsequently, the American Recovery and Reinvestment Act of 2009 provided $602 million for the deployment of energy efficient technologies in buildings and industry.

In June 2011, DOE launched an Advanced Manufacturing Partnership aimed at bringing together industry, universities, and the federal government to invest in emerging technologies and leverage existing programs and proposals. DOE's Industrial Technology Program sponsors detailed energy efficiency audits to identify and recommend cost-effective efficiency investments at industrial facilities. DOE is also working closely with EPA to help industrial facilities comply with the industrial air toxics standards, including assessing different compliance strategies and options to reduce costs (e.g., through CHP systems). Finally, DOE is leading a coalition of federal and state governments, industrial companies, and other stakeholders to identify barriers and solutions to advancing industrial-sector energy efficiency. This coalition, which is being called the State Energy Efficiency Action Network (SEE Action) Workgroup on Industrial Efficiency and CHP, proposed a national goal of (a) reducing industrial-sector energy intensity by 2.5 percent per year and (b) adding 40 gigawatts of CHP capacity by 2020. Estimated energy savings from these two actions could total as much as 13.4 quadrillion Btu by 2020.[336]

In August 2012, President Obama signed an executive order to accelerate private-sector investment in industrial energy efficiency.[337] Under this order, the president aims to set a goal, highlight the benefits of investment, improve coordination at the federal level, enhance federal-state partnerships and support for states, and encourage the adoption of investment models identified as beneficial to multiple stakeholders. The order directs federal agencies to carry out a number of activities and also adopts a national goal of deploying 40 gigawatts of new, cost-effective industrial CHP in the United States by 2020.[338] (This would represent a 50-percent increase over the current level of U.S. CHP.)

Recommendations for Improving Energy Productivity in the Industrial Sector

As the economy recovers and business investment rebounds, there will be an important window for promoting investments that offer long-term energy savings. To some extent, the effectiveness of various policy interventions depends on the timing and the current business environment in which they are applied. Thus, it is beneficial to have an array of policy tools to choose from to match current conditions and industry needs. The list of recommendations below includes a variety of policies and approaches aimed at overcoming barriers to cost-effective industrial efficiency improvements.

RECOMMENDATION: Create incentives and remove disincentives for utility promotion of cost-effective industrial efficiency on-site. State PUCs and local utility boards should consider policies and incentives to promote cost effective industrial efficiency. State and federal authorities should also consider streamlined permitting for combined heat and power (CHP) projects.

RECOMMENDATION: Explore the feasibility of including combined heat and power and waste-energy-based generation in state EERS or RES programs. States should consider including on-site industrial measures like CHP and waste energy utilization in EERS programs or RES programs that allow for the inclusion of energy efficiency resources.

RECOMMENDATION: Accelerate the development and adoption of cost-effective DOE efficiency standards and establish cost-effective industrial standards for certain types of products. DOE should move forward on cost-effective industrial efficiency standards for pumps and other relatively homogenous mass-produced equipment.

RECOMMENDATION: Create incentives for utilities to implement sub-metering at industrial/commercial facilities. State PUCs and local utility boards should consider programs and incentives to promote sub-metering at industrial and commercial facilities to increase awareness of energy use and motivate energy efficiency improvements.

RECOMMENDATION: Support electric utility investment in cost-effective industrial efficiency through grants, loans, training, funding for audits/retrofits, and other programs. State PUCs, local utility boards, and DOE should continue to adopt and promote utility investment in industrial efficiency through a variety of incentive, training, and technical assistance programs.

RECOMMENDATION: Support utility-industrial partnerships, including dedicated staff, to establish energy management best practices and promote greater deployment of cost-effective efficiency technologies that deliver benefits to both utilities and industry. There are numerous examples of successful partnerships between utilities and industry to promote cost-effective energy efficiency. State PUCs, local utility boards, and DOE should encourage these partnerships, which include financing, technical assistance, and technology demonstration.

Freight Rail

The freight rail industry is an intensive user of diesel fuel. In 1980, one gallon of diesel fuel moved one ton of freight by rail an average of 235 miles. In 2011, one gallon of fuel moved one ton of freight by rail an average of 469 miles—a 99 percent improvement since 1980. From 1980 through 2011, U.S. freight railroads consumed 62.4 billion fewer gallons of fuel and emitted 699 million fewer tons of carbon dioxide than they would have if their fuel efficiency had not improved. In addition, railroad operating practices have produced fuel efficiency and emissions reductions. For example, longer trains, distributed power, and the use of train operations software have made a significant improvement in fuel use, along with variety of technological advancements to cut fuel consumption and greenhouse gas emissions.

Source: Association of American Railroads, Freight Railroads Help Reduce Greenhouse Gas Emissions, July 2012, https://www.aar.org/keyissues/Documents/Background-Papers/RRs-and-Greenhouse-Gas-Emissions-Oct-12-2012.pdf.

Energy Productivity in the Transportation Sector

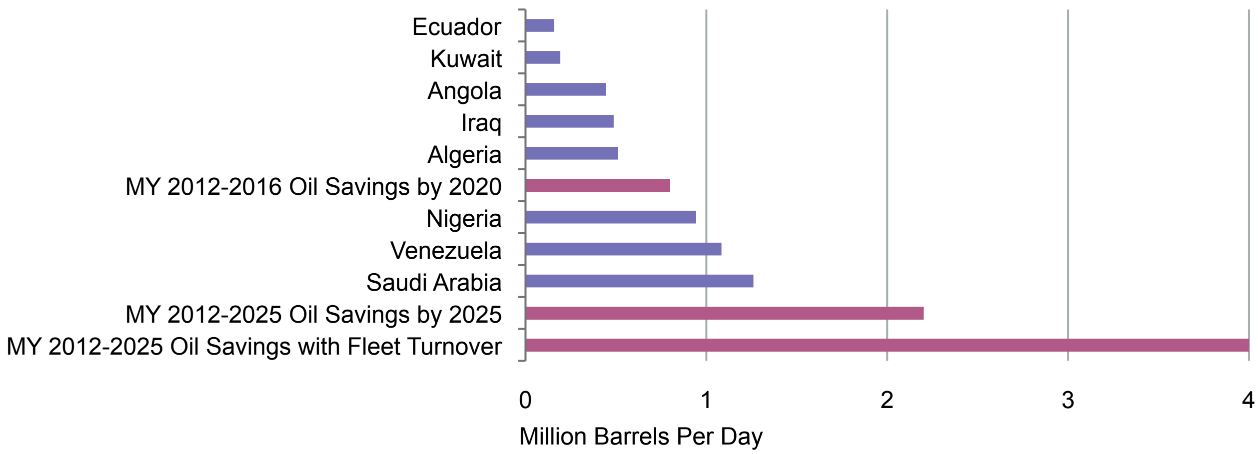
In 2011, the transportation sector accounted for 28 percent of total U.S. energy consumption (27 quads). According to the EIA, the level of consumption is projected to remain relatively constant, with just a 0.1 percent annual decline from 2011 through 2035, as the effect of rising average vehicle efficiency is roughly matched by expected growth in miles traveled.[339] Petroleum-based liquid fuels accounted for 93 percent of total consumption in this sector.[340] Given this oil dependence, fuel diversification, and increased efficiency is valuable. Improved vehicle fuel efficiency will complement new supplies of petroleum and increased use of alternative fuels to enhance America's energy security, improve environmental quality, and reduce the U.S. economy's exposure to world oil price volatility.

First enacted by Congress in 1975, corporate average fuel economy (CAFE) standards require manufacturers to design vehicles that can travel farther on a gallon of fuel. The initial standards produced significant efficiency gains and large oil savings in the late 1970s through the mid-1980s, but further progress on transportation efficiency stalled for nearly two decades until Congress acted to again raise fuel economy requirements as part of the Energy Independence and Security Act of 2007. This bipartisan legislation established a proactive fuel economy policy for new cars and light-duty trucks that called for a phased increase in average miles per gallon of roughly 4 percent per year,[341] with fleet-average standards to be set at maximum feasible levels through 2030. The fuel economy standards adopted in August 2012 by the U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA) continue this trajectory and were developed with cooperation from other agencies and strong bipartisan support in Congress.

In May 2010, NHTSA issued attribute-based standards for cars and light-duty trucks for model years 2012 to 2016. Building on these standards, the fuel economy requirements for light-duty vehicles produced in model years 2017 to 2025 will increase gradually to a target corporate average fuel economy level equivalent to 54.5 miles per gallon by 2025.[342] Besides dramatically increasing the fuel economy of conventional vehicles, the new rules will also encourage innovative natural gas vehicles, electric vehicles, plug-in electric hybrids (PHEVs), and fuel-cell vehicles. The averaging and accounting provisions of the new standards both encourage fuel economy improvements in the conventional fleet and reward automakers for offering innovative vehicles to the market. Unlike in the past, the auto industry and auto workers welcomed these standards, seeing them as a way to bolster sales, increase profits, create more jobs, and stay competitive. With strong consumer demand for more efficient vehicles, innovation is already occurring, increasing the U.S. auto industry's financial position.[343]

According to U.S. government estimates, new fuel economy standards to be phased in between 2011 and 2025 will reduce oil consumption by an estimated 2.2 million barrels per day by 2025, which is more oil than net U.S. imports from any one OPEC country. (Figure 3-13).[344]

Figure 3-13: Net Oil Imports to the U.S. from Select OPEC Countries vs. Oil Saved from Fuel Economy Standards



Note: Net Imports for OPEC countries are calculated as a 5-year average over the period 2007-2011. Persian Gulf exports averaged 1.95 million barrels per day over this period. Federal fuel economy standards for model year 2012-2016 vehicles, announced in 2009 and finalized in 2010, will raise the average fuel economy of new cars and light-duty trucks to 35.5 miles per gallon (mpg); the standards for 2017-2025 model year vehicles, which were announced in 2011 and finalized in 2012, will raise the average fuel economy of new, light-duty vehicles to 54.5 mpg.

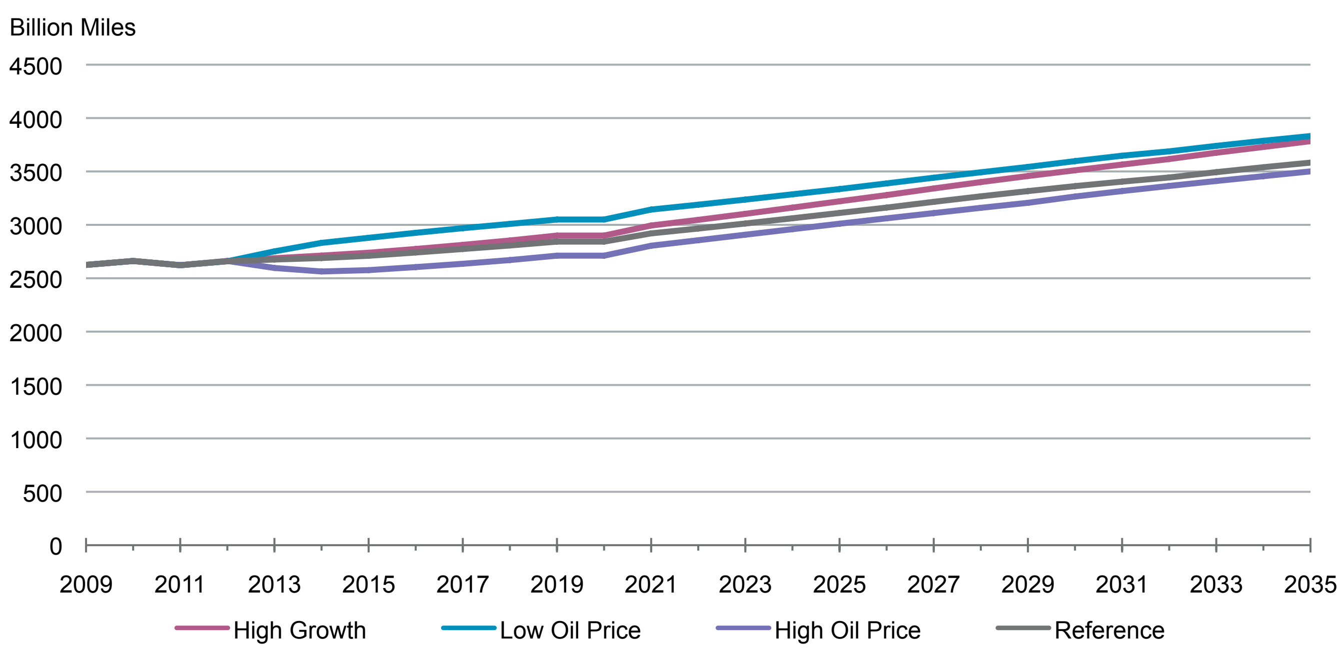
Source: U.S. Energy Information Administration, "U.S. Net Imports by Country," http://www.eia.gov/dnav/pet/pet_move_neti_a_ep00_IMN_mbblpd_m.htm.

Current law also mandates that NHTSA implement a program designed to achieve the maximum feasible improvements in fuel economy for commercial medium- and heavy-duty trucks. To meet this requirement, NHTSA issued standards in September 2011 for medium- and heavy-duty trucks. These standards require a reduction in fuel consumption between 10 and 20 percent, depending on the specific truck type, by 2018 and are projected to save one to four gallons of fuel for every 100 miles traveled.[345]

Light-duty vehicles use the largest share of transportation related energy in the U.S. economy (57 percent) and, as noted, they are expected to improve their efficiency significantly over the coming years.[346] Other modes of transportation have made or are expected to make improvements as well.

Improving vehicle efficiency alone, however, is not sufficient. To produce overall reductions in fuel use, vehicle efficiency improvements must be paired with efforts to reduce vehicle miles traveled (VMT). Historically, VMT growth has outpaced gains in average vehicle fuel economy, resulting in rising national gasoline consumption.[347] Further, even though the rate of growth in VMT for cars and light duty trucks is expected to slow in coming years (Figure 3-14), EIA still projects that overall light-duty vehicle miles per year will increase by more than 900 billion miles and heavy-duty vehicle miles will increase by more than 100 billion miles over the next 25 years.[348] Thus, rising VMT could offset much of the expected fuel savings from recent updates to fuel economy standards.

Figure 3-14: U.S. Light-Duty Vehicle Miles Traveled, 2009-2035



Note: In the 2012 Annual Energy Outlook, EIA compared light-duty vehicle miles traveled in its reference case and also with three sensitivities – high oil prices, low oil prices, and high economic growth. All four scenarios generally illustrate a study increase in miles, especially after 2015.

Source: U.S. Energy Information Administration, "Table 60. Light-Duty Vehicle Miles Traveled by Technology Type," *Annual Energy Outlook 2012*, June 25, 2012, http://www.eia.gov/forecasts/aeo/tables_ref.cfm.

In a recent report that addressed the potential for achieving significant reductions in transportation-related greenhouse gas emissions, the National Petroleum Council acknowledged that, absent transformative innovations, technology gains in vehicles and fuels are likely to be dwarfed by growth in miles traveled and thus will not be sufficient to reduce transport-sector greenhouse gas emissions 50 percent by 2050.[349,350] In fact, the use of all transportation modes is expected to increase in the future, with particularly rapid growth predicted for freight and air travel.

Fortunately, the United States is far from running out of options for meeting its transportation needs more efficiently while also reducing total vehicle miles traveled and/or fuel consumed. For example, efforts to reduce engine idling and congestion—through strategies such as congestion pricing, traffic and air traffic control management, and truck stop electrification—have been successful at reducing fuel consumption and emissions per mile. Furthermore, policies to promote telecommuting, mass transit, carpooling, bicycle and pedestrian travel, as well as compact land-use development all have potential to advance the nation's broader energy policy goals while producing other important local, quality-of-life benefits. For this reason, a variety of innovative policies are attracting interest at the state, regional, and local levels.

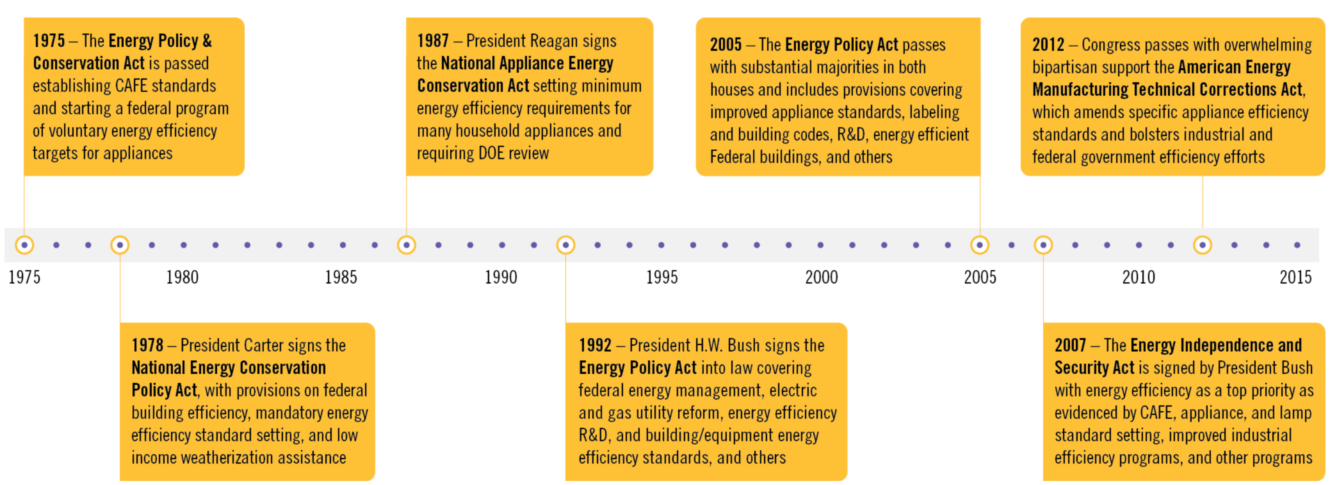
RECOMMENDATION: Encourage the adoption of cost-effective policies aimed at reducing energy demand for transportation services and make full use of existing authorities to ensure continuous improvement in fuel economy for new vehicles under, for example, the bipartisan 2007 Energy Independence and Security Act.

Congress, the Department of Transportation, states, and localities should continue to implement existing policies and to experiment with new policies to improve vehicle efficiency, reduce vehicle miles traveled, and reduce fuel consumption. Examples of relevant policies include fuel economy standards, telecommuting, traffic management, compact land use development, and truck stop electrification among others.

Continuing the Bipartisan Tradition on Energy Efficiency Policy

Congress has a long history of taking bipartisan action to promote energy efficiency (Figure 3-15). For example,

Figure 3-15: Bipartisan History of Energy Efficiency



appliance standards were first authorized in 1975 by the Energy Policy and Conservation Act. They have since been codified and updated multiple times, each time with bipartisan support.[351] The 2005 Energy Policy Act was passed by a Republican-controlled Congress and the 2007 Energy Independence and Security Act was enacted while the Democrats controlled the House and Senate; both pieces of legislation included energy efficiency measures and both were signed by President George W. Bush.

Bipartisan legislation and efforts have been successful at reducing the nation's energy use and also at minimizing the energy footprint of the federal government, which is the largest single consumer of electricity and fuel in the country. The 2007 Energy Independence and Security Act required federal agencies to reduce energy use in their facilities by 30 percent from a 2005 baseline by 2015.[352] An executive order from 2009 also requires agencies to reduce greenhouse gas emissions throughout the government by 2020 from a 2008 baseline, meet energy, fuel, and water targets, and report all progress annually.[353]

This bipartisan tradition continued in the most recent Congress. In December 2012, the Senate and House passed with overwhelming bipartisan support the *American Energy Manufacturing Technical Corrections Act,* which President Obama later signed. This energy efficiency legislation amends specific appliance efficiency standards and bolsters industrial and federal government efficiency efforts. The legislation was approved unanimously in the Senate and only had two dissenters in the House (398-2). The bill combines a number of provisions from the *Energy Savings and Industrial Competitiveness Act of 2011* (Shaheen-Portman) with language that reworks requirements for specific appliances, including walk-in freezers and air conditioners. Among the included provisions are the establishment and coordination of R&D partnerships for energy efficiency technologies for industry and a study on best practices for advanced metering for federal facilities, buildings, and equipment.[354]

Energy & Infrastructure Program
Energy Project



Chapter 4: Accelerate Energy Innovation

The Critical Need for Energy Technology Innovation

The delivery of affordable, secure, resilient, and reliable supplies of energy in the future while ensuring continuous improvement in environmental performance will require new technologies. U.S. investment in energy innovation is critical to lead in the $5 trillion global energy industry and maintain global economic leadership more broadly.[355] For this reason, accelerating the pace of energy innovation, from early research and development through demonstration and commercialization, must be seen as a central component of U.S. energy policy.[356,357] This chapter outlines a set of specific recommendations designed to nurture robust innovation in the U.S. energy sector in ways that maximize the effectiveness of scarce federal dollars and promote private-sector investment in energy technology development in order to advance the many energy-related national objectives with respect to energy security, economic competitiveness, and environmental improvement.

Technological progress has long been recognized as the main source of economic growth, and the United States has been a leader in driving technology innovation for decades. Nobel prize–winning economist Robert Solow at MIT, a pioneer in studying this field, argued that 80 percent of economic growth in the first half of the 20th century was attributable to technological advances.[358] Over the last half-century, numerous additional studies have pointed to the critical importance of public and private investments in research and development. In 2007, for example, the National Academies of Science concluded that federal investment in research and development has led to high annual rates of return on investment (on the order of 20–67 percent).[359] Other research has found that private-sector R&D investments likewise yield significant productivity gains.[360,361] Technological innovation has led to remarkable developments in the oil and natural gas industry (e.g., deepwater drilling and unconventional drilling), cost reductions for renewable energy, energy efficiency improvements, and reduced environmental impacts. All of these improvements contribute to the strength of our nation's energy posture today.

Despite broad recognition of the importance of innovation—especially in the energy sector—today's challenging economic and fiscal climate is having a dampening effect on private- and public-sector energy R&D investments. The clear result today is a substantial shortfall in overall U.S. energy innovation investment—public and private—relative to the scale and importance of the national interests at stake. These national interests and objectives have been expounded in a number of studies that seek to identify research priorities and necessarily demand increased funding in various areas to achieve broad energy policy goals.[362] This shortfall is also illustrated sharply in

Defining Innovation Terms:

Innovation occurs through complex and dynamic processes, and technological development often does not follow a linear path from research to commercialization. Below we define the terms used in this chapter to describe components of the innovation ecosystem.[363]

- **Research:** Fundamental and applied research intended to generate and validate new scientific knowledge.
- **Development:** The transformation of knowledge into applications. In contrast to research toward basic understanding, development generally refers to the creation of something new.
- **Prototype Demonstration:** Development activity aimed to determine whether new technology works from a technical perspective in particular settings and applications.
- **Commercial Demonstration:** Design, creation, and testing of technologies in final or close-to-final form under real-world conditions.
- **Deployment:** The commercial-scale establishment of efficient manufacturing processes, bringing product to market, market penetration, and ultimate profitability.

Figure 4-1: Energy Technology Development Ecosystem

	RESEARCH & DEVELOPMENT	DEMO/PROOF OF CONCEPT	DEPLOY/ PILOT FACILITY	DIFFUSION/ COMMERCIALIZATION	COMMERCIAL MATURITY
PRIVATE SECTOR	• Angel/Series A Venture Capital	• Series B Venture Capital	• Series C and Later	• Limited VC or Corporate Equity for a Few Companies	• Corporate Investor/Public Markets • Project Finance
PUBLIC SECTOR	• Grants (e.g., ARPA-E, Energy Innovation Hubs) • State Programs • University Funding • Tax Credits (e.g., R&D tax credit) • National Labs	• Grants (e.g., ARPA-E, Energy Innovation Hubs) • State Programs • University Funding • Tax Credits (e.g., R&D tax credit) • National Labs	• Demonstration programs (e.g., CCS regional partnerships) • Grants (e.g., Clean Coal Power Initiative) • Insurance (e.g., cost over run support)	• Loan Guarantee Programs • Government mandates (e.g., state RPS, CAFE standards)	• Investment/ Production Tax Credits • Government mandates (e.g., state RPS, CAFE standards)

Source: Modified from U.S. Department of Energy, "Deployment: How the Government Delivers Clean Energy and U.S. Jobs Today," 3 (presentation, August 2011) http://lpo.energy.gov/wp-content/uploads/2010/09/LPO-Presentation-August-2011.pdf.

comparisons of U.S. R&D investments as a percentage of GDP to other nations (Figure 4-2). Our recommendations will address specific barriers that are inhibiting American innovators and entrepreneurs from developing and deploying new technologies in the energy sector. Before discussing these recommendations, however, it is useful to review key barriers in the innovation process.

Barriers to Energy Innovation

Innovation in the energy sector—especially innovation to develop new technologies—presents several challenges. Although the production and use of U.S. energy is largely driven by private markets, it is also shaped by federal and state policies. To effectively foster an environment conducive to energy innovation, federal interventions should target specific market inefficiencies.

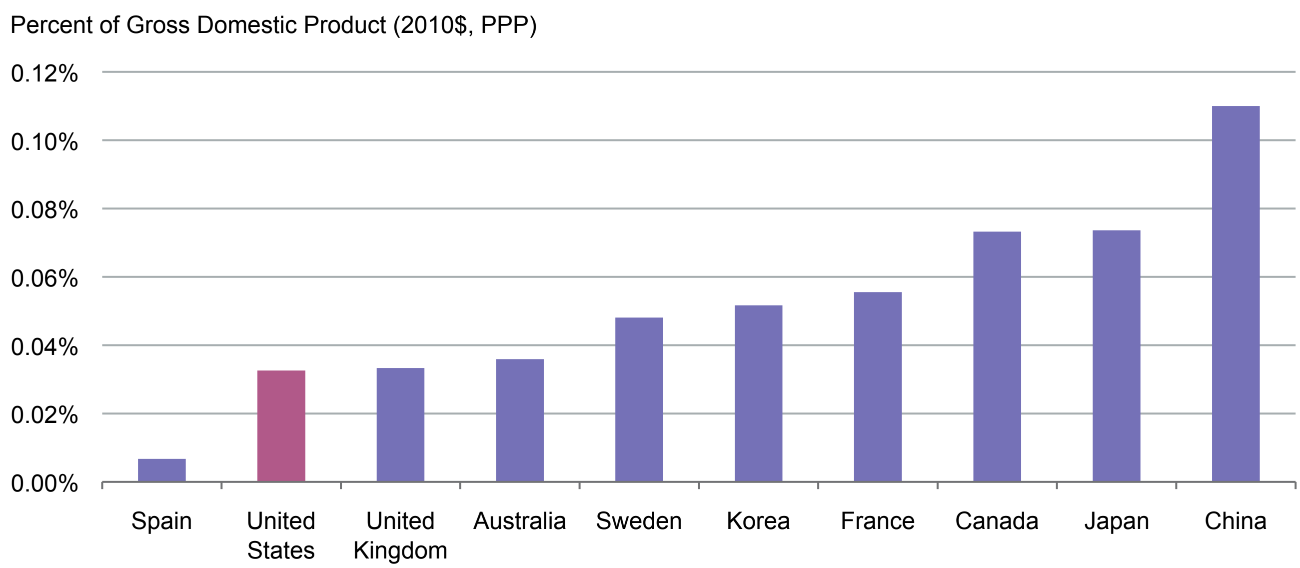
One feature of energy markets that tends to dampen incentives for innovation is that "energy" itself is an undifferentiated product. In other words, energy is valued for the goods and services it provides, not as a product in and of itself.[364] Consequently, energy innovation is less likely to be driven by the potential for large profit margins associated with introducing a new product (as might be the case with a new drug or communications technology), but rather by an interest in driving down costs or developing new resources.[365,366]

In addition, many energy supply technologies are large-scale, capital-intensive, high-risk, and long-lived, making technology scale-up and market entry difficult. The proverbial "valley of death" that stands between a newly developed and demonstrated technology and its successful large-scale commercialization is—for many energy technologies—primarily a problem of capital formation and risk management. Moreover, the development of innovative energy technologies does not necessarily translate into the development of a company capable of commercializing that technology. Few established financing or risk-management models exist for first-of-a-kind projects in the energy sector, especially those that require billion-dollar investments and carry some technology and/or regulatory risk (carbon capture and storage and nuclear power are two such examples). Therefore, for understandable reasons, the private sector is often unwilling or unable to make these investments on its own. And without first movers, new energy technologies cannot benefit from the cost reductions that would come from "learning by doing."

A further problem is that many energy markets are not truly competitive due to market fragmentation, regulatory complexity, and sometimes disjointed and uncertain public policies. These conditions typically slow the adoption of new technologies. Similarly, markets that do not account for externalities, including climate change and other environmental and public health impacts, can lead market actors to make decisions that may seem rational on a cost-accounting basis but overall are in fact less economically efficient when those externalities are factored in as costs. This tendency also hinders investment in new and innovative technologies.

Even where markets are functioning efficiently and externalities have been properly dealt with, economic theory predicts that private firms will systematically under-invest in R&D. This is because R&D—especially early-stage, basic science R&D—creates "knowledge spillovers" that benefit society as a whole. As long as private companies cannot capture or appropriate all of the economic value generated by these knowledge spillovers, their R&D expenditures fall short of the investment that would be justified if the societal benefits were factored in. The investment gap due to the

Figure 4-2: Public 2010 Energy RD&D Spending as Share of GDP, 2010



Note: France data is 2009; China data is 2008.
Source: International Energy Agency, "Energy Technology RD&D 2012 edition (free access)," http://wds.iea.org/wds/ReportFolders/ReportFolders.aspx?CS_referer=&CS_ChosenLang=en; Central Intelligence Agency, "The World Fact Book," https://www.cia.gov/library/publications/the-world-factbook/.

knowledge spillover problem varies at different stages in the technology development cycle, and is particularly important in the early stages of R&D.[367]

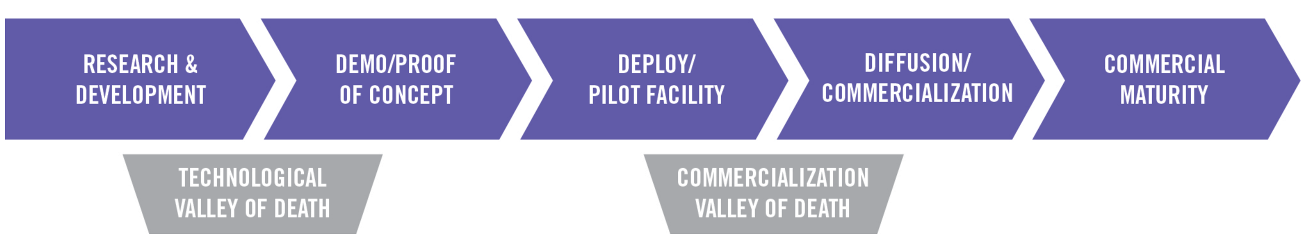
Another impediment to innovation arises from the substantial advantages that incumbent technologies and industries often have over new technologies and industries due to the presence of complementary assets. This problem of "lock-in" is especially acute in the energy sector, where many key supply and end-use technologies—from power plants to vehicles—depend on large-scale, long-lived infrastructure (for example, transmission lines and refueling stations in the case of power plants and cars, respectively). In such cases, new technologies may need to solve a "chicken and egg" problem, and it becomes even more difficult for new technologies to gain market entry and achieve widespread adoption outside of niche applications.

For all of these reasons, the energy sector could benefit from higher levels of R&D and related initiatives to promote innovation. Despite the existence of a number of incentives geared to spurring private-sector investment in this area, such as the corporate R&D tax credit, the recent trend in the utility sector has been toward less investment in R&D, which now accounts for less than 0.1 percent of revenues.[368,369]

The problem of underinvestment is especially acute at two critical transition points in the innovation cycle: 1) the transition from laboratory to proof-of-concept and 2) the transition from proof-of-concept to demonstration, especially in the case of large-scale, first-of-a-kind technologies. Because so many technologies fail to make it through these junctures, each is known as a "valley of death" and each presents specific challenges in terms of attracting adequate investment. For private companies, demonstrating the technological viability of new ideas is a fundamentally risky proposition, and one with uncertain payoffs in terms of future markets—hence the first, technological valley of death.[370] Different challenges arise for companies that want to move a new technology from proof-of-concept to full commercialization.

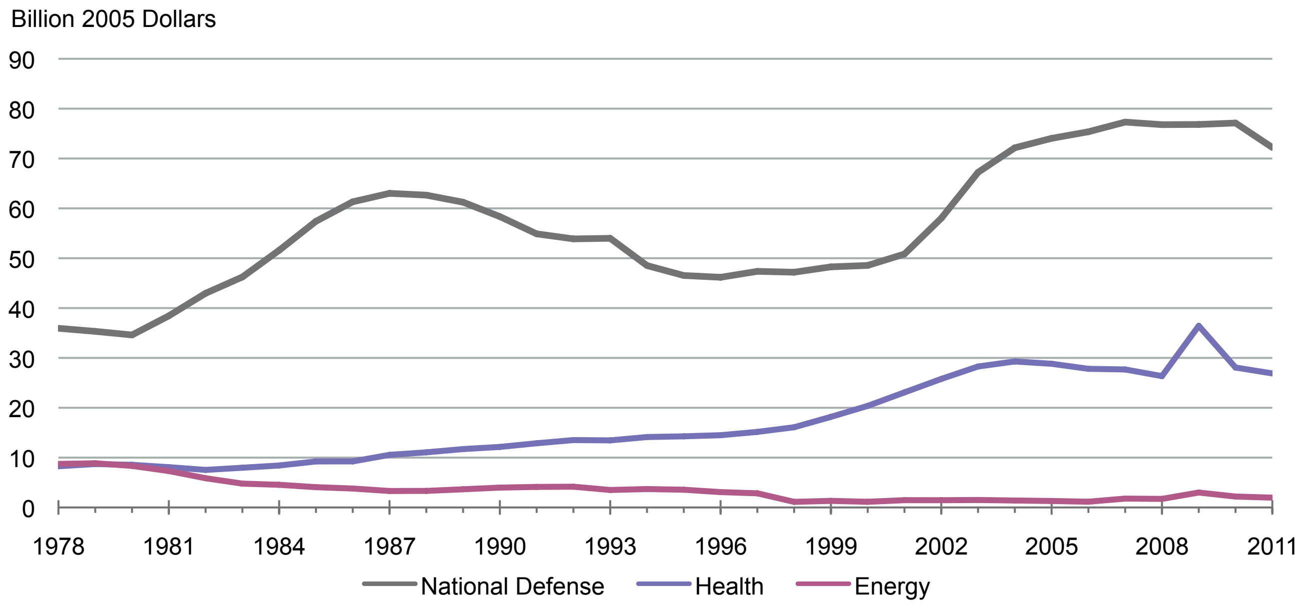
Existing business models and typical commercial banking, private equity, and institutional funds can be a barrier to scale-up of innovative energy technologies, as they often cannot accommodate the risks associated with technologies that are not yet commercially operational. In fact, the private investment community generally will not back first-of-a-kind projects or even the first follow-on projects because it prefers tried and true projects backed by strong vendor guarantees. It is important to note, however, that this is not always the case for mature industries, which often take risks

Figure 4-3: The Valleys of Death



Source: Modified from Jesse Jenkins and Sara Mansur,The Breakthrough Institute, *Bridging the Clean Energy Valleys of Death: Helping American Entrepreneurs Meet the Nation's Energy Innovation Imperative*, 5, November 2011, http://thebreakthrough.org/blog/Valleys_of_Death.pdf.

Figure 4-4: U.S. Federal R&D Budget Authority, 1978-2012



Source: National Science Foundation, National Center for Science and Engineering Statistics, "Federal R&D Funding by Budget Function: Fiscal Years 2010-12," Tables NSF 12-322, http://www.nsf.gov/statistics/nsf12322.

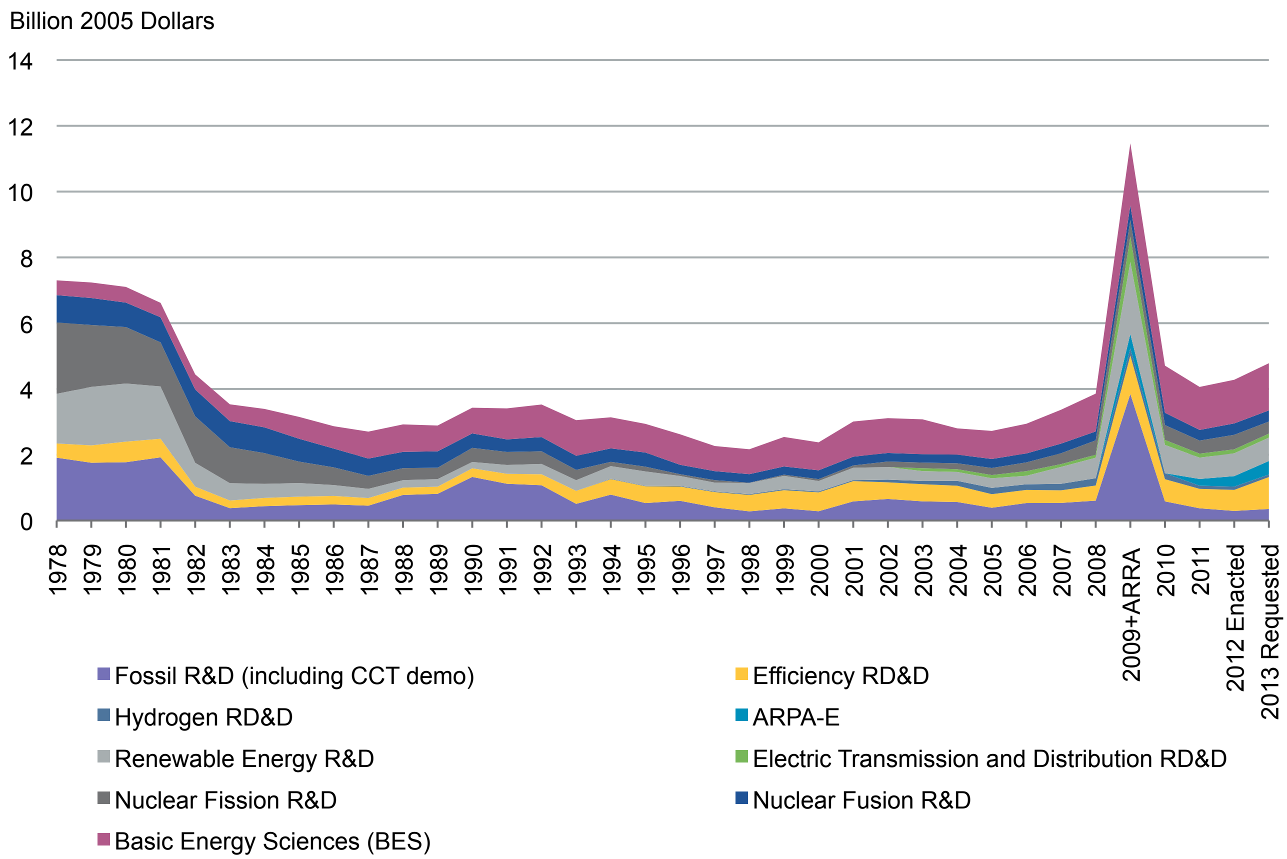
to deploy new technologies when they are forecast to be commercially successful (the exploration and production of offshore oil and gas is one example).

Even venture capitalists (VCs) have typically avoided major energy projects, for several reasons. First, VCs usually want to develop and build companies and control technologies that will gain market share, not invest in one-off projects. In addition, they perceive these investments as too risky since they often amount to a big bet on a single technology. Finally, many equity-intensive projects are simply too large for VCs: a typical energy project can cost $100–$500 million; whereas VCs usually invest in the $5–$50 million range. Project timeframes are also often too long for VCs, which typically expect to see investment returns over a five- to seven-year payback period.

Similarly, regulated utilities are not well-suited to develop innovative new energy technologies because they are typically required by law to provide their customers with reliable power using the lowest cost option available. From the perspectives of a utility and its regulators, the risks of failing to provide reliable low-cost power if an innovation is unsuccessful far outweigh the typically small benefits they might realize from deploying new technologies. Moreover, the effect of pressure to meet short-term earnings targets can reduce the incentive to make longer-term investments. In fact, before a utility commits to a new project, it typically insists on redundant engineering designs and strong technology guarantees.

In sum, established sources of private capital are unlikely to provide adequate support for the early commercialization

Figure 4-5: U.S. DOE Energy RD&D, FY1978-FY2013 Administration Request



Source: Kelly Sims Gallagher and Laura Diaz Anadon, Belfer Center for Science and International Affairs, John F. Kennedy School of Government, Harvard University, "DOE Budget Authority for Energy Research, Development, and Demonstration Database," February 29, 2012.

of some new energy technologies. This will remain true unless and until energy markets create a strong demand signal for technologies with inherently different performance characteristics than incumbent technologies (such as lower carbon emissions).

The Vital Federal Role in Energy Innovation

Absent sufficient private-sector investment, the federal government has a vital role to play in spurring the technology innovation needed to meet current and future energy challenges. The federal government can do this in two ways: first, by directly performing and/or funding RD&D activities, and second, by creating incentives for private-sector investment (e.g., tax credits, loan guarantees, and procurement policies) to help overcome the barriers identified in the previous section. Both types of federal involvement in energy RD&D have won broad bipartisan support for decades, including, most recently, in key provisions of the Energy Policy Act of 2005 (Pub. L. 109-58) and the Energy Independence and Security Act of 2007 (Pub. L. 110-140).

That said, federal investment in energy RD&D has historically been small. In real terms, direct federal spending on energy RD&D peaked in 1978 at $6.9 billion. A second, more recent peak occurred in 2009 when the federal government directed approximately $6.3 billion to energy RD&D as part of the American Recovery and Reinvestment Act (ARRA). Otherwise, federal funding for energy RD&D has averaged approximately $3.8 billion per year for the last 15 years (1995–2010). To put these expenditures in context, in 2010 U.S. defense R&D spending totaled $77 billion, while federal spending on health R&D totaled $28 billion.[371] Thus, federal investment in energy R&D remains small compared with federal spending in other R&D areas; it is also modest in light of the government's national interest in energy.

Given a fiscal environment that is creating intense pressure to cut budgets in all areas of government spending, the challenge will be to leverage scarce public and private resources for technology innovation in ways that maximize long-term returns to the nation's security and prosperity. In addition, despite bipartisan support for increasing the magnitude of public investment in energy RD&D, a number of criticisms of the relative effectiveness of DOE's programs have been leveled in recent years. Specific recommendations for improving the coordination and effectiveness of the government's energy technology programs are described at the end of this chapter. First, however, it is useful to review the various ways in which the federal government is currently supporting energy innovation through all stages of the RD&D and commercialization process.

Federal R&D Programs

Federal R&D is implemented by numerous federal agencies. Total federal budget authority for R&D in FY2009 was approximately $157 billion, including a one-time $14.7 billion increase provided under the American Recovery and Investment Act of 2009 (Pub L. 111-5).[372] Many energy technology programs—especially early stage and applied R&D—are administered by DOE, with the nation's universities and 17 national laboratories playing a significant role in performing the research. Other agencies, such as the Department of Defense (DOD), are increasingly playing a role by sponsoring research, demonstration, testing, evaluation, and procurement activities on energy-related technologies.[373,374]

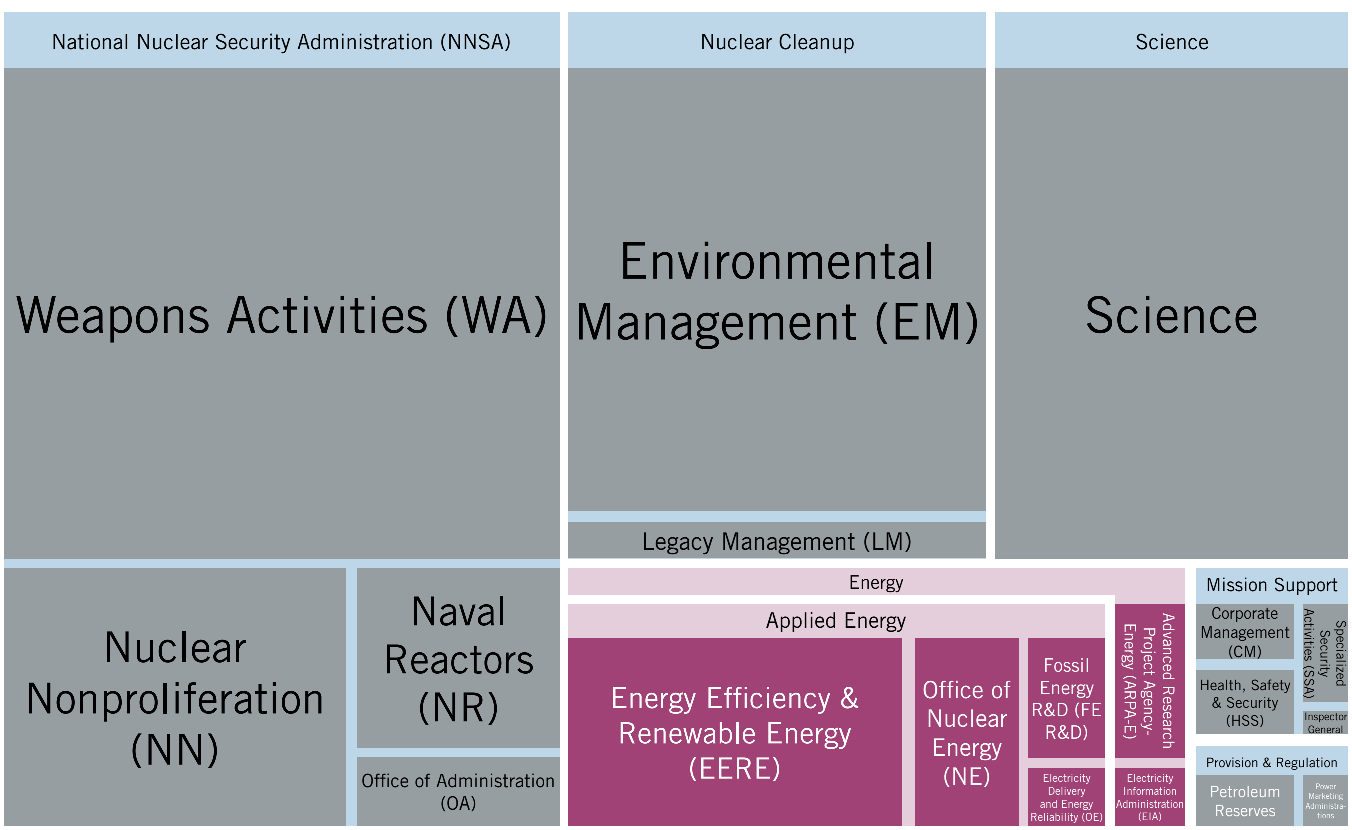
DOE operates numerous programs related to weapons management, nuclear waste cleanup, science, and energy with a total annual budget of approximately $26 billion.[375] Of that total, the amount of funding dedicated to energy research, development, and demonstration programs is quite small—approximately $4 billion, with an additional

$2 billion devoted to basic energy sciences at the Office of Science (Figure 4-6).[376]

Vigorous bipartisan support for federal investments in basic and applied R&D has persisted for decades. Still, energy R&D budgets have remained a small fraction of total federal R&D. As the nation faces daunting fiscal challenges, there will likely be pressure to reduce budgets even further. We believe that increasing federal investment in energy R&D is critical to the nation's future. Despite budget constraints, DOE engages in a wide range of energy innovation activities, focusing on increasing the effectiveness of its investments and the management and oversight of their portfolio.

A robust long-term foundation for energy innovation must include a portfolio of investments in basic science and engineering. Fundamental transformations in energy supply or application depend, in part, on research and development funded by numerous institutions and agencies. Too often, government or industry investment is focused solely on science or engineering questions that are directly related to the technology objective being pursued. A robust long-term foundation for energy innovation, by

Figure 4-6: DOE's Fiscal Year 2013 Budget

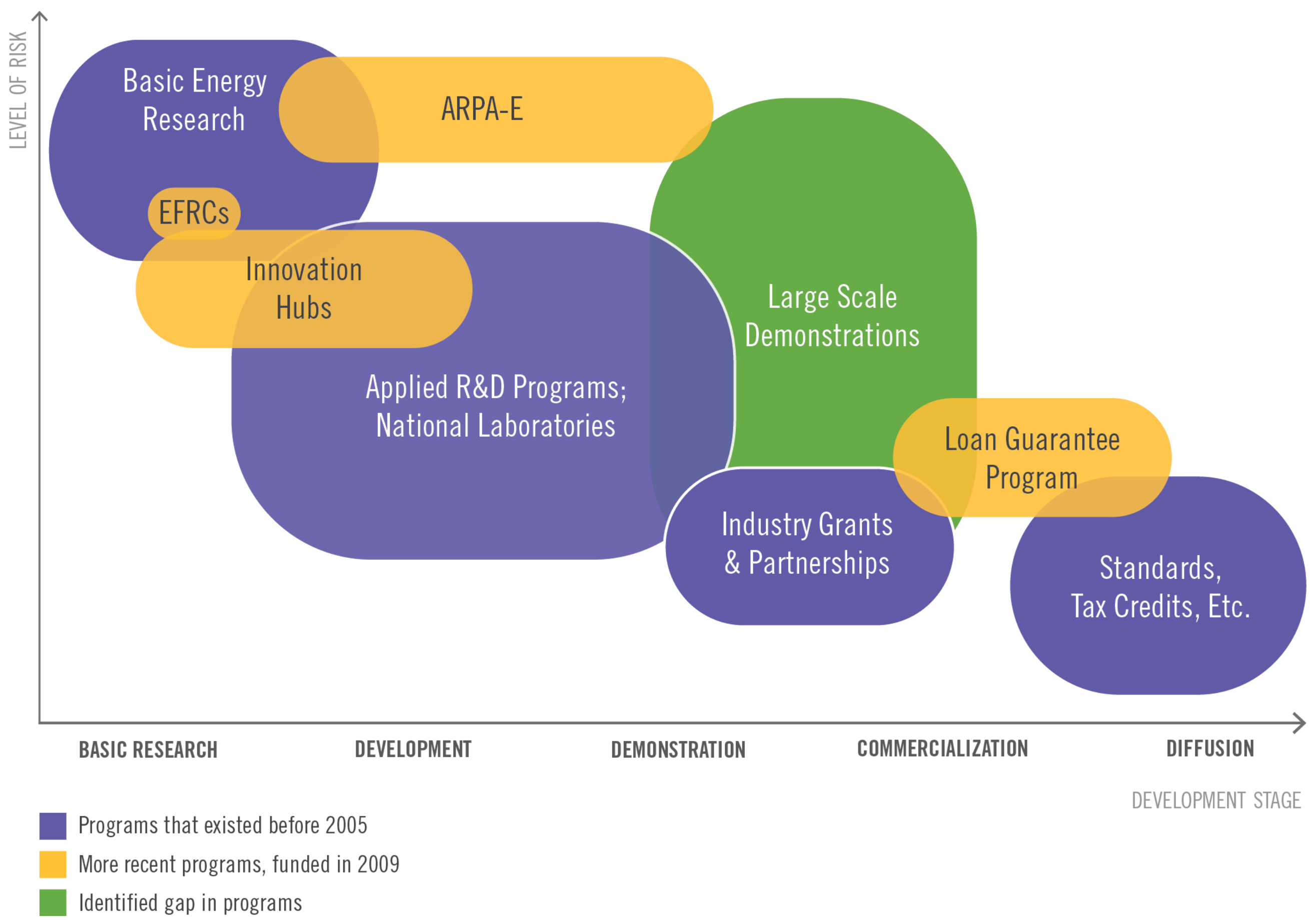


Source: U.S. Department of Energy, Office of the Chief Financial Officer, Office of Budget, http://www.cfo.doe.gov/crorg/cf30.htm.

contrast, must include a portfolio of investments that embraces basic research in science and engineering. It is important to note that those investments are not necessarily all made by DOE. Still, numerous experts have advocated for increasing the budget of DOE's Office of Science to scale-up federal investment in fundamental research. The 2010 reauthorization of the America COMPETES Act, on an overwhelmingly bipartisan vote, put the Office of Science on track to double its budget over 11 years.[377]

In addition to basic research conducted through its Office of Science, DOE funds R&D on applied energy technologies through its Office of Energy Efficiency and Renewable Energy (EERE), Office of Fossil Energy (FE), Office of Nuclear Energy (NE), and Office of Electricity Delivery and Energy Reliability (OE), using in many cases its network of national laboratories and universities. While increasing the magnitude of public investment in basic and applied R&D must remain a priority, governance of those investments

Figure 4-7: Schematic of DOE's Innovation Institutions and Policies



Source: Laura Diaz Anadon, Matthew Bunn, Gabriel Chan, Melissa Chan, et. al., Belfer Center for Science and International Affairs, John F. Kennedy School of Government, Harvard University, *Transforming Energy Innovation*, 39, November 2011, http://belfercenter.ksg.harvard.edu/files/uploads/energy-report-january-2012.pdf.

is also critical. To this end, and to address concerns about the relative effectiveness of DOE's innovation activities, DOE has implemented a number of reforms and instituted new programs in recent years.

Beginning in 2010, DOE launched several Energy Innovation Hubs. The Hubs are designed to be major multidisciplinary, multi-investigator, multi-institutional integrated research centers. They are modeled after the centralized scientific management characteristics of the Manhattan Project (e.g., Los Alamos and the Metallurgical Laboratory at the University of Chicago), Lincoln Lab at MIT (which developed radar), and AT&T Bell Laboratories (which developed the transistor), and on the three Bioenergy Research Centers (BRCs) established by DOE's Office of Science in 2007.

Energy Innovation Hubs aim to bring together top researchers from academia, industry, and the national laboratories with expertise that spans multiple scientific and engineering disciplines under the leadership of a scientist-manager. These teams orchestrate an integrated, multidisciplinary systems approach to overcome critical barriers to transformative advances in energy technology. Each Hub's management structure is designed to allow empowered scientist-managers to execute quick decisions that shape the course of research. Energy Secretary Steven Chu has stated that each hub should be "ideally under one roof" in the sense that it has a clear lead institution and a central location. Hubs are also designed to maintain robust links to industry and thereby help bridge the gap between basic scientific breakthroughs and industrial commercialization. To date, five hubs have been funded and aim at a diverse array of fundamental energy challenges: converting fuels from sunlight, next-generation energy storage technologies, critical materials, advanced nuclear modeling, and energy-efficient building design.

In addition to the Hubs, DOE recently established 46 Energy Frontier Research Centers (EFRCs) located at research institutions across the nation. The goal of the EFRCs is to advance fundamental science relevant to real-world energy systems. Each Center focuses on the long-term basic research needed to overcome technology roadblocks in a particular area. The EFRCs are mostly multi-institutional centers composed of a self-assembled group of investigators, often spanning several science and engineering disciplines. Their research is focused on the grand challenge and use inspired fundamental science needed to solve specific problems.

Funding for the EFRCs ranges from $2–$5 million per year per project, and overall scientific direction is provided by staff in DOE's Basic Energy Sciences program to ensure a unified management strategy and structure.[378] Currently, the 46 EFRCs span 35 states and focus on solar energy, biofuels, transportation, energy efficiency, electricity storage and transmission, carbon capture and sequestration, and nuclear energy.[379]

Finally, Congress established a new energy-innovation entity, the Advanced Research Project Agency-Energy (ARPA-E), as part of the America COMPETES Act of 2007. ARPA-E is modeled on the Defense Advanced Research Project Agency (DARPA), which takes a highly entrepreneurial approach to mission-oriented R&D by funding scientists and technologists to accelerate the development of technologies that could have exceptional potential but that are considered too risky or uncertain to attract private investors. ARPA-E is designed to focus exclusively on high-risk, high-payoff technologies that can change the ways energy is generated, stored, and utilized. It will not fund basic science or support incremental improvements to current technologies. ARPA-E program managers are expected to take a hands-on approach to managing the activities of the researchers they fund and emphasize interdisciplinary partnerships that bring together companies, labs, and universities. The funding per project ranges from $500,000 to $10 million. Projects are selected on the basis of potential to make rapid progress toward commercialization, and funding will not be extended without demonstrable progress in a two- to three-year timeframe.

Authorized in 2007 but without an initial budget, ARPA-E received $400 million in funding through the American Recovery and Reinvestment Act of 2009 (Pub. L 111-5). It received $250 million in FY2012, and the administration has requested $350 million for FY2013. To date, ARPA-E has invested in 180 projects. Eleven ARPA-E projects that received $40 million in direct federal support have now received over $200 million in follow-on private-sector financing, and the program has cut several non-performing projects.[380] While it is too soon to evaluate ARPA-E's success in launching transformational technologies, the new agency is off to a promising start by almost all accounts and has already marked several milestones:

- Investing in high-potential projects.
- Successfully attracting talent from the private sector and academia.
- Creating an "open architecture" organizational design that is well adapted to meeting current program needs.
- Developing processes that support transparency and enhanced coordination with the private sector.

In addition to efforts supported by DOE, other federal agencies have historically played a role in catalyzing innovation in the energy sector.[381] DOD and the General Services Administration (GSA), in particular, have both invested in energy-related R&D. In addition, they have supported the adoption of innovative energy technologies through a number of other mechanisms, including through testing, demonstration, procurement, and standard-setting.[382] To ensure that DOD's innovation capacities in the energy realm are fully utilized, DOE and DOD signed a memorandum of understanding in 2010 noting the importance of the nexus between energy and national security and "identifying a framework for cooperation and partnership between the DOE and DOD."[383]

Energy Innovation at the Department of Defense

DOD has a sustained program of energy R&D and procurement, which has had spillover benefits for civilian society. For example, DOD's energy investments have advanced both nuclear power and natural gas turbine technology. More recently, DOD has pursued renewable power, energy efficiency, and alternative transportation fuels; indeed, the military is on its way to meeting a stated goal of having 25 percent of its energy come from renewable sources by 2025. DOD is the single largest consumer of energy in the nation; in 2011, its energy bills totaled $20 billion and its petroleum consumption totaled five billion gallons.

DOD invests in alternative fuel research, development, and procurement, as well as testing and certification of alternative fuels (e.g., hydrogen and biofuels) in new applications, including military aircrafts and marine vessels. DOD's alternative fuel goals are largely tactical: the Department's aim is to improve the readiness, effectiveness, flexibility, and reliability of fueling its transport vehicles.[384] In addition to the potential advantages improved transportation technologies can offer in battle situations (e.g., the ability to go farther on the same gallon of fuel and/or to produce fuel on-location), DOD recognizes its broader interest in promoting energy options that reduce the long-term potential for international conflict or instability related to competition for oil or environmental problems like climate change.[385] Importantly, the impetus for DOD's investment in energy innovation is—and must be—the desire to meet practical, mission-relevant defense objectives.

Public-Private Partnerships

In addition to directly funding energy R&D through the programs described in the previous section, DOE has increasingly focused on improving collaboration between the federal government and private-industry partners in energy R&D. Many of these efforts have involved the national laboratories and other federal facilities. The new Technology Transfer Office works with the national laboratories to accelerate the transfer of commercially promising laboratory innovations to the private sector. The office was authorized in the Energy Policy Act of 2005, and in 2010 DOE filled this position for the first time. Noting that this collaboration can yield mutually beneficial results, industry and DOE utilize a number of mechanisms to foster public-private partnerships, including cooperative research and development agreements (CRADAs), "work for others" agreements (WFOs), user facility agreements, licensing, grants, and sub-contracts. In 2008, the 17 national labs and five federal facilities participated in more than 700 CRADAs, 2,500 WFOs, 2,800 user facility agreements, and 5,000 licenses. These collaborations resulted in 1,400 inventions and over 900 patent applications.[386]

- **Cooperative Research and Development Agreements:** CRADAs are intended to enhance opportunities for mutually beneficial collaboration between the federal government and the private sector. A CRADA is defined as an agreement between the federal government and a private-sector party under which the government provides personnel, services, facilities, equipment, intellectual property, or other resources with or without reimbursement (but does not fund) while the non-federal party provides the funds, along with personnel, services, facilities, equipment, intellectual property, or other resources toward the conduct of specified R&D project.

Current Public-Private Partnerships

By providing incentives to the energy sector that reduce financial and technical risks for emerging technologies, public sector agencies: (a) support the development of evolutionary or revolutionary energy sector technologies, (b) verify the commercial and cost readiness of these new technologies, and (c) facilitate the industry adoption of new technologies that can meet more stringent regulation.

Two DOE programs that illustrate the potential of public-private partnerships to make progress on technologically challenging problems are the Power Plant Improvement Initiative (PPII) and the Clean Coal Power Initiative (CCPI). These initiatives grow out of DOE's earlier Clean Coal Technology (CCT) program and are focused on working with industry to develop technologies for coal-fired electricity generation that allow for the cost-effective control of key air pollutants and carbon dioxide. Past work in this area has achieved important successes: New NO_x and SO_2 control technology has been retrofitted to existing generating plants, and the first generation of advanced coal-based power systems has been placed in commercial service. These advanced power systems represent a leap forward in terms of efficiency, reliability, and environmental performance and provide a springboard for further technology development and widespread, global deployment.

Today, efforts to develop cost-effective, commercially viable CO_2 capture technologies are underway at the National Carbon Capture Center (NCCC), housed at DOE's Power Systems Development Facility in Wilsonville, Alabama. The NCCC operates a flexible applied R&D test facility that provides commercially representative flue gas and syngas and the necessary infrastructure to develop and test CCS technologies under realistic operating conditions. By offering a unique, central, R&D test facility available to all CCS technology developers, DOE is trying to minimize redundancy in testing sites and equipment, generate high-quality data for performance verification, and assure the cost-effective use of R&D funds—thereby ultimately providing a less costly way to bridge the gaps between fundamental R&D and more demanding large-scale commercial demonstrations.

This type of agreement allows a private company to fund some or all (many CRADAs are completely industry funded) of the government's effort but not vice versa (in other words, federal funds cannot be used to support the private-sector party). The treatment of intellectual property (IP), rights to patents, protection of information, and licensing can be negotiated as part of the CRADA. Generally speaking, intellectual property developed under a CRADA is owned by the party that invented the technology, whether that party is the national lab or the industry partner, or both.[387]

- **Work for Others contracts:** WFO agreements represent a form of sponsored research, where the federal laboratories conduct R&D for a private-sector partner that funds the work directly. In general, the sponsoring company maintains intellectual property and data rights, but the government maintains the right to use the technology.
- **User Facility agreements:** DOE's laboratories are available to industry users. Typically, the industry user must cover the cost of conducting research at the federal facility (unless the private-sector participant agrees to publish the research results); the industry user maintains intellectual property and data rights to the research results.
- **Agreement for Commercializing Technology (ACT):** In 2011, DOE initiated the ACT program as a pilot to encourage private industry to partner with certain DOE laboratories to conduct R&D.[388] ACTs differ from CRADAs and WFOs in that it provides a more flexible framework for negotiating intellectual property rights. It also allows contractors—rather than the government—to assume some financial and performance risk and more readily facilitates multi-party research.

Recent efforts by DOE to promote increased partnerships with the private sector have been promising, though there is certainly room for further improvement. More work could be done to analyze and address real or perceived barriers to collaboration, such as the treatment of intellectual property rights. Nevertheless, recent actions—particularly the establishment of the Technology Transfer Office at DOE and the ACT pilot program—represent important steps in the right direction.

Federal Incentives also Promote Private-Sector R&D and Demonstration Projects

In addition to DOE's own research programs and its efforts to partner with industry, the federal government has historically used the tax code as another tool to generate incentives for private-sector investments in energy R&D. For example, the Research & Experimentation Tax Credit (later the corporate R&D tax credit) has existed since 1981 when it was introduced as part of the Economic Recovery Act.[389] The current credit builds on tax provisions dating back to 1954 that allow companies to take an annual deduction for R&D spending; it allows companies to credit certain types of R&D spending over and above a specified base level against their tax liability, thereby making it more valuable than a deduction.[390] In FY2009, U.S. companies claimed an estimated $5.6 billion in corporate R&D tax credits.[391] Over the last three decades, the credit has been renamed, restructured, and renewed many times—and has become increasingly complex in the process. On December 31, 2011, however, it expired altogether. The White House Office of Management and Budget (OMB) estimated that a five-year extension of the current credit from 2011 to 2015 would cost the U.S. Treasury approximately $12.9 billion.[392]

There is a vigorous debate about the relative effectiveness of the R&D tax credit as a tool for stimulating private-sector R&D investment. Though a number of analysts argue that the current credit has been effective, on the whole,[393] the ideal evidentiary base for assessing its effectiveness—for example, by measuring the amount of additional corporate R&D spending induced and the social returns to that spending, minus the costs of the credit—is difficult to compile, both because it is difficult to measure social returns to R&D investment and because the costs of administering the credit have not been carefully tracked since its enactment. As a result, many economic studies of the R&D tax credit rely on a comparison of the tax cost and incremental R&D spending, together with the price elasticity of R&D ("a measure of the ratio of the percentage change in R&D spending for a given percentage change in the tax cost of the credit").[394] Using these measures, most studies support the conclusion that the credit has been at least as effective in stimulating private sector R&D as direct federal funding.[395]

The president's FY2013 Budget proposal requests several changes to the corporate R&D tax credit that would: (1) make the tax credit permanent, (2) change the way "base amounts" are calculated so that they are indexed to the average of qualified research expenditures during the most recent three years (rather than expenditures from 1984 to 1988), and (3) increase the credit to 17 percent from the original level of 14 percent. The President's Council on Jobs and Competitiveness has touted the importance of the R&D tax credit, particularly for energy investment, and highlighted the president's budget proposal in its 2011 report.[396] In 2011, multiple pieces of legislation to extend and reform the tax credit were introduced in Congress and referred to their respective committees, but none have passed out of committee at the time of this writing.[397]

As noted in the introduction, there is generally broad support among economists and policy makers for the notion that government has a constructive and important role to play in funding basic and applied sciences, where the divergence between society's long-term interest and private industry's near-term incentives is largest. As technologies progress along the innovation process from basic research to applied research, development, demonstration, and ultimately deployment, both theory and practice suggest that the private sector's role should increase while the public sector's role declines.[398] For this reason, the stage between development and deployment—the demonstration phase—is conducted principally by the private sector in many industries. For a number of reasons outlined in this chapter, however, this may not always be feasible in the energy sector, where the transition to early deployment often constitutes another formidable "valley of death" for new technologies. Consequently, DOE has a long history of undertaking limited activities to support the demonstration of high-risk, capital-intensive energy technologies (a notable historical example is the civilian nuclear power industry, which was launched by DOE's predecessor and other federal agencies in the 1950s). As the term implies, demonstration projects are intended to "demonstrate" or prove that new technologies are economically feasible at or near commercial scale. Recent demonstration projects supported by DOE have included large-scale advanced coal projects, carbon sequestration efforts, and Smart Grid projects, among others. According to the DOE website, these programs "are designed to correct market imperfections and remove the non-market forces that restrict advanced energy technologies' deployment."[399]

To reduce barriers to commercialization and early-stage deployment—especially in the case of large-scale, expensive, first-of-a-kind projects—governments commonly adopt one of two tactics, and often they use both: reducing or defraying the cost of the new technology to make it more competitive with existing technologies and/or broadening the pool of available capital for demonstrating the technology. A number of mechanisms have been adopted at the state and federal level to achieve these goals, many of which are discussed in Chapter 5: Overhaul Federal Interventions in Energy Markets.

One example that is managed by DOE is the loan guarantee program, established with bipartisan support as part of the Energy Policy Act of 2005 (Title XVII, Section 1703). The intent of the program is to "accelerate the domestic commercial deployment of innovative and advanced clean energy technologies at a scale sufficient to contribute meaningfully to the achievement of our national clean energy objectives."[400] Under the program, DOE can issue loan guarantees to renewable, advanced nuclear, and energy efficiency projects with the requirement that the borrower pay the credit subsidy cost (CSC) or the estimated long-term liability to the government in issuing the loan guarantee. The original 1703 authorizing language requires "reasonable prospect of repayment of the principal and interest on the obligation by the borrower," but definitional ambiguity has led to confusion about the program's primary purpose.[401] The program is not set to expire, but has a volumetric cap of $1.5 billion. To date, the program has made two conditional commitments to nuclear projects. Additionally, Congress appropriated approximately $170 million in credit subsidy costs that have been carried over from previous fiscal years.[402] President Obama did not request any new loan authority for the 1703 program for FY2013.

In 2009, Congress established an additional loan guarantee program (the 1705 program) as part of the American Recovery and Reinvestment Act. This program offers loan guarantees to eligible renewable energy projects, power transmission systems, and certain biofuels projects that began construction by September 30, 2011. Eligible projects qualified for $2.5 billion in appropriated funding to cover the credit subsidy, which, in this case, was paid by DOE through appropriated funds.[403] Overall, the 1705 program issued 28 loan guarantees worth $16.1 billion. Of the $2.5 billion in federal funding that was appropriated to cover credit subsidy costs under the 1705 program, $600 million remained unused when the program expired in September 2011.[404]

The loan guarantee program has come under intense scrutiny as a result of the high-profile collapse of three companies that received section 1705 loan guarantees, Solyndra, Abound, and Beacon Power (loan guarantees to these companies totaled $535 million, $400 million, and $43 million, respectively).[405] Less widely publicized has been the fact that the majority of loan guarantee recipients have not defaulted on their loans or cost the U.S. Treasury to date. Moreover, the 1705 program expired in 2011. Nonetheless concerns are still being raised about the efficacy, management, and oversight of DOE's remaining 1703 loan guarantee program. Specifically, critics cite the lengthy loan application review process and approval time, lack of insulation from political pressure, the absence of a portfolio approach to risk management, dependence on budgetary outlays (for programs covering credit subsidy costs), and an inability to adequately leverage private-sector expertise.

Recommendations to Accelerate Energy Innovation

The focus of the recommendations that follow is on ensuring that federal investments in energy technology innovation are as effective and efficient as possible, and that federal policy is oriented to promote private innovation. This is particularly important as the federal government confronts unprecedented fiscal constraints and budget pressures in the years ahead. Reconciling the need for investment, including investment in energy innovation to build a foundation for America's future prosperity, with the equally urgent imperative of bringing the nation's escalating debt and deficit problems under control is a central challenge for policy makers in the years ahead.

RECOMMENDATION: Congress should require a regular, rigorous retrospective review of DOE's Research, Development, and Demonstration (RD&D) energy portfolio. This review should be conducted by an outside body (e.g., the National Academy of Sciences) and should examine the

effectiveness and management of DOE's RD&D portfolio while also providing options to maximize the benefits from these federally funded programs. The idea of an outside review is not wholly new: In fact, Congress requested an evaluation of the benefits that have accrued from energy R&D conducted since 1978 in DOE's applied programs for energy efficiency and fossil energy programs as part of its FY2000 appropriations bill. The resulting study by the National Research Council (NRC), "Energy Research at DOE: Was it Worth It?," concluded that $1.7 billion of DOE investments in energy efficiency over the study period ultimately yielded $30 billion in societal benefits. Looking just at the more recent period from 1986 to 2000, the NRC concluded that DOE'S investment of $4.5 billion in fossil energy programs produced $7.5 billion in benefits.[406] We recommend a similar study, but one that is broader in scope and regularly conducted and reported to Congress.

RECOMMENDATION: Congress should significantly increase federal investments in basic and applied energy R&D. Despite the current economic and fiscal situation, the United States cannot afford to undercut investments upon which our very economic future depends. As Norm Augustine stated in *Rising Above the Gathering Storm, Revisited,* "doubling the research budget are investments that will need to be made if the nation is to maintain the economic strength to provide for its citizens healthcare, social security, national security, and more. One seemingly relevant analogy is that a non-solution to making an over-weight aircraft flight-worthy is to remove an engine."[407] The economic and policy case for sustained increased investment in basic and applied energy R&D is made throughout this report, and echoed by others, including the National Academy of Sciences, the President's Council of Advisors on Science and Technology, and the American Energy Innovation Council, among others.

RECOMMENDATION: Congress and federal agencies should, when appropriate, consider mechanisms to leverage public-sector resources to demonstrate and deploy energy technologies. As this chapter notes, there is widespread support for a robust public-sector role in funding basic and applied sciences. As technologies move from basic and applied research and development to demonstration and deployment, theory and practice suggest that the private sector's role should increase as the public sector's role declines. Not only is the private sector better equipped to judge a new technology's readiness for market and to spearhead early deployment efforts, but also private incentives to invest in a new technology naturally increase as the technology approaches commercial readiness. As a result, the gap between private incentives and societal interest is much smaller in the latter stages of the innovation process, and there is less justification for government intervention. Still, as this chapter identifies, there are exceptions where clearly identified market failures are barriers to demonstrating technology scale-up. In these instances, the federal government should employ mechanisms—such as cost-sharing partnerships and loan guarantees—to support private-sector investment in innovative demonstration projects.

RECOMMENDATION: Congress should reauthorize the America COMPETES Act, important provisions of which are set to expire at the end of FY2013.[408] The America COMPETES Act (PL 110-69) was signed into law in 2007 and reauthorized in 2010. The law focuses on improving U.S. competitiveness and innovation by authorizing increased federal support for research in science and engineering and investments in science, technology, engineering, and mathematics education. Specifically, the 2010 act reauthorized the doubling of DOE's Office of Science budget and funded ARPA-E.[409] In light of the nation's current fiscal challenges, doubling the Office of Science budget seems unlikely at this time. Nonetheless, we support a significant budget increase over the coming years.[410]

RECOMMENDATION: As a component of the government-wide Quadrennial Energy Review (QER), DOE should undertake a regular review of its technology programs (a Quadrennial Technology Review) to rebalance its energy R&D portfolio and guide budget priorities in light of energy-market conditions, technology advances, and emerging national priorities.[411] A number of groups, including the President's Council of Advisors on Science and Technology have called for better prioritization and planning for federal energy-related activities, and have recommended a periodic government-wide Quadrennial Energy Review. We endorse this idea. In addition, PCAST called for a more narrow review of DOE activities to be conducted in the near-term as one component of the larger Quadrennial Energy Review. The first Quadrennial Technology Review (QTR) was initiated in February 2011, and the final report was released in September of that year. The QTR represents an important first step toward systematically balancing DOE's energy R&D portfolio and prioritizing its research activities and should be undertaken on a regular basis going forward.

RECOMMENDATION: DOE should reform elements of its institutional structure to prioritize energy innovation. While it may be too early to conduct a robust analysis of the relative effectiveness of ARPA-E and other new DOE programs and entities, we conclude that many of the organization and management characteristics they are piloting could serve as broad best practices for driving innovation across the department. Many of the new processes, tools, and authorities exercised by ARPA-E could be broadly applicable to other branches of DOE, including, for example, the applied offices. Some of those attributes include: (1) a portfolio approach to project and risk management, including a focus on overall program success rather than a project-by-project basis; (2) flexibility in hiring and empowering project managers; (3) coordination and coherence from basic R&D through later-stage efforts[412]; (4) encouraging a competitive culture that rewards the cancellation of non-performing projects.

RECOMMENDATION: DOE should take additional action to address intellectual property (IP) issues in its funding and collaboration processes. This includes establishing general principles for the role of IP, ensuring that the economic value of successfully commercialized energy technologies to the public is widely recognized and valued, and providing flexibility for the implementation of relevant IP principles in individual agreements. The recently implemented Agreement for Commercializing Technology (ACT) pilot program, while directionally positive, is focused on the DOE labs and will take quite some time to produce results. DOE headquarters and ARPA-E should collaborate with the private sector and develop more near term improvements in their IP sharing practices to encourage greater private sector partnering with the Department.

RECOMMENDATION: The section 1703 DOE loan guarantee program should be maintained and reformed. The federal government should have the capacity to utilize certain financial instruments—including loan guarantees—to reduce barriers to private-sector investment in projects that demonstrate innovative large-scale energy technologies. Specific reforms should be undertaken in several areas.[413]

- **Risk management:** DOE should take a portfolio approach to risk management and should form a risk management department. An early warning system should be implemented to examine market and regulatory changes, the performance of individual projects, loans, and internal operation. DOE's position as a creditor should be bolstered, and there should be a clear and effective process for cutting off funds for non-performing projects.
- **Data management and record-keeping:** DOE should improve its data collection with respect to the status of current applications and overall program performance and develop a more effective records management system.
- **Funding and staffing:** Congress should ensure that the relatively small funds necessary for effective

administration at the loan guarantee program are provided and span the anticipated duration of the projects. DOE should clarify the authority of its managers.

- **Accountability:** DOE should improve public reporting about the program and establish an interagency advisory board to review the program's governance and advise the Secretary of Energy on policy matters.

RECOMMENDATION: DOD, in direct support of its national security mission, and other federal departments and agencies should strive for continued improvement in aligning their energy innovation activities with broader national energy goals. Federal energy R&D is not solely the purview of DOE. DOD plays a significant role in energy technology R&D through research and development, demonstration, testing, and evaluation of energy technologies. DOD's energy technology activities must fundamentally contribute to its primary national security mission. The Quadrennial Energy Review recommended in our November 2012 report, *The Executive Branch and National Energy Policy: Time for Renewal,* would help to illuminate and improve multi-agency R&D priorities and investments.

RECOMMENDATION: Treasury, DOE, and Congress should assess the effectiveness of the tax code in spurring private-sector energy innovation. We agree that the R&D tax credit should be made permanent, increased, and expanded. The administration and Congress should consider and propose reforms to existing tax incentive programs in the context of broader tax reform efforts. This would include taking an inventory of existing legislative energy tax provisions and aligning tax policies with the priorities articulated in the National Energy Strategy (NES) and/or Quadrennial Energy Review (QER). (Energy tax expenditures are further addressed in Chapter 5.)

Energy & Infrastructure Program
Energy Project



Chapter 5: Overhaul Federal Interventions in Energy Markets

In energy, as in other key sectors of the U.S. economy, the nation relies on markets to produce an efficient allocation of resources and to ensure that the demands of consumers and businesses for high-quality, reliable energy products and services are met as cost-effectively as possible. However, the government has historically set the rules by which energy markets operate. As we outlined in our previous report, *The Executive Branch and National Energy Policy: Time for Renewal,* our nation's federalist system of government grants the states the larger share of legal authority for many of the energy policies that most directly impact consumers and businesses. That said, U.S. energy markets have also long been influenced to a significant extent by federal government interventions. Such interventions may take a variety of forms, from direct regulation and even price controls or fuel mandates, to an assortment of direct and indirect incentives, tax deductions, public expenditures, and subsidies. Whatever their specific form, however, these interventions generally share the same justification: namely, that the market—left to itself—will not produce results that are optimal for society as a whole, typically because of the existence of one or more market failures. (A classic example of a market failure occurs when the society-wide benefits or costs of an activity exceed the private benefits or costs and are thus not represented in market prices.) Certain societal interests in particular are frequently cited, as providing a rationale for energy market interventions:

- **Energy security.** A high level of reliance on oil supplies from other countries has historically been viewed as undesirable, primarily as a result of the Arab oil embargo and oil crises of the 1970s that resulted in soaring domestic prices for petroleum products. Given the integrated nature of international oil markets today, however, significant supply disruptions in any region around the globe will affect domestic oil prices even with substantial anticipated increases in domestic production.
- **Protection of health and environment.** Impacts on public health and the environment are associated with nearly every kind of energy resource and virtually all aspects of the current energy system. The scale of those impacts varies widely across energy resources. In some cases, these impacts have been fully or partially internalized through regulation; in other cases, impacts are not reflected in market prices, which can distort price and cost comparisons.
- **Long-term economic competitiveness.** As discussed at more length in the previous chapter on innovation, private companies tend to underinvest in basic R&D relative to the societal benefits that could be realized through such investment. This occurs because the diffusion of basic scientific and technical knowledge—while potentially valuable in terms of the nation's long-term economic competitiveness—cannot be readily valued or monetized by private investors.

Overview of Federal Energy Interventions

Table 5-1 summarizes the different types of federal support available to different fuels and technologies, along with their cost to the U.S. Treasury, in FY2010.[414] As is clear from the table, tax expenditures have emerged as the leading form of federal support for specific energy technologies. In recent years Congress has shown a growing preference for shaping energy markets through tax preferences rather than through direct federal expenditures. Reflecting this shift, the remainder of this section and the recommendations focus on tax-related federal expenditures.

Tax expenditures are provisions enacted through the tax code that lower the overall tax liabilities for a set of beneficiaries. Whereas direct expenditures improve the balance sheet of beneficiaries through increased revenues, tax expenditures improve the balance sheet of beneficiaries

Table 5-1: Federal Support for Specific Energy Technologies by Type, FY2010 (Millions of Dollars)

Beneficiary	Direct Expenditures	Tax Expenditures	Research & Development	DOE Loan Guarantee Program	Federal & RUS Electricity	Total	ARRA Related
Coal	42	561	663	0	91	1,358	97
Refined Coal	0	0	0	0	0	0	0
Natural Gas and Petroleum Liquids	4	2,690	70	0	56	2,820	0
Nuclear	0	908	1,169	265	157	2,499	147
Renewables	4,696	8,168	1,409	269	133	14,674	6,193
Biomass	57	523	537	0	0	1,117	10
Geothermal	160	1	100	12	0	273	228
Hydro	17	17	52	0	130	216	16
Solar	496	120	348	173	0	1,134	788
Wind*	3,556	1,178	166	85	1	4,986	4,852
Other	95	0	205	0	1	302	130
Biofuels	314	6,330	0	0	0	6,644	169
Electricity - Smart Grid & Transmission	461	58	222	20	211	971	495
Conservation	3,387	3,206	0	4	0	6,597	6,305
End-Use	5,705	693	832	1,011	0	8,241	1,549
LIHEAP	5,000	0	0	0	0	5,000	0
Other	705	693	832	1,011	0	3,241	1,549
All	**14,295**	**16,284**	**4,365**	**1,570**	**648**	**37,160**	**14,786**

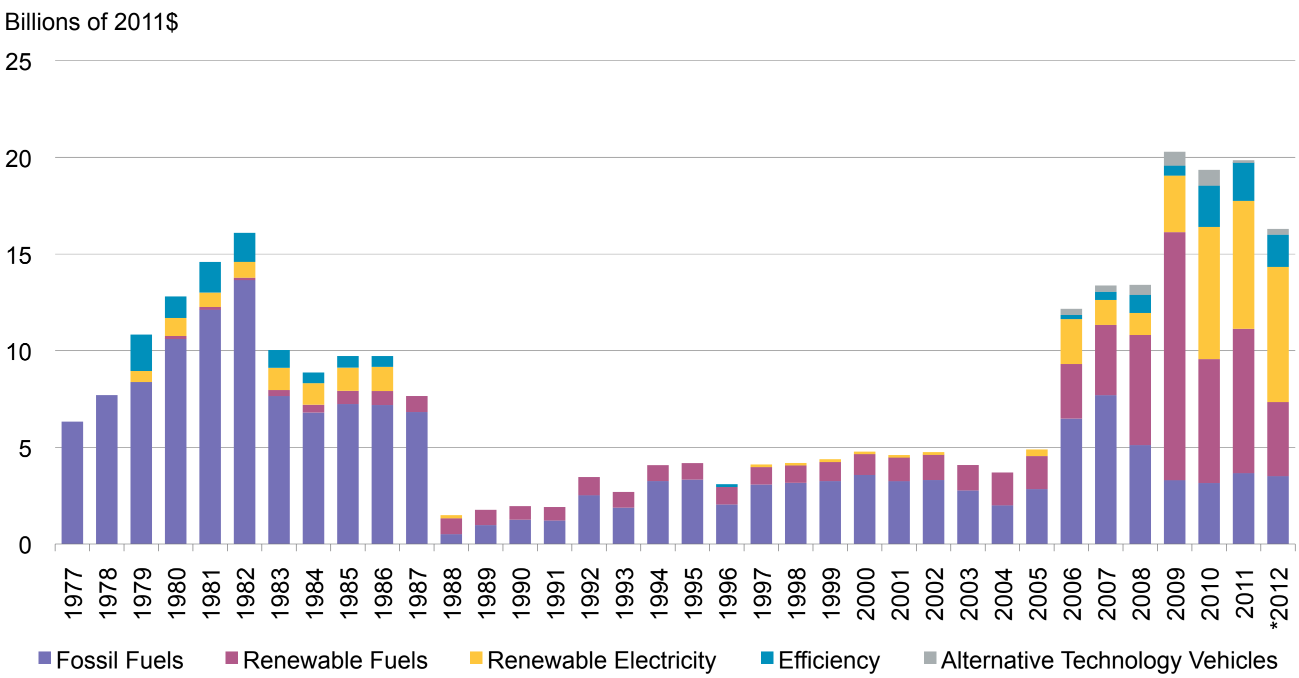
Source: U.S. Energy Information Administration, "Table ES1: Value of energy subsidies by major use, FY 2007 and FY 2010 (million 2010 dollars)," Direct Federal Financial Interventions and Subsidies in Energy in Fiscal Year 2010, http://www.eia.gov/analysis/requests/subsidy/pdf/subsidy.pdf.

through reduced taxes. While tax expenditures often take the form of discrete deductions or credits for specified activities, they can also refer to tax-advantaged alternative business structures, such as master limited partnerships (MLPs) and real estate investment trusts (REITs). MLPs are sometimes favored by energy companies for financing midstream and downstream oil and gas facilities. Though they make up only a small portion of the total financing in the energy industry, energy companies account for the bulk of MLPs—as of August 2012, 80 percent of MLPs were oil, gas, or coal companies, collectively accounting for 81 percent of total market capital in MLPs.[415] Although alternative business structures warrant further interest, a productive exploration is beyond the scope of this report. The remainder of this chapter focuses exclusively on discrete tax deductions and credits.

Energy Tax Expenditures

Though the composition of energy-related tax expenditures has shifted over the course of the past century, the overall magnitude of these expenditures has remained relatively stable as a percentage of total federal tax expenditures (hovering around 3 percent at the peak).[416] From 1916 through 1970, federal energy tax policy focused on supporting domestic oil and gas exploration and production. Changing political, economic, and international conditions in the 1970s led the government to support alternative fuels and energy efficiency, as well as unconventional oil and gas production. Evolving views on price controls and market interventions in the late 1970s and early 1980s, coupled with falling oil prices in the mid- and late 1980s and comprehensive tax reform efforts, prompted Congress to reduce the number and total cost of energy tax expenditures across fuels and technologies. During the 1990s—a period of relatively low energy prices—tax incentives focused on encouraging investment in alternative sources and reducing consumption. As prices rose in the 2000s, security of supply fears increased post-9/11 and concern over climate change grew, energy tax policy increasingly focused on renewable and alternative energy sources. A series of comprehensive energy bills— notably the Energy Policy Act of 2005, the Energy Independence and Security Act

Figure 5-1: Energy-Specific Tax Expenditures Fiscal Years 1977-2012



Note: Annual cost estimates are the sum of individual tax expenditure provisions and do not reflect possible additions or subtractions due to interactions between tax policies (e.g., tax deductions lowering the tax liability available for tax credits). The estimates also do not reflect the revenue that could be raised should specific provisions be eliminated. For all years, tax expenditure estimates are projections, not actual revenue losses. The figure does include outlays associated with excise tax credits for alcohol fuels (e.g., ethanol), other biofuels, and alternative fuels, and outlays for grants paid out under the Section 1603 program. The figure does not include energy-related tax expenditure provisions that cannot be attributed to a specific fuel or technology, such as Section 199 domestic manufacturing deductions.

Source: Molly Sherlock, U.S. Congressional Research Service, *Energy Tax Incentives: Measuring Value Across Different Types of Energy Resources*, September 18, 2012, R41953, http://www.fas.org/sgp/crs/misc/R41953.pdf.

of 2007, and the American Recovery and Reinvestment Act of 2009 (ARRA)—significantly expanded the use of tax expenditures.

For 2010 through 2012, the Congressional Research Service estimated the total value of energy-specific tax expenditures, including Section 1603 grants and excise tax credits for alternative fuels,[417] at approximately $55.5 billion, or an average of $18.5 billion per year—equivalent to about 0.8 percent of government revenues and 1.5 percent of the annual deficit each year.[418] Many of these tax expenditures were created or expanded for a defined short period of time as part of the ARRA. Of these expenditures, approximately 37 percent was directed to renewable energy sources, 32 percent was directed to alternative fuels, 19 percent was directed to fossil fuels, and 11 percent was directed to energy conservation.[419]

Because several energy tax provisions, including a number of tax expenditures introduced under the ARRA, expired in 2011 and 2012, overall energy tax expenditures are on track to decline in the next few years. For example, the grain ethanol blender's tax credit, which at $6.5 billion was the largest single energy subsidy in FY2011, expired at the end of 2011.[420] At the same time, current law predictions are of limited value since renewal of tax expenditure provisions is common; for example, the American Taxpayer Relief Act (H.R. 8) of 2013 not only extended a variety of renewable energy and other tax credits, but also allowed retroactive application of most of those credits to 2012.

The Case for Reforming Energy Tax Expenditures

Despite the popularity of tax expenditures as a vehicle for supporting favored energy technologies, they are widely regarded as an imprudent tool for implementing policy. First, tax expenditures can mask the costs of federal policy. Because they work by reducing revenues to the government rather than by increasing appropriations and outlays, they are not considered in the course of conventional appropriations processes, which have traditionally provided oversight to federal energy market interventions. The volume of tax expenditures can also vary tremendously depending on factors outside of congressional control; as a result, policy makers often cannot accurately forecast the actual costs of these measures. Tax expenditures often start as a temporary form of support and later become actually or effectively permanent. Though they are often introduced with a one-to-ten-year expiration date, experience shows that some tax expenditures have been made permanent and many are routinely renewed or extended, often temporarily and sometimes retroactively. This effectively turns temporary provisions into semi-permanent ones and makes the costs of such provisions difficult to forecast. The tax code includes many tax expenditures for mature technologies, with these provisions having persisted for decades.

Tax expenditures can also be inefficient compared with other policies. By relying on adjustments to taxable income or tax liabilities, they narrow the eligible population of beneficiaries to only those individuals or companies with significant tax exposure. Particularly for firms in emerging industries often without significant tax liabilities, tax expenditures need to be monetized by third parties; such tax equity financing raises transaction costs and lowers the amount of the incentive used for the intended purpose. As a result, tax expenditures that seek to incentivize private investment often do so at greater cost to taxpayers than equivalent direct expenditures.[421] Also, tax expenditures often require policy makers to specify particular technologies eligible for support. This increases the risk that companies will make suboptimal investment decisions insulated from market forces. Finally, the cycles of expiration and renewal that typically apply to tax expenditures can substantially exacerbate investment uncertainty for affected industries, creating boom-bust cycles and potentially undermining long-term progress toward the underlying policy goal.

Moreover, as with any incentive, tax incentives for specific energy resources and technologies encourage the greater overall use of energy. These efforts are inconsistent with goals of increasing the energy productivity of the U.S. economy.

Recommendations for Energy Tax Expenditures

We support phasing out most energy-specific tax expenditures and emphasizing other policy tools for two reasons. First, the nation's current fiscal situation demands that policy makers make decisions needed to restore long-term financial sustainability and bolster economic growth. Second, in line with BPC's debt-reduction plan proposed by former Senator Pete Domenici and Dr. Alice Rivlin in 2010,[422] all tax expenditures should be phased out in favor of lower across-the-board tax rates that will spur growth. The federal tax code can be effective, but it is at best an imprudent and inefficient instrument for achieving national energy policy goals, for reasons outlined in the previous section.

While historically energy markets have been structured and highly influenced by a long history of government intervention, in principle the government should intervene in energy markets only when markets alone are unable to provide solutions to particular challenges. Where intervention is warranted on the basis of a bona fide market failure, the tax code should be used only when more effective policies are not available to address the specific market failure in question. Where tax expenditures or similar mechanisms are the best or only available option, they should be enacted for only so long as necessary to meet their intended goals. (In other words, they should have a clear and predictable sunset date or trigger that fulfills a market's need for certainty.) Finally, once enacted, these policies should be reviewed periodically and ended if not effective. Because the current system of federal supports for different energy technologies is imbalanced with both permanent policies and repeatedly renewed temporary policies, it warrants a comprehensive overhaul.

RECOMMENDATION: As part of broad, comprehensive tax reform, Congress should review the full range of energy tax expenditures and develop a reasonable phase-out plan, such as 4 years, for those tax expenditures that constitute subsidies for mature fuels and technologies.

Given the accretion of many long-standing energy-related tax expenditures, the substantial increases in energy-related tax expenditures over the past several years, and the drawbacks in using the tax code as an energy policy mechanism, we recommend phasing out tax expenditures that subsidize mature fuels and technologies. For newer expenditures, these changes should be made gradually because a sudden end to current policies could be needlessly disruptive and potentially harmful to industries, companies and their employees, and investors who have made plans and investments on the basis of current policy. We caution that not all energy-specific tax expenditures should be construed as subsidies. For example, we do not consider the exclusion from taxable income of disability payments from the Black Lung Trust Fund to former coalminers to be an energy-specific tax expenditure, and we do not recommend phasing out this provision. Although we recognize that there are numerous debates regarding whether specific tax expenditures constitute a subsidy to a particular industry, these debates are generally beyond the scope of this report.[423] Nevertheless, Congress should review the full range of energy tax expenditures with the goal of ensuring that mature fuels and technologies compete with one another on a level playing field, and implement, if warranted, policy tools other than tax expenditures to ensure that end.

Furthermore, too much of the discussion surrounding energy policy has focused on unproductive debates about which fuels and technologies are more deserving of federal support compared with others. Instead, major changes to current support mechanisms for energy are best addressed through broad-based, comprehensive tax reform and/

or energy subsidy reform, rather than through piecemeal efforts to target a particular industry or technology. In sum, the same principles and criteria for federal support should apply to all energy technologies and sources. And by the same token, all energy sources and technologies should have an opportunity to compete equally on their merits for public support.

RECOMMENDATION: Congress should extend the renewable energy production tax credit, initially at its current level and develop a specific decline path to achieve a complete phase-out by the end of 2016.

Congress extended the production tax credit on January 1, 2013, as part of the American Taxpayer Relief Act (H.R. 8). In addition to extending the credit to expire on January 1, 2014, the legislation expanded credit eligibility to projects with qualified starts of construction prior to that date, rather than only projects completed by that date—effectively extending the credit to projects that will begin generating electricity in 2014 and possibly 2015.

Nearly all renewable energy production tax credits go to support wind energy. The levelized cost of wind energy is declining steadily, thanks in part to increasing efficiencies from innovation and steady deployment. The National Renewable Energy Laboratory reports that the levelized cost of energy from wind power can be expected to decrease on average between 1 percent and 6 percent per year until 2020.[424] At the same time, the revenues that wind power projects can anticipate is rising as wholesale electricity prices across the United States gradually increase over time.[425] The result is that the gap between new wind power costs and market electricity prices is narrowing.

Phasing out the production tax credit for renewable energy by the end of 2016 would align the incentive program with actual and expected reductions in wind project costs and increases in energy revenues.[426] In order to increase exposure to market forces at a pace that permits industry adaptation, the value of the credit should decline over time on a pre-determined schedule or other basis informed by relevant market conditions. As mentioned in the previous recommendation, phase out of the renewable production tax credit should accompany a phase out of all energy-specific tax expenditures to mature fuels and technologies to ensure a more competitive and level playing field.

Phasing out the production tax credit will also limit anomalous energy market operations. Currently, the production tax credit allows greater opportunity for electricity generators to profitably bid negative prices for their energy, since the amount of the credit can make such generation profitable. The increasing incidence of negative wholesale prices resulting from these renewable energy bids has the potential to adversely affect cost recovery for less-flexible baseload generation. While a phase out will remedy anomalous market operations over time, the Federal Energy Regulatory Commission (FERC) should direct organizations that oversee electricity markets, such as regional transmission organizations (RTO) and independent system operators (ISOs), to mitigate potentially disruptive bidding behavior when production tax credits create perverse incentives in the markets.

Other Policy Mechanisms to Achieve Strategic Energy Goals

In the absence of comprehensive climate policy, Congress needs to consider other policy mechanisms—in particular policies designed to unleash private sector investment—to increase the penetration of low and non-carbon energy and technologies that are not being supplied by the market. Although policies aimed at correcting the market failures listed at the beginning of this chapter can have the same negative characteristics as tax expenditures, they can also be designed to provide greater transparency about costs and effectiveness. A variety of policy mechanisms—many of which have been debated in previous Congresses and

Administrations—should be considered by policy makers to address energy diversity and environmental performance, and to create markets for innovative, clean technologies. Several alternatives are described below.[427]

Energy Standards

- Although several clean or renewable energy standard (CES or RES[428]) proposals have advanced part way through Congress in recent years, there is currently no national program in place. A CES or RES typically requires electricity distribution companies to generate or purchase a specified percentage of electricity that they sell from qualifying clean energy sources.
- As of January 2013, 29 states and the District of Columbia had enforceable renewable portfolio standards or other mandated renewable policies.[429] In addition, eight states have voluntary goals for renewable generation. These programs vary widely in terms of program structure, enforcement mechanisms, size, and application. Existing state RPSs have made progress toward developing diverse energy resources and reducing energy-related emissions, and we support state-level efforts along these lines.
- Though the concept of a CES or RES is simple, we have diverse views regarding the merits of a CES and agree there are numerous controversial details regarding program design that must be examined should Congress consider a national standard. These include:

– The definition and amount of "clean" power is contested; previous CES proposals have chosen alternately to exclude or minimize contributions from nuclear power, natural gas, energy efficiency resources, and coal with carbon capture and sequestration. Previous proposals have also differed in whether or not to credit existing generation or focus only on new generation.

– Penalties for noncompliance must be determined, effectively setting a ceiling price on clean energy.

– Any discussion of a federal standard should take regional approaches and regional variation into consideration (such as regulatory paradigm, generation mix, amount, and cost of qualifying clean energy resources, future energy needs, and cost impacts to customers). If pursued, a federal CES should be designed to accommodate regional differences in the availability of qualifying clean energy resources and should not preempt existing state RPS programs. To that end, any discussion of a federal standard should determine whether and to what extent to make credits for clean-generation tradable nationwide.

– A CES mandate could increase costs to consumers, often substantially on a dollar per unit of energy basis. Accordingly, it is important that any CES program proposal include a rigorous cost-benefit analysis that examines the full cost of deployment, including the need to address intermittency issues, additional transmission investments, and grid integration.

– A CES alters wholesale electricity prices on which long-term generation planning and procurement decisions are based. It is important that a CES mandate be designed to incent construction of baseload resources needed to ensure reliable electricity supply in the future.

Loan Guarantees

- The DOE loan guarantee program was established with bipartisan support as part of the Energy Policy Act of 2005 (Title XVII, Section 1703) with the intent of "accelerating commercial deployment of innovative and advanced clean energy technologies at a scale sufficient to contribute meaningfully to the achievement of our national clean energy objectives."[430] Under the program, DOE can issue loan guarantees to renewable, advanced nuclear, and energy efficiency projects with the requirement that the borrower pay the credit subsidy cost (CSC) or the estimated long-term liability to the government in issuing the loan guarantee. The 1703 program currently has $34 billion in loan authority and approximately $170 million in appropriated credit subsidy costs that have been carried over from previous fiscal years. President Obama did not request any new loan authority for the 1703 program for FY2013.[431]

- In 2009, Congress established an additional loan guarantee program (the 1705 program) as part of the ARRA, which offers loan guarantees to eligible renewable energy projects, power transmission systems, and certain biofuels projects that began construction by September 30, 2011. Eligible projects qualified for $2.5 billion in appropriated funding to cover the credit subsidy, which, in this case, was paid by DOE through appropriated funds. Overall, the 1705 program issued 28 loan guarantees worth $16.1 billion. Of the $2.5 billion in federal funding that was appropriated to cover credit subsidy costs under the 1705 program, $600 million remained unused when the program expired in September 2011.[432]
- While the DOE loan guarantee program has come under intense scrutiny as a result of the high-profile collapse of at least three companies that received section 1705 loan guarantees, the majority of loan guarantee recipients have not defaulted on their loans or cost the U.S. Treasury to date.
- The federal government should have the capacity to use certain financial instruments—including loan guarantees—to reduce barriers to private-sector investment in innovative large-scale energy technologies when that investment is likely to advance the state of the art; though specific reforms should be undertaken in several areas.[433] Our full recommendation, including the need for significant reform of the current program, is detailed in Chapter 4 of this report.

Direct Expenditures

- Direct expenditures are easier subjects of congressional oversight, as they must pass through the appropriations process. Direct expenditures are also more cost-effective than tax expenditures at promoting renewable energy generation because they obviate the need for more expensive tax equity financing and allow recipients to better attract less expensive debt financing. Moreover, direct expenditures enable recipients to take advantage of existing incentives in the tax code, such as accelerated depreciation.
- A taxable cash grant for renewable generation that delivers the same benefits as the current production tax credit would cost 20 to 40 percent less than the current production tax credit, as project developers could leverage less expensive debt financing rather than depend on more expensive tax equity financing.[434]
- An investment cash grant (such as the Section 1603 Treasury Program authorized under the 2009 ARRA) could also provide the same benefits as the production tax credit at 25 to 30 percent less cost, as project developers could leverage less expensive debt financing rather than depend on more expensive tax equity financing.[435] An investment-based grant incentivizes renewable energy production by reducing installation costs, rather than by increasing the value of generation. As such, the primary downside of an investment-based incentive is risk of subsidizing poorly performing projects.
- The federal government could conduct reverse auctions for such incentives to ensure promotion of only the lowest-cost renewable energy resources. In a reverse auction, the government effectively would solicit bids from project developers for a particular incentive rate, awarding those that come in at the lowest level. Such reverse auctions are already being used for purchase power agreements in California.

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Appendix A: Notable Recent Lease Sales on Federal Lands

2008 Utah Lease Sale[436]

In December 2008, the BLM's Utah State Office auctioned 116 parcels. The sale was controversial because some of the parcels were very close (3 miles) to Arches National Park, and several environmental groups filed a challenge arguing the plans failed to consider a variety of environmental impacts including air quality, off-highway vehicle use, wilderness values, and climate change.
In January 2009, the Federal District Court entered a temporary injunction against the sale of 77 parcels from the auction and sent the leases back to Interior for review. Secretary Salazar subsequently concluded that the issues raised by the court merit a special review, noting questions about the degree of coordination between BLM and the National Park Service and about the adequacy of the environmental review and underlying Resource Management Plan in this case. Following a further interdisciplinary review of the 77 parcels in question, 17 of the parcels were recommended for leasing; 52 parcels were deferred pending corrections to leasing documents and additional reviews; and eight parcels were withdrawn from leasing. BLM is currently being sued by the Utah Attorney General over these actions; the case is pending.

West Tavaputs Plateau Project[437]

On February 1, 2008, the BLM began accepting public comments on the Draft EIS for the West Tavaputs Plateau Natural Gas Full Field Development Plan, situated in Utah. Ultimately, BLM received more than 58,000 comments on the operator's, Bill Barrett Corporation, proposed plan to drill 807 wells from 538 pads. Bill Barrett Corporation and the Southern Utah Wilderness Alliance successfully negotiated a new development plan that reduced the initial proposal by 181 wells and 418 pads and lowered the number of impacted acres from 3,656 to 1,603. The Record of Decision encapsulating the comprise that was struck was signed by the Utah State BLM Director on July 2, 2010. Both the developer, stakeholder representatives, and BLM officials have heralded the project as "historic in many ways. It clearly provides for the orderly and balanced development of our nation's energy supply while, at the same time, serving as an outstanding example of the fresh look of how we can better manage our energy resources. It improves protections for air, land, water, and cultural resources, while reducing potential conflicts that can lead to costly and time-consuming litigation."

Colorado Oil Shale Leases[438]

The Energy Policy Act of 2005 directed Interior to amend its existing land use plans and carry out the required environmental reviews in order to develop a commercial leasing program for oil shale and tar sands.[439] In September 2008, BLM issued a Programmatic Environmental Impact Statement (PEIS) that proposed to make 2,017,714 acres of land available for commercial oil shale leasing, including 30,720 acres for shale RD&D. The proposal was adopted shortly thereafter, in November 2008. In January 2009, a coalition of environmental organizations filed a lawsuit challenging BLM's land allocation decisions; legal challenges were also mounted on the basis of water use issues related to shale oil development. Under the resulting settlement agreement, BLM reconsidered its plans and issued six RD&D leases (five in Colorado; one in Utah). In February 2012, BLM issued a new PEIS that covers a smaller area (460,000 acres) and reduces the federal acreage available for commercial oil shale development by roughly 75 percent. This area will be available for RD&D leases; meanwhile, development can go forward on the existing six RD&D leases as these are recognized as pre-existing rights.[440] Development is also possible on private holdings, with approximately 21 percent of the Piceance Basin held by oil shale developers.[441] In November 2012, BLM issued the final PEIS and issued two RD&D leases, which went into effect on December 1, 2012.

Montana and North & South Dakota[442]

In Montana, 61 leases issued by BLM in 2008 were suspended by order of U.S. District Court in Missoula, Montana. In March 2010, BLM entered into a settlement agreement with plaintiffs to perform eight additional environmental assessments. In December 2010, suspensions were lifted on 45 of the leases; in two cases, the suspension was partially lifted; six of the leases remained suspended, and eight leases had reached the end of their term. Meanwhile, plans to auction leases on approximately 148,000 acres in Montana, North Dakota, and South Dakota were postponed in August 2010 on grounds that BLM's environmental review of the affected parcels had not adequately analyzed how oil and gas activities contribute to climate change. BLM subsequently completed a Supplemental Information Report and the lease sale (involving approximately 80,000 acres) took place in December 2010.

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Appendix B: Recommendations to Address Environmental Issues for Shale Oil & Gas Development

Table B-1: Recommendations to Address Environmental Issues for Shale Oil & Gas Development

	SEAB	NPC	Current Status
Sharing Best Practices	• The subcommittee recommends that an organization "dedicated to continuous improvement of best practices" be created. • The subcommittee envisions that the "industry organization would be governed by a board of directors composed of member companies, on a rotating basis, along with external members, for example from non-governmental organizations and academic institutions, as determined by the board."[443] • The subcommittee noted that "industry intends to establish 'centers of excellence' regionally, that involve public interest groups, state and local regulatory and local colleges and universities."[444]	• The NPC recommends the establishment of industry-led "regionally focused council(s) of excellence in effective environmental, health, and safety practices." • "The governance structures, participation processes, and transparency should be designed to: promote engagement of industry and other interested parties; and enhance the credibility of a council's products and the likelihood they can be relied upon by regulators at the state and federal level."[445]	• Important efforts to develop best practices are underway, notably through the American Petroleum Institute's "Best Practices on Hydraulic Fracturing (HF)" series, the Marcellus Shale Coalition's development of "Recommended Practices," and the Appalachian Shale Recommended Practices Group's "Recommended Standards and Practices."[446] • While commendable, the API, MSC, and ASRPG efforts do not satisfy the SEAB or NPC recommendation that the "board of directors" or "governance structures" include stakeholder participation from "non-governmental organizations and academic institutions" or "other interested parties." • The Environmental Defense Fund is seeking to line up state regulators and energy companies behind a model regulatory framework for shale gas and oil development that protects underground drinking water supplies and public health. States continue to strengthen their regulations with industry and public participation. EDF has been unable to obtain significant industry input for their initiative proposal.[447]

	SEAB	NPC	Current Status
Transparency and Disclosure	• The subcommittee recommends public disclosure of fracturing fluid composition, noting that while companies and regulators are moving in this direction with participation in the FracFocus database, progress needs to be accelerated. • The subcommittee welcomes the announcement of the Department of the Interior of its intent to require disclosure of fracturing fluid composition on federal lands. Similarly, the subcommittee welcomes the GWPC and IOGCC announcement that their members will require disclosure of all chemicals by operators utilizing the FracFocus registry.[448] • Funding should be provided for STRONGER and for the Ground Water Protection Council's project to extend and expand the *Risk Based Data Management System.*[449]	• "Natural gas and oil companies should engage affected communities to establish shared understandings of expectations and awareness of issues and facts." Such engagement must be transparent and science-based.[450] • All companies should participate in the FracFocus project in order to ensure industry transparency.[451] • The Department of the Interior should require every natural gas and oil company that uses hydraulic fracturing on federal lands to participate in FracFocus. • Industry should also participate in predevelopment planning in order to identify concerns and seek ways to mitigate them. • STRONGER should be bolstered and increase the scope of its activities. All states with natural gas and oil production should actively participate in STRONGER and use its recommendations to continuously improve regulation. It should be adequately funded, including from the federal government.	• The Ground Water Protection Council's FracFocus database has been widely heralded by industry and stakeholders alike for its success in providing public disclosure of fracturing fluids used in natural gas wells. As of January 24, 2013, 35,200 well sites had been registered with FracFocus.org.[452] • While universal disclosure is a stated goal for many companies participating in voluntary disclosure programs such as FracFocus, a recent Bloomberg analysis revealed that a number of companies have not disclosed chemicals in a significant number of fractured wells.[453] • In October 2012, the Board of STRONGER agreed to a number of recommendations put forward by its Air Discussion Workgroup—a multi-stakeholder group convened to evaluate potential involvement of STRONGER in air quality programs. The recommendations adopted by the Board include: conducting a survey of state air programs, developing guidelines for state air programs that apply to program development and implementation, conducting several reviews of state programs, evaluating the adequacy of the guidelines based on the results of the state reviews, and modifying the guidelines as necessary based on actual state reviews. The recommendations also encourage education, communication and outreach with agencies, industry and public interest groups regarding oil and gas air quality issues. • At this time we are not aware of any additional Federal or private funding for STRONGER or the GWPC's *Risk Based Data Management System.*

	SEAB	NPC	Current Status
Air Emissions	• SEAB recommends that federal agencies should work with industry to investigate the total amount of greenhouse gases emitted by shale gas drilling in order to resolve the conflicting studies on how natural gas compares to coal in terms of life cycle greenhouse gas emissions. • The subcommittee recommends "enlisting a subset of producers in different basins, on a voluntary basis, to immediately launch projects to design and rapidly implement measurement systems to collect comprehensive methane and other air emissions data."[454] • The subcommittee also recommends "industry and regulators immediately expand efforts to reduce air emissions using proven technologies and practices."[455] • The subcommittee also recognizes "the need for a thorough assessment of the greenhouse gas footprint for cradle-to-grave use of natural gas."[456] • The subcommittee is aware that "operating companies are considering projects to collect and disclose air emissions data from shale gas sites."[457] • The subcommittee commended EPA for proposing the New Source Performance Standards and National Emissions Standards for Hazardous Air Pollutants for the oil and gas sector. However, the subcommittee noted its disappointment that these rules do not directly control methane emissions, and that the NSPS rules do not cover existing shale gas sources except for fractured or re-fractured existing wells.[458]	• The NPC recommends taking action to measure and reduce methane emissions, as well as the establishment of industry-government partnerships to facilitate adoption of control technologies. • The council recommends making use of "industry-government partnerships to promote technologies, protocols, and practices to measure, estimate, report, and reduce emissions of methane in all cycles of production and delivery. Ensure greater adoption of these technologies and practices within all sectors of the natural gas industry, with a focus on significantly reducing methane emissions while maintaining high safety and reliability standards."[459] • The NPC recommends "the federal government should complete development of and adopt consistent methodologies for assessing full fuel cycle effects."[460]	• On April 18, 2012, the EPA finalized new source performance standards and national emissions standards for hazardous air pollutants released during oil and gas production. The EPA rule requires operators of new fractured and re-fractured natural gas wells to utilize equipment and practices that will limit emissions.[461] While the rule does not specifically target methane emissions, the required VOC and sulfur dioxide control technologies are expected to have a significant co-benefit of reducing methane, a greenhouse gas 20 times more potent than carbon dioxide. • The University of Texas at Austin, in partnership with the Environmental Defense Fund is conducting a major field study to measure the methane emissions from natural gas production.[462] Nine oil and gas producers, including Anadarko Petroleum Corporation, BG Group plc, Chevron, Encana Oil & Gas (USA) Inc., Pioneer Natural Resources Company, Shell, Southwestern Energy, Talisman Energy, USA, and XTO Energy, an ExxonMobil subsidiary are participating in the effort.[463] The study is expected to be completed in January, 2013.[464]

	SEAB	NPC	Current Status
Groundwater Protection	• The subcommittee recommends that shale gas companies and regulators "measure and publicly report the composition of water stocks and flow throughout the fracturing and clean-up process." • In addition, regulatory agencies should "adopt requirements for background water quality measurements (e.g., existing methane levels in nearby water wells prior to drilling for gas) and report in advance of shale gas production activity."[465] • The subcommittee noted, "EPA has a number of regulatory actions in process… [including] an announced schedule setting waste water discharge standards that will affect some shale gas production activities.[466]	• Although the NPC report does not address groundwater quality specifically, it does note that the recommended "councils of excellence" could "benefit from the substantive work of many existing industry and public-sector organizations" such as the Groundwater Protection Council.[467]	• According to EPA, rules on hydraulic fracturing waste water discharge will be proposed by 2014.[468] • Nine states have regulations that "require operators to test nearby water wells before drilling shale gas wells. Pre-drilling water well testing establishes the baseline water quality for an area prior to drilling activity."[469] • Twenty-two states have regulations that "do not mention baseline water well testing. Some states do require testing within a specific distance from the proposed gas well, given as a radius from the wellhead (the average radius is about ½ mile)."[470] • Both API and ASRPG recommend testing samples from any source of water located near the well (determined based on anticipated fracture length) before drilling or hydraulic fracturing.[471]

	SEAB	NPC	Current Status
Regulatory Resources	• Although it was "not within the scope of [its] 90-day report to make recommendations about the proper regulatory roles for state and federal governments," the subcommittee emphasizes "effective and capable regulation is essential to protect the public interest." • The subcommittee suggests "fees, royalty payments and severance taxes are appropriate sources of funds to finance these needed regulatory activities."[472]	• The NPC recognizes that regulators require adequate resources, and notes that "a fee-based funding mechanism is one approach that could provide these resources in states where there are neither the resources nor adequate industry contributions to support this function, provided that such fees support the institutional mission of efficient and effective regulation and are not used solely to increase taxes for general budgetary support."[473]	• Severance tax rates vary across states. The national average severance tax rate is 4.5 percent or about 11 cents per MCF.[474]

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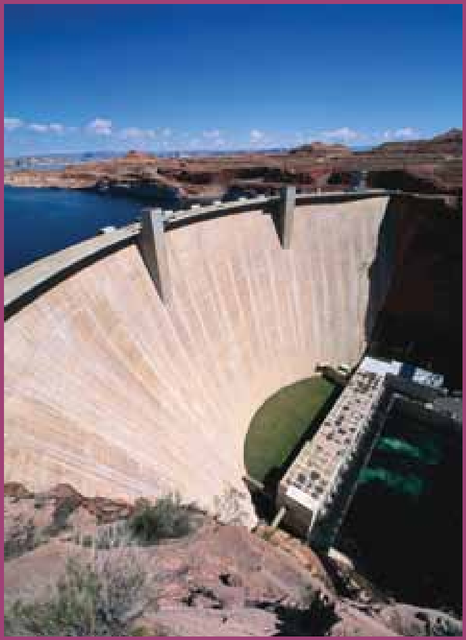


Appendix C: Comparing the Costs of Electricity Sources

Levelized Cost of Energy (LCOE) is the most widely used metric for comparing costs of electricity from diverse energy sources with significantly different characteristics. At heart, the metric is simple and intuitive: LCOE equals the total lifecycle cost of a project divided by the total lifecycle electricity production of the project. LCOE is thus expressed in dollars per unit of energy (usually megawatt-hours).

Despite its conceptual elegance, LCOE calculations have numerous non-trivial assumptions baked in. Several factors must be known or assumed, among them:

- project installation costs;
- lifetime of cost recovery;
- cost of capital/discount rate, including financing costs;
- capacity factor, i.e., project performance relative to nameplate capacity;
- future variable costs, including both fuel costs and O&M costs;
- state/federal tax incentives, including depreciation treatment; and
- project size, i.e., utility-scale versus distributed generation.

As a result, LCOE calculations are rarely comparable across studies, since different studies make different assumptions. Also, different studies break out technology groups differently; for example, many renewable sources are presented with subcategories (e.g., solar PV broken into thin film versus polycrystalline silicon). Moreover, LCOE values can be highly sensitive to even small changes in base assumptions, in particular the cost of capital/discount rate; several studies show their LCOE calculations under a range of rates for this reason.

Additionally, conventional LCOE calculations exclude numerous factors that affect resource valuation, such as:

- environmental externalities, such as greenhouse gas emissions, criteria pollutants, and thermal and chemical discharges in water;
- capacity value, i.e., whether or not a resource is dispatchable, as well as the extent to which output is variable and the extent to which such variability is predictable;
- portfolio value, i.e., the value of resource diversity as a method of economic risk management; and
- relative value of output, i.e., the extent to which the resource's output correlates with system-wide demand for electricity.

Finally, LCOEs are often presented at an aggregated level and should be interpreted as an average value of varying project sizes, resource qualities, and regional economic and regulatory conditions; as such, aggregate LCOE calculations can diverge substantially from many observed project LCOEs.

Although many LCOE studies exist, the EIA's Estimated Levelized Cost of New Generation Resources presents less controversial LCOE calculations than other studies.[475] It is fairly transparent, as it uses the EIA's Annual Energy Outlook 2012 Reference Case to predict costs for each technology in 2017. Estimates are for utility-scale technologies only and are calculated using 30-year cost recovery, a 6.8 percent cost of capital, and a 3 percent cost of capital adder for carbon-intensive sources (i.e., coal without CCS), which is roughly equivalent to a $15-per-ton levy on carbon. EIA estimates exclude targeted tax credits (i.e., PTC and ITC) but include current law with respect to tax depreciation and other non-source specific incentives. EIA warns that, because wind and solar are non-dispatchable, "their levelized costs are not directly comparable to those for other technologies."

Furthermore, EIA computes LCOE for projects in 2017, rather than currently existing projects. While this may be helpful in capturing the technology "learning curve" for each source, it does not provide an accurate representation of current energy costs.

Furthermore, EIA computes LCOE for projects in 2017, rather than currently existing projects. While this may be helpful in capturing the technology "learning curve" for each source, it does not provide an accurate representation of current energy costs.

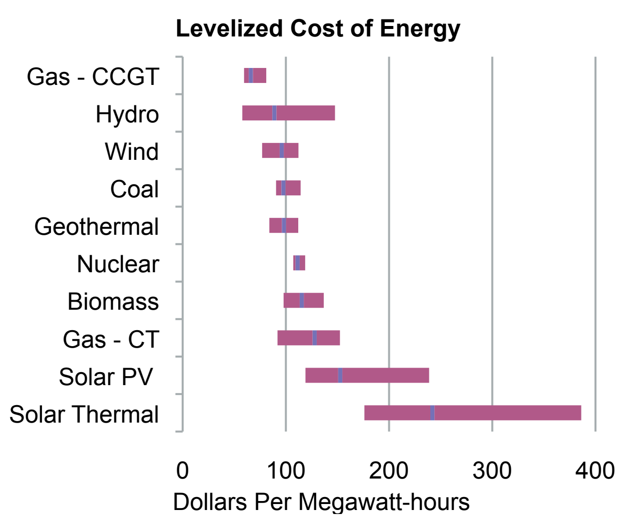
Bloomberg New Energy Finance's 4Q2012 LCOE calculations provide an alternative, as they estimate current LCOEs according to internal research.[476] However, BNEF's model lacks transparency, as many of its assumptions are unstated (presumably to protect internal research). Moreover, BNEF's numbers are a snapshot and do not indicate how LCOEs for various sources are expected to change over time.

Cost Changes Over Time

Besides the current cost of energy, we are interested in understanding what future energy sources are likely to cost. Experience curves—the reductions in project costs associated with a doubling of installed capacity—are a prevalent convention for forecasting cost declines in energy technologies. However, experience curves tend to be established on an equipment- or installed-cost basis,

Figure C-1: 2017 Levelized Costs of Energy, U.S. Energy Information Administration

Source	LCOE ($/MWh)		
	Low	Average	High
Gas - CCGT	$60	$66	$81
Hydro	$58	$89	$148
Wind	$77	$96	$112
Coal	$91	$98	$114
Geothermal	$84	$98	$112
Nuclear	$107	$111	$119
Biomass	$98	$115	$137
Gas - CT	$92	$128	$152
Solar PV	$119	$153	$239
Solar Thermal	$176	$242	$386



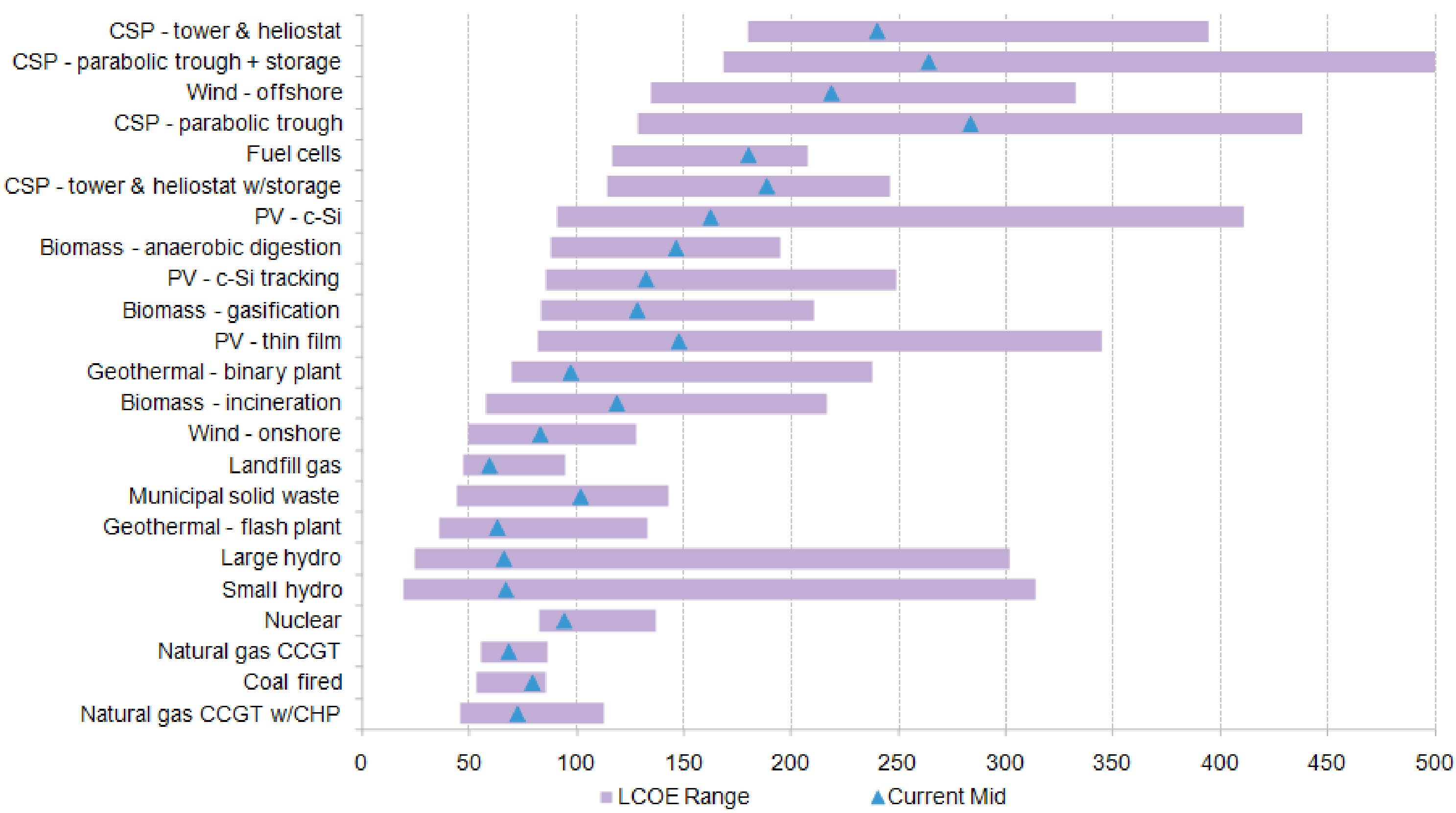
Source: U.S. Energy Information Administration, *Levelized Cost of New Generation Resources* in the *Annual Energy Outlook 2012*, July 20, 2012, http://www.eia.gov/forecasts/aeo/electricity_generation.cfm.

rather than an LCOE basis, and the two curves diverge. For example, BNEF estimates that LCOE for onshore wind has a 14 percent learning curve and a 7 percent learning curve for wind turbine prices, demonstrating that changes in equipment prices do not equal changes in LCOE.[477]

Various recent studies estimate learning curves of 15 – 24 percent for solar PV generation,[478] 10 percent for solar thermal,[479] and 7 – 9 percent for wind[480]—all on an equipment cost basis. Other studies indicate a 2 – 7 percent learning curve for particular efficiency technologies of natural gas combined cycle plants[481] and an 11 – 12 percent learning curve for environmental mitigation technologies of natural gas and coal plants.[482] All of these calculations are subject to some amount of discretion and uncertainty. Nonetheless, they illustrate that LCOEs are expected to change over time.

While it is possible to apply learning curves to existing LCOEs based on EIA's projected capacity additions, this level of analysis is beyond the scope of the report at hand.

Figure C-2: 4Q2012 Levelized Costs of Energy, Bloomberg New Energy Finance



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Department of Defense); adjacent BLM state and field offices, if lease nominations span or are close to administrative boundaries; National Landscape Conservation System managers; tribal governments; state and local agencies (e.g., fish and game, environmental quality, and historic preservation); local community stakeholders (e.g., managers of municipal watersheds and local parks). Specifically, BLM state and field offices will provide for public participation as part of the review of parcels identified for potential leasing through the NEPA compliance documentation process. Specifically, the reforms require that proposed oil and gas drilling activities be screened for "extraordinary circumstances" before applying the categorical exclusions established under the Energy Policy Act of 2005 for such activities. Categorical exclusions are categories of actions that are deemed to not have a significant effect on the quality of the human environment, and for which the BLM is generally not required to prepare extensive environmental reviews. A review for extraordinary circumstances has been required for all administratively-established categorical exclusions, and will now apply to the categorical exclusions for oil and gas drilling as well. See "Interior Finalizes Onshore Oil and Gas Leasing Reforms," U.S. Department of the Interior, Bureau of Land Management press release, May 5, 2010, http://www.blm.gov/wo/st/en/info/newsroom/2010/may/NR_05_17_2010.html, accessed January 23, 2013.

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408. The America COMPETES Act was signed into law in 2007, and authorized programs through FY2010. See America COMPETES Act, Pub. L. No. 110-69 (2007).

409. The 2010 act authorized approximately $45.6 billion in funding from FY2010-FY2013.

410. The President's FY2013 budget request included a 2.4% increase over FY2012 levels for DOE's Office of Science (16.8% less than the authorized level in America COMPETES 2010). Similarly, the President requests $350 million for ARPA-E, which is 12.2% less than the amount authorized in America COMPETES 2010.

411. Bipartisan Policy Center, *The Executive Branch and National Energy Policy: Time for Renewal,* November 2012, http://bipartisanpolicy.org/sites/default/files/BPC_Governance_Report_0.pdf.

412. DOE's SunShot Initiative is one relevant example. Launched in 2011, the SunShot Initiative comprises a number of projects aimed at reducing the costs of utility scale photovoltaic solar energy installations by 75 percent by the end of the decade (to $1 per watt). The effort represents a recent attempt to align offices and programs across the department, from basic science through applied and commercial programs, to achieve a clearly articulated goal. While it is too soon to determine the outcome of the program, we believe that this grand challenge approach to energy innovation is laudable and will increase the efficiency of DOE's activities moving forward.

413. Many of these recommendations draw on the Government Accountability Office and Independent Consultant review of the Loan Guarantee Program. U.S. Government Accountability Office, Report to Congressional Committees, *DOE Loan Guarantees: Further Actions Are Needed to Improve Tracking and Review of Applications,* March 2012, http://www.gao.gov/assets/590/589210.pdf and *Report of the Independent Consultant's Review with Respect to the Department of Energy Loan and Loan Guarantee Portfolio,* January 2012, http://www.whitehouse.gov/sites/default/files/docs/report_on_doe_loan_and_guarantee_portfolio.pdf, respectively.

414. Federal support for energy was unusually pronounced in FY2010, due to provisions in the 2009 American Recovery and Reinvestment Act. As detailed later in this chapter, many of those provisions have since expired or phased down.

415. National Association of Publicly Traded Partnerships, "Master Limited Partnerships 101" (presentation, August 2012) http://www.naptp.org/documentlinks/Investor_Relations/MLP_101.pdf.

416. Molly Sherlock, U.S. Congressional Research Service, *Energy Tax Policy: Historical Perspectives on and Current Status of Energy Tax Expenditures,* R41227, May 7, 2010 http://www.nationalaglawcenter.org/assets/crs/R41227.pdf.

417. Section 1603 Grants and excise tax credits for alternative fuels have previously been listed as outlays in the President's budget. Section 1603 Grants were a temporary outlay in lieu of a tax expenditure, and alternative fuel excise tax credits are technically tax expenditures; as a result, we include both here.

418. Tax expenditure totals come from Molly Sherlock, U.S. Congressional Research Service, *Energy Tax Incentives: Measuring Value Across Different Types of Energy Resources,* September 18, 2012, R41953, http://www.fas.org/sgp/crs/misc/R41953.pdf. Revenue and deficit totals come from Congressional Budget Office, *Monthly Budget Review,* October 2012, accessed Jan 24, 2013, http://www.cbo.gov/publication/43656; Congressional Budget Office, *Monthly Budget Review,* October 2011, accessed Jan 24, 2013, http://www.cbo.gov/publication/42532.

419. The figure represents a conservative estimate of total energy-specific support, since it excludes subsidies not specific to energy, such as accelerated depreciation, tax credits for taxes paid to foreign countries, and the Section 199 domestic manufacturing deduction. Estimates of the domestic manufacturing deduction for coal, oil, and gas sources alone are estimated at over $500 million in FY2013, and it is likely that a full inclusion of tax expenditures not specific to energy would significantly alter proportions. See Energy Information Administration, *Direct Federal Financial Interventions and Subsidies in Energy in Fiscal Year 2010,* http://www.eia.gov/analysis/requests/subsidy/pdf/subsidy.pdf.

420. Molly Sherlock, U.S. Congressional Research Service, *Energy Tax Incentives: Measuring Value Across Different Types of Energy Resources,* September 18, 2012, R41953, http://www.fas.org/sgp/crs/misc/R41953.pdf.

421. Bipartisan Policy Center, *Issue Brief: Reassessing Renewable Energy Subsidies,* March 25, 2011, http://bipartisanpolicy.org/sites/default/files/BPC_RE%20Issue%20Brief_3-22.pdf.

422. Bipartisan Policy Center, *Restoring America's Future: Reviving the Economy, Cutting Spending and Debt, and Creating a Simple, Pro-Growth Tax System,* November 2010,http://bipartisanpolicy.org/sites/default/files/BPC%20FINAL%20REPORT%20FOR%20PRINTER%2002%2028%2011.pdf.

423. In addition, tax deductions that provide for normal cost recovery and asset depreciation should not be considered subsidies, and should not phased out with other energy tax expenditures.

424. Eric Lantz, Ryan Wiser, and Maureen Hand, International Energy Agency, "The Past and Future Cost of Wind Energy," *IEA Wind Task 26,* May 2012, http://www.nrel.gov/docs/fy12osti/53510.pdf.

425. In Texas, the largest wind market, this levelized value of output is expected to rise by 4-5% per year; in California, the second largest wind market, it is expected to rise by 3-4% per year. See NYMEX Futures Data for ERCOT North Power and Henry Hub Gas as of 11/16/2012 for the first and California 2011 Market Price Referent Model. (http://www.cpuc.ca.gov/PUC/energy/Renewables/mpr) for the latter.

426. NREL reports that Class 2-3 wind power LCOEs have decreased 20% from 2002-03 to 2012-13. The Energy Policy Act of 2005 re-established the 2.2 cents per kilowatt-hour level, after which most new wind has been built. An equivalent LCOE reduction since 2005 would be approximately 12%. Eric Lantz, Ryan Wiser, and Maureen Hand, International Energy Agency, "The Past and Future Cost of Wind Energy," *IEA Wind Task 26,* May 2012,http://www.nrel.gov/docs/fy12osti/53510.pdf.

427. Other options include expanding the availability of advantageous business structures—master limited partnerships (MLPs) or real estate investment trusts (REITs)—to companies that develop renewable generation facilities. By limiting or eliminating corporate taxation, MLPs and REITs are to some extent another form of tax expenditure; however, such expenditures would be permanent and thus figured into economic forecasts that Congress uses for policy-making and oversight. We did not consider these in any detail given the recommendation to phase out all tax expenditures in the context of comprehensive tax reform.

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429. Database of State Incentives for Renewables & Efficiency, "Renewable Portfolio Standard Policies," Jan 2013, accessed Jan 24,2013, http://www.dsireusa.org/documents/summarymaps/RPS_map.pdf.

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