CHAPTER 6

THE ENERGY REVOLUTION: ECONOMIC BENEFITS AND THE FOUNDATION FOR A LOW-CARBON ENERGY FUTURE

Over the past ten years, the U.S. economy has undergone a revolution in the production and consumption of energy. Increasing production of oil, natural gas, and renewable energy has contributed broadly to employment and gross domestic product (GDP) growth during the recovery from the Great Recession. Energy efficiency has increased, with gasoline consumption falling 2 percent over the last decade despite a 17 percent increase in real GDP. Declining net oil imports have helped reduce the U.S. trade deficit and improve energy security. On balance, the energy revolution lays the foundation for U.S. leadership in global efforts to address climate change and paves the way toward a low-carbon energy future.

Recent changes in the energy sector, and their consequences for economic growth and combating climate change, have been remarkable. Breakthroughs in unconventional oil and natural gas extraction technology have reversed the decades-long decline in their production. Continued technological progress in wind, solar, and biofuels, as well as innovation and deployment policies at the local, State, and Federal levels, has caused an equally dramatic boom in the use of renewables. The composition of the Nation's energy sources has begun to shift: petroleum and coal are now being replaced by the growing use of natural gas and renewables, which are cleaner sources with lower, or even zero, carbon emissions. In 2014, renewable energy sources accounted for one-half of new installed capacity, and natural gas units comprised most of the remainder. These developments have contributed to a dramatic drop in the price of oil amidst geopolitical tension that might otherwise have caused oil prices to increase. Although oil prices will continue to fluctuate, the energy-sector developments will have a durable impact on our economy and our climate over the longer run regardless of future fluctuations in the price of oil.

To further build on this progress, foster continuing economic growth, and ensure that growth is sustainable for future generations, the President will continue his aggressive All-of-the-Above strategy for a cleaner energy future. The strategy has three elements, the first of which is to support economic growth and job creation. Expanded production of oil, natural gas, and renewables has raised employment in these industries during a period of labor market slack. Technological innovation and greater production help reduce energy prices, to the benefit of energy-consuming businesses and households. These developments have contributed broadly to employment and GDP growth, and will continue to do so.

The second element of the President's energy strategy is improving energy security. Lower net oil imports reduce the macroeconomic vulnerability of the United States to foreign oil supply disruptions. In today's domestic liquid fuels markets and globally integrated oil markets, a sudden international supply disruption means a sharp jump in prices. The combination of declining gasoline demand, increasing domestic crude oil production, and increasing use of biofuels, however, enhances the resilience of the U.S. economy to these oil price shocks. Although international oil supply shocks and oil price volatility will always present risks, reductions in net petroleum imports and the lower domestic oil consumption will reduce those risks. To further reduce net oil imports in the long run, the Administration has taken steps to curb petroleum demand by aggressively raising standards for vehicle fuel economy. Efforts are also being made to boost the use of biofuels, electric vehicles, natural gas, and other petroleum substitutes.

The third element of the All-of-the-Above Energy Strategy addresses the challenges of global climate change. The need to act now to stem climate change is clear; delaying would only lead to larger costs for future generations. Delaying action is costly because it means less incentive for research and development of effective carbon-reducing technologies, while at the same time encouraging investments in older and carbon-intensive technologies. After having delayed, making up for lost time requires more stringent and costly policies in the future. In practice, delay also may render unrealistic the climate targets that are within reach today. Delaying action imposes greater mitigation costs and economic damages than would have otherwise occurred. Higher temperatures, more acidic oceans, and increasingly severe storms, droughts, and wildfires could all result from avoidable higher greenhouse gas emissions.

The energy revolution lays the groundwork for reducing domestic greenhouse gas emissions. From 2005 through 2012, the United States cut its total carbon dioxide (CO_2) pollution by 12 percent, partly reflecting a domestic shift toward cleaner natural gas, increased use of renewables, and improved energy efficiency. Although the reductions in CO_2 emissions represent an historic shift from past trends, much more work remains.

The Climate Action Plan is the centerpiece of the President's efforts to confront climate change. With this plan, the President has put in motion steps that will immediately and substantially reduce greenhouse gas emissions. These steps include direct regulation of emissions, such as the Clean Power Plan, which will further the shift toward cleaner sources of electricity and complement carbon regulations already in place for other sectors, such as fuel economy and greenhouse gas standards for light, medium, and heavy-duty vehicles.

The President's Climate Action steps also include a strategy to reduce methane emissions (a potent greenhouse gas). Through a recent announcement, the Administration identified opportunities to further reduce methane emissions from the oil and gas sector; this topic is also a focus of the Quadrennial Energy Review. Additionally, the Administration supports research, development, and commercialization of technologies that help to bring down the costs of renewables; for example, through solar programs such as the U.S. Department of Energy's SunShot initiative, which seeks to make solar energy cost-competitive with other forms of electricity by 2020. These efforts support continuing U.S. leadership in global efforts to address climate change, as evidenced by the November 2014 joint announcement of climate targets with China.

This chapter discusses the three elements of the All-of-the-Above Energy Strategy, and takes stock of both the progress that has been made to date and the work that remains to be done to transition to a low-carbon energy system. The third element, laying the foundation for a clean energy future, dovetails with the President's Climate Action Plan, which is the focus of the final section in this chapter. The chapter builds on two previous Council of Economic Advisers (CEA) reports: The All-of-the-Above Energy Strategy as a Path to Sustainable Economic Growth (CEA 2014a), and The Cost of Delaying Action to Stem Climate Change (CEA 2014b).

The Energy Revolution: Historical Perspective and Economic Benefits

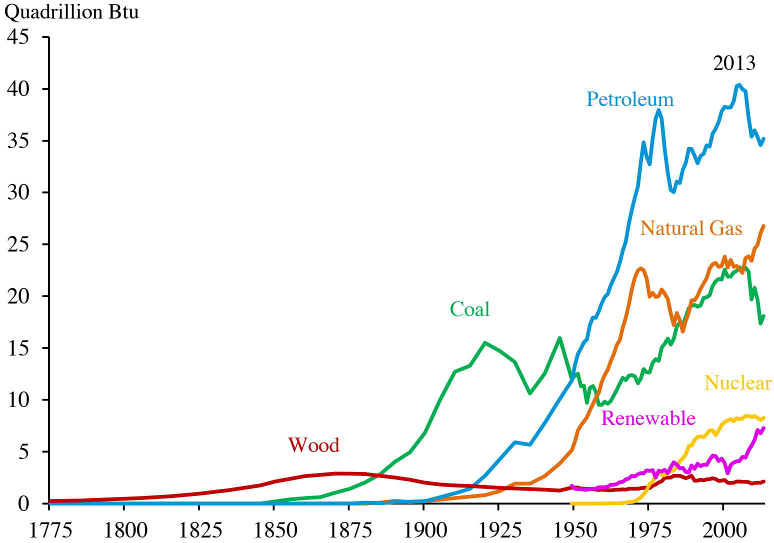
The Energy Revolution in Historical Perspective

Over the past two centuries, the amount of energy consumed in the United States has increased dramatically and our energy sources have become more convenient. As Figure 6-1 shows, wood was the main U.S. energy source through the middle of the 19th century. The use of coal rose sharply through the early 20th century, plateaued, and then increased in the 1970s for the generation of electricity. For most of the 20th century, petroleum consumption grew sharply, dropping off temporarily after the oil crises of the 1970s but then resuming its growth, albeit at a slower pace than previously. Natural gas consumption spread during the second half of the 20th century, with greater use of this fuel in homes and industry and to meet peak electricity demand. During the last quarter of the 20th century, nuclear electricity generation burgeoned to the point that it now supplies 19 percent of electricity, and wood—the original biofuel—saw a small regional resurgence (primarily for home heating) because of the increases in home heating oil prices in the 1970s. Meanwhile, production of renewables—which includes biomass and biofuels, hydroelectric, wind, solar, and geothermal energy—has approached nuclear energy production levels.

Energy consumption trends have already shifted dramatically in the 21st century (Figure 6-1b): coal consumption dropped by 21 percent between its 2005 peak and 2013; and total petroleum consumption declined by 13 percent between its 2005 peak and 2013. Natural gas consumption has risen sharply, with much of this increase displacing coal for electricity generation. In addition, total energy obtained from renewables rose 77 percent between 2005 and 2013.

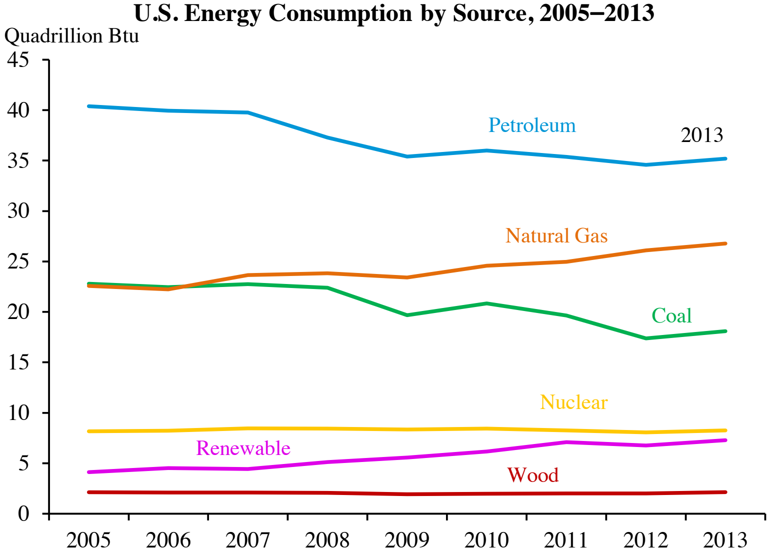
The decline in petroleum consumption, starting in 2006, was unexpected. In the case of energy, industry-standard benchmark projections are produced annually by the Energy Information Administration (EIA) in its Annual Energy Outlook. Revisions to those projections include the effects of unforeseen developments in the energy sector. Figure 6-2a shows U.S. petroleum consumption since 1950 and projected consumption from the 2006, 2010, and 2014 editions of the Annual Energy Outlook. Only nine years ago, EIA projected an increase in petroleum consumption during the subsequent 25 years. But events dramatically affected subsequent projections: by 2010, EIA had reduced both the level and rate of growth of its projection; its 2014 outlook now projects petroleum consumption to decline through 2030 after a slight increase over the next five years. The reversal in projected petroleum consumption is led by the reversal in actual and projected gasoline consumption (Figure 6-2b): the 2014 EIA projection of consumption in 2030 is 44 percent below the projection made in 2006. Actual gasoline consumption declined between 2006 and 2010 mainly due to the recession and rising fuel prices, but much of the revision to the 2030 levels reflects the largely unexpected fuel economy improvements stemming from the Energy Independence and Security Act of 2007 and the Administration's subsequent

Figure 6-1a
U.S. Energy Consumption by Source, 1775–2013



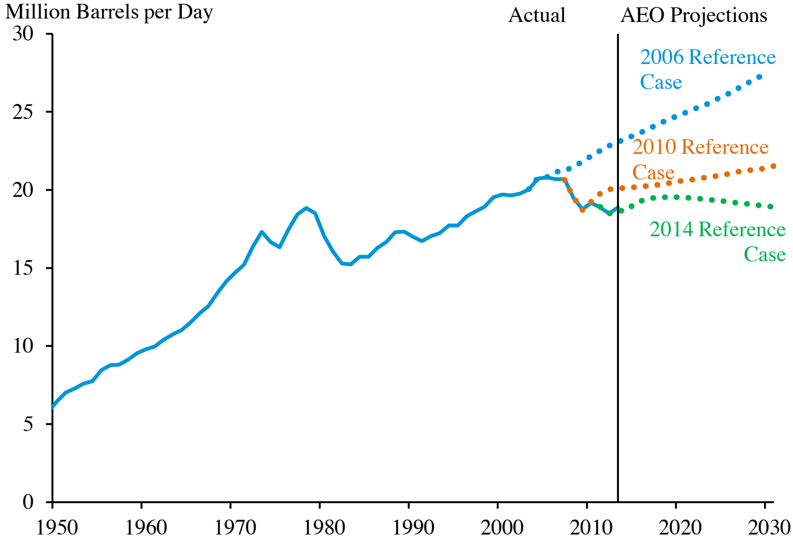
Source: Energy Information Administration, Energy Perspectives (1949-2011) and Monthly Energy Review (Dec 2014).

Figure 6-1b
U.S. Energy Consumption by Source, 2005–2013



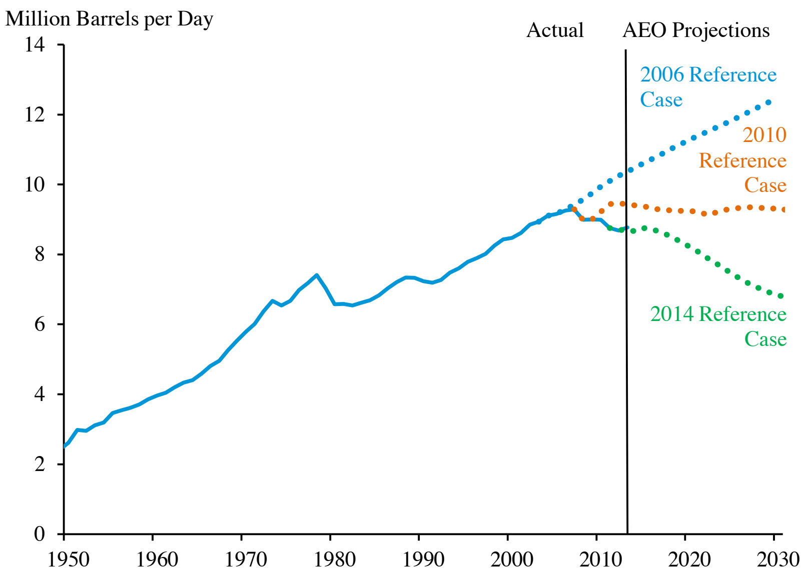
Source: Energy Information Administration, Monthly Energy Review (Dec 2014).

Figure 6-2a
U.S.Petroleum Consumption, 1950–2030



Source: Energy Information Administration, Annual Energy Outlook (AEO) 2006, 2010 and 2014.

Figure 6-2b
U.S. Consumption of Motor Gasoline, 1950–2030

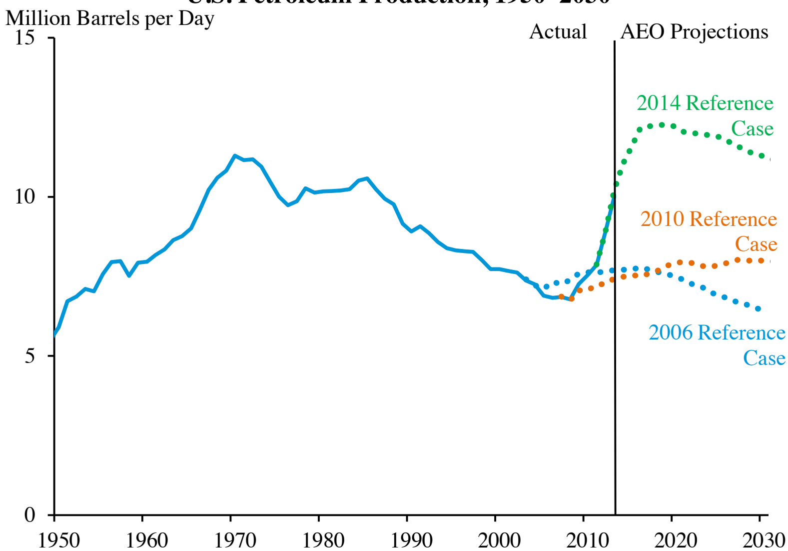


Source: Energy Information Administration, Annual Energy Outlook (AEO) 2006, 2010 and 2014.

tightening of those standards. The 2014 projections further reflect the 2012 light-duty vehicle fuel economy and greenhouse gas emissions rate standards, which apply to model years 2017 through 2025. The Administration's fuel economy and greenhouse gas standards for medium and heavy-duty trucks also contribute to the reduction in projected petroleum consumption between the 2010 and 2014 Outlooks.

The recent increase in U.S. petroleum production was equally unforeseen. As Figure 6-3 shows, domestic petroleum production peaked in 1970 at 11 million barrels per day (bpd). Production plateaued through the mid-1980s and then declined steadily through the late 2000s as producers depleted conventional domestic deposits. Since then, however, entrepreneurs adapted horizontal drilling and hydraulic fracturing technology that had previously been more widely used for natural gas. The newer technology enables the extraction of oil from within rocky formations once considered uneconomic, like the Eagle Ford in Texas, and development of new regions such as the Bakken in North Dakota. This chapter uses the term "unconventional oil" to describe oil produced from shale and other relatively impermeable formations, and produced using new drilling methods. These unforeseen technological developments are recent: most of the revision to EIA's earlier projections has occurred since 2010, and now EIA projects

Figure 6-3
U.S. Petroleum Production, 1950–2030



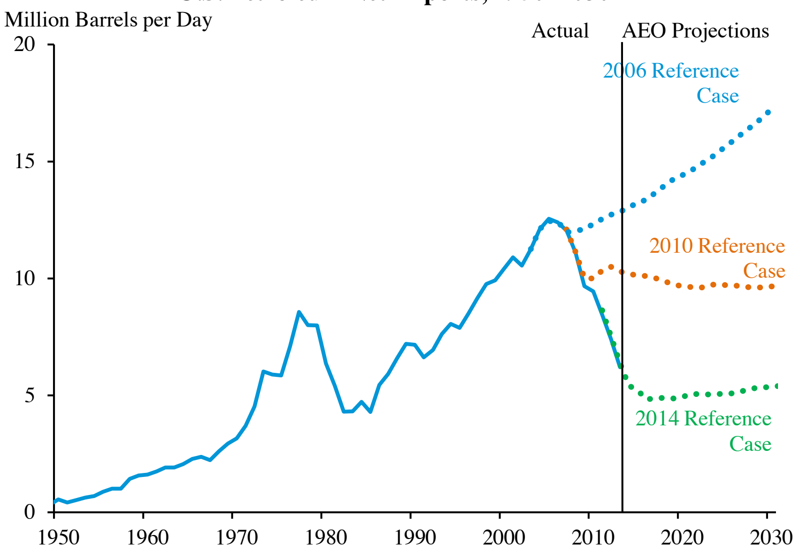
Source: Energy Information Administration, Annual Energy Outlook (AEO) 2006, 2010, and 2014.

production to surpass its earlier 1970 peak this year. The EIA Reference case, which includes the baseline assumptions, projects production to decline slowly after 2019. But because extraction technology is still advancing, there is considerable uncertainty about the United States' economically recoverable resource potential.

The decline in demand for petroleum and increase in production have triggered a sharp turnaround in net petroleum imports (Figure 6-4). U.S. net petroleum imports fell from a peak of 12 million bpd in 2005 to 6 million bpd in 2013, representing a decrease of 6 million bpd compared to EIA's 2006 projection of 2013 imports. Comparing actual 2013 imports and the 2006 projection of 2013 imports, roughly 4 million bpd, or 65 percent, of the reduction stem from the fall in consumption; and 2 million bpd, or 35 percent, are due to the unforeseen increase in production.

The Administration has supported oil production on Federal and Indian lands. In fiscal year 2013, onshore oil production on Federal and Indian lands increased 58 percent compared with 2008. In 2014, the U.S. Interior Department held 25 onshore lease sales, generating about $200 million in revenue for States, Tribes, and the American taxpayer. The Administration has also promoted the environmentally responsible development of offshore resources through the Interior Department's Five-Year Outer Continental Shelf Oil and Gas Leasing Program. In early 2015 the

Figure 6-4
U.S. Petroleum Net Imports, 1950–2030



Source: Energy Information Administration, Annual Energy Outlook (AEO) 2006, 2010, and 2014.

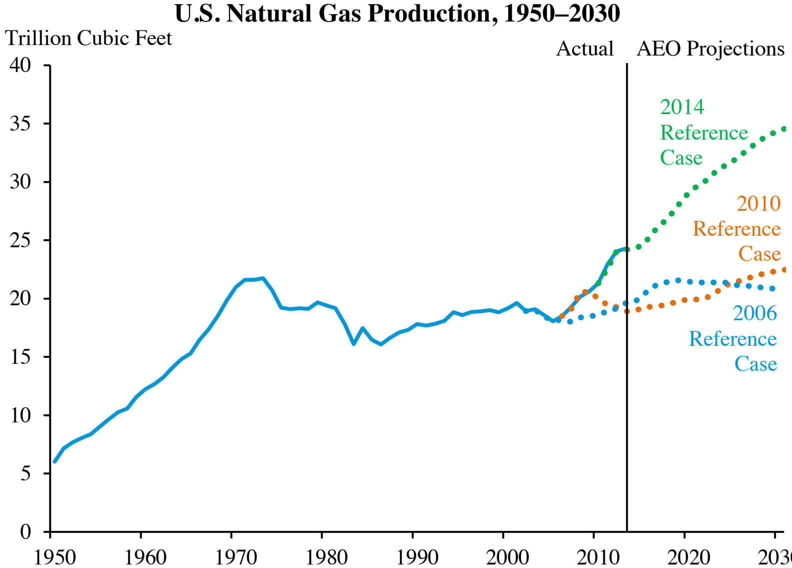
Interior Department announced a Draft Proposed Program for 2017 to 2022 that includes potential lease sales in the Gulf of Mexico, off the Alaska coast, and in the Atlantic. Following the Deepwater Horizon incident in 2010, the Interior Department has implemented new safety standards for new wells. In 2014, the Interior Department issued 68 new deep water well permits.

The rise in unconventional natural gas production preceded the rise in unconventional oil production (unconventional gas is defined similarly to unconventional oil, as gas produced from impermeable formations using new drilling methods). Figure 6-5, which presents domestic natural gas production and historical EIA projections, shows that the EIA's 2014 projections indicate an upswing in natural gas production through 2030. Already, well over one-half of natural gas production is from unconventional formations (tight gas and shale gas), a fraction that is projected to increase as the conventional resource base becomes less productive and competitive. The resulting benefits of these innovations to natural gas producers and consumers are discussed in a subsequent subsection.

Domestic use of renewable energy sources has also increased substantially since 2000. Figure 6-6 shows that the use of liquid biofuels—primarily ethanol from corn and biodiesel from various sources including waste oil and soy oil—grew sharply in the mid-2000s. Several factors contributed to this growth, including the Renewable Fuel Standard, which mandates

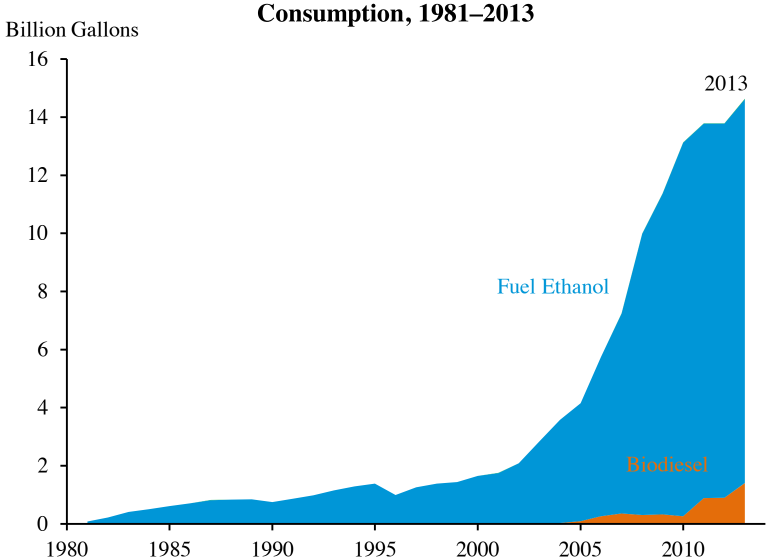
Figure 6-5

U.S. Natural Gas Production, 1950–2030



Source: Energy Information Administration, Annual Energy Outlook (AEO) 2006, 2010, and 2014.

Figure 6-6
U.S. Fuel Ethanol and Biodiesel Consumption, 1981–2013



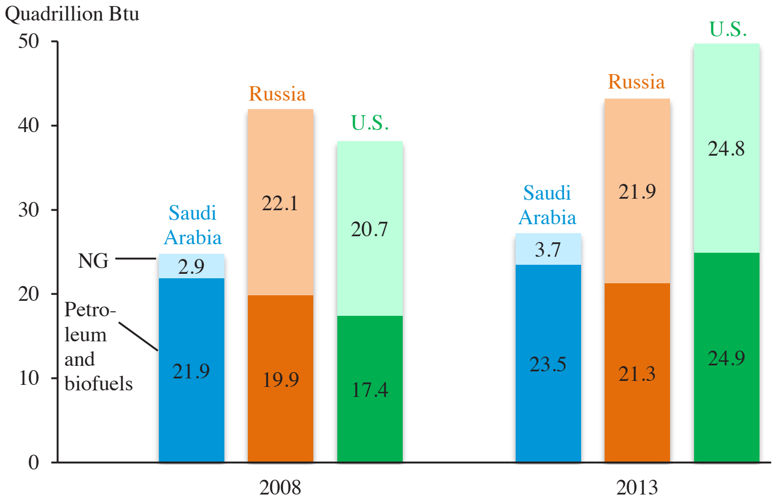
Source: Energy Information Administration, Monthly Energy Review (Dec 2014).

ethanol volumes under the 2005 Energy Policy Act and was modified by the 2007 Energy Independence and Security Act. The combined effect of increased production of natural gas, oil, and liquid biofuels has positioned the United States as the leading petroleum, natural gas, and biofuels producer in the world (Figure 6-7).

The U.S. energy revolution also encompasses a dramatic rise in the use of renewables for electricity generation. At the end of 2013, wind generation capacity totaled 61 gigawatts, which was more than double its 2008 level.[1] Wind generator construction has occurred throughout the Midwest, Southwest, West Coast, and New England (Figure 6-8) and a record 13 gigawatts of new wind power capacity was installed in 2012 alone, roughly double the amount of newly installed capacity in 2011. This new wind capacity represented the largest share of addition by a single fuel source to total U.S. electric generation capacity in 2012. As a result, wind-powered electricity generation nearly tripled from a monthly rate of 17 thousand gigawatt hours at the beginning of 2009 to 50 thousand gigawatt hours at the beginning of 2014 (Figure 6-9). Similarly, solar-powered electricity generation nearly quadrupled from a monthly rate of just above two thousand gigawatt hours to more than eight thousand gigawatt hours over the same period.

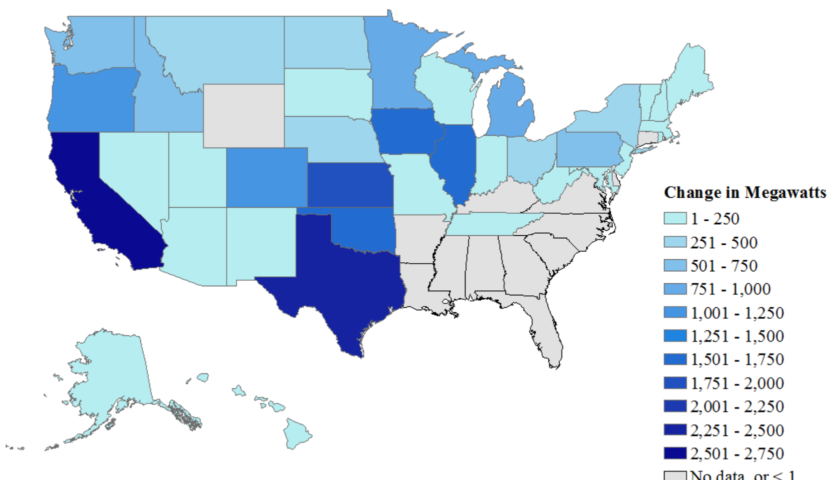
[1] One gigawatt is equal to 1 billion watts, and is a common unit of generation capacity; the entire U.S. power system contains roughly 1,100 gigawatts of installed capacity.

Figure 6-7
Petroleum, Biofuels, and Natural Gas Production, 2008–2013



Note: Petroleum production includes crude oil, natural gas liquids, condensates, refinery processing gains and other liquids including biofuels.
Source: Energy Information Administration, International Energy Statistics.

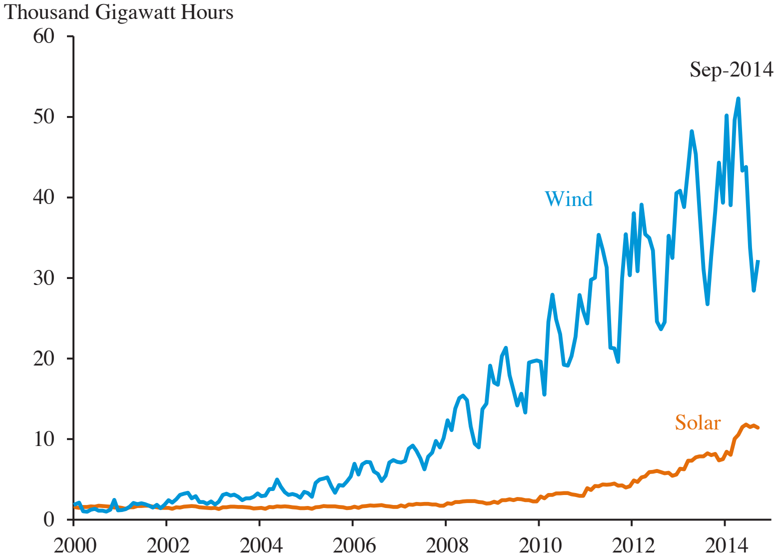
Figure 6-8
Change in Wind Power Generation Capacity, 2010–2013



Source: Department of Energy, National Renewable Energy Laboratory.

Figure 6-9

Total Monthly Wind and Solar Energy Production, 2000–2014



Source: Energy Information Administration, Monthly Energy Review (Dec 2014).

In 2013, wind accounted for 66 percent of non-hydro renewable electricity generation, biomass for 24 percent, solar for 4 percent, and geothermal for 6 percent; between 2009 and 2013, wind and solar had the fastest growth rates among non-hydro renewables.

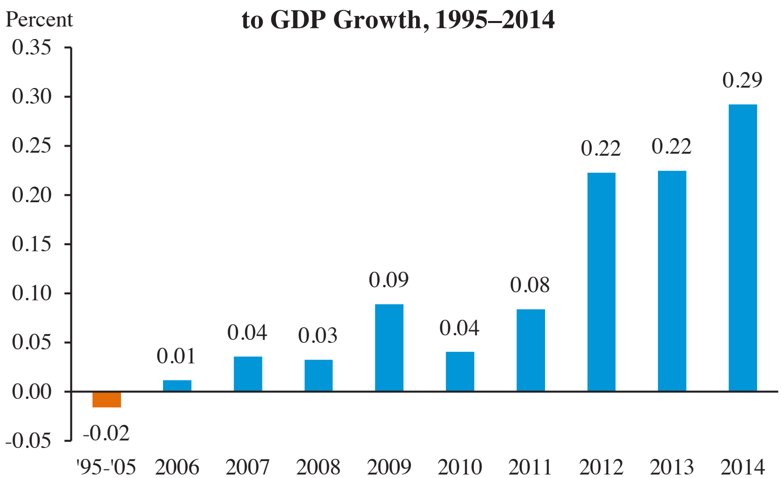
The American Recovery and Reinvestment Act of 2009 played a significant role in the rising use of renewables for electricity generation. Since the early 1990s, the Federal Government has helped spur most wind and solar investments by offering tax credits. Investors in wind projects that began construction before the end of 2013 received a tax credit of $23 for each megawatt-hour of electricity generation; solar projects are currently eligible for a tax credit of 30 percent of the up-front investment cost. The Recovery Act provided eligible wind, solar, and other low-carbon projects the option of a grant from the U.S. Treasury equal to 30 percent of the project's cost, rather than a tax credit. Since 2009, the program has provided almost $22 billion in grants for 22 gigawatts of wind capacity and 5 gigawatts of solar capacity. The President's approach to business tax reform includes proposals to make permanent and more effective tax incentives for renewable energy (see further discussion in Chapter 5).

GDP, Jobs, and the Trade Deficit

The U.S. energy revolution has contributed to economic growth, both in terms of net economic output as measured by GDP and overall employment. It has also contributed to a declining trade deficit as the Nation has recovered from the Great Recession. CEA estimates that the oil and natural gas sectors alone contributed more than 0.2 percentage point to real GDP growth between 2012 and 2014, in contrast to a slight negative contribution on average from 1995 to 2005 (Figure 6-10). The contribution between 2012 and 2014, which does not count all economic spillovers, added substantially to the 2.4 percent average annualized rate of U.S. economic growth over these three years.

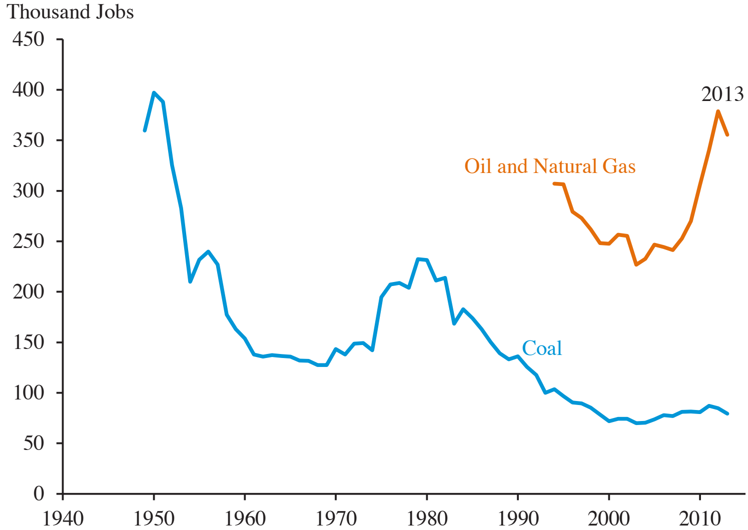
Growth in oil and gas production has directly and indirectly created jobs over the past several years. As Figure 6-11 shows, total employment in the oil and natural gas industries, which includes extraction and support activities, increased by 133,000 jobs between 2010 and 2013, and continued to grow through 2014 (not shown); coal employment has also edged up only slightly over this period. Much oil and gas job growth has been concentrated in a handful of states like Texas, Pennsylvania, and North Dakota that are at the forefront of developing new energy resources (Cruz, Smith and Stanley 2014). The oil and gas employment increase in Figure 6-11 understates the

Figure 6-10
Contributions of Oil and Natural Gas Production to GDP Growth, 1995–2014



Note: CEA calculations use physical quantity data for oil and natural gas production and implicitly include contributions from the sectors that service and sell equipment to the oil and gas drilling industry. 2014 contribution is estimated based on partial data for the year as a whole.
Source: Energy Information Administration, Spot Prices for Crude Oil and Petroleum Products and Short-Term Energy Outlook (Jan 2015); CEA calculations.

Figure 6-11
Coal, Oil and Natural Gas Employment, 1949–2013



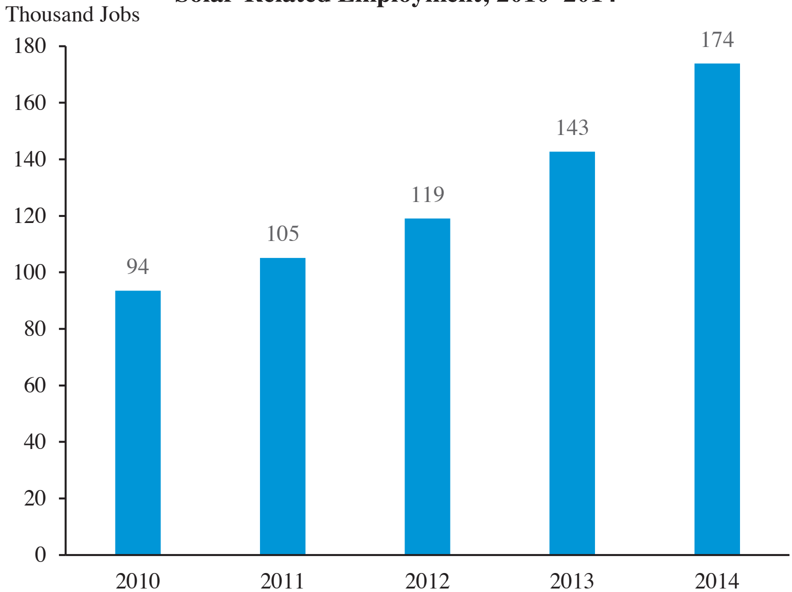
Note: Both series include extraction/mining as well as support activities for the industry.
Source: Bureau of Labor Statistics, Current Employment Statistics and National Industry Specific Occupational Employment and Wage Estimates.

full short-run effect of oil and gas development on U.S. employment for two reasons. First, jobs have also been created in companies that provide goods and services to the oil and gas industries, including manufacturing, transportation, and leisure and hospitality. Second, workers in all of these industries create additional jobs when they spend their incomes, as do State and local governments that spend additional tax revenue. As a result, new oil and gas regions have seen employment growth in schools, retail, health care, and other sectors. Because of labor market slack reflected in elevated unemployment rates during the recovery, the number of additional jobs created by spending tax revenue and income could be quite large—perhaps equal to one-half the increase in the oil and gas industries, or about 65,000 additional jobs in 2013 compared to 2010 (CEA 2014c).[2]

Expansion of renewable energy capacity has similarly contributed to economic growth. Employment in the renewable sector spans several categories in Federal data collection systems, which complicates direct estimation of job growth and output in the sector. However, trade association data suggest that, in addition to rapid expansion in wind and solar electricity generation, there has also been a sharp rise in employment. As Figure 6-12 shows, from 2010 to 2014, employment in the solar energy industry grew by more than 85 percent. Moreover, employment in the solar industry is

[2] CEA (2014c) provides estimates of the fiscal multiplier for the Recovery Act.

Figure 6-12
Solar-Related Employment, 2010–2014



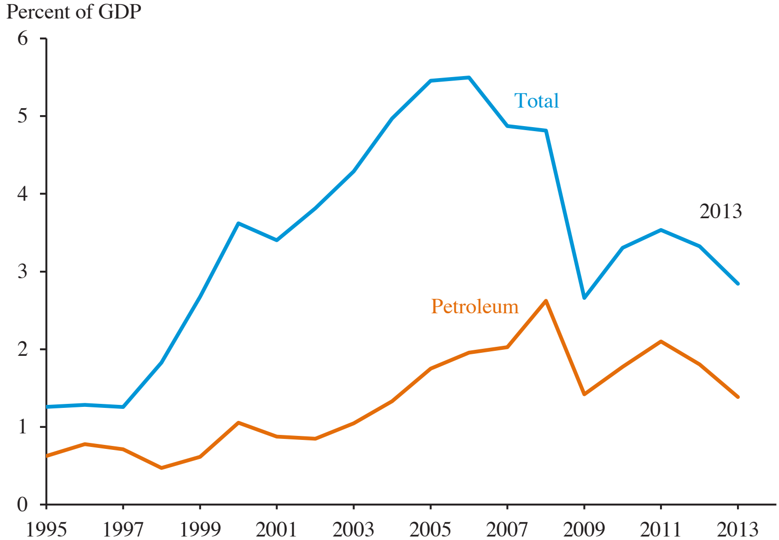
Source: The Solar Foundation, National Solar Jobs Census 2014.

projected to increase by another 21 percent in 2015.[3] Wind industry employment totaled roughly 50,000 workers in 2013.[4] The solar and wind employment levels are not directly comparable to the oil, gas, and coal employment levels shown in Figure 6-11; the solar and wind employment figures include a broader range of related activities.

The increase in domestic oil production, combined with reduced demand for oil, has also led to a sharp drop in net petroleum imports and, as a result, a decline in the Nation's trade deficit. In 2006, the total trade deficit was 5.4 percent of GDP, the highest ever recorded for the United States. By the end of 2013, the trade deficit had fallen to 2.8 percent of GDP, which, excluding the crisis-affected year of 2009, was the lowest since 1999 (Figure 6-13). While the U.S. trade balance is subject to a number of influences and depends in large part on domestic and global macroeconomic conditions, the rise in domestic energy production has been a substantial factor in the recent improvement. Of the 2.7 percentage-point decline in the trade deficit

[3] Estimates of employment related to the solar energy industry are from the Solar Foundation's 2014 National Solar Jobs Census. The National Solar Jobs Census uses a statistical survey methodology broadly comparable to the Bureau of Labor Statistics' Quarterly Census of Employment and Wages and Current Employment Statistics surveys.
[4] Estimates of national employment related to the wind power sector come from the 2013 American Wind Energy Association's *U.S. Wind Industry Annual Market Report*.

Figure 6-13
Total and Petroleum Trade Deficits, 1995–2013



Source: Census Bureau, U.S. International Trade in Goods and Services; Bureau of Economic Analysis, National Income and Product Accounts.

since 2006, about 0.6 percentage point (or just over one-fifth) is accounted for by a shrinking trade deficit in petroleum products.

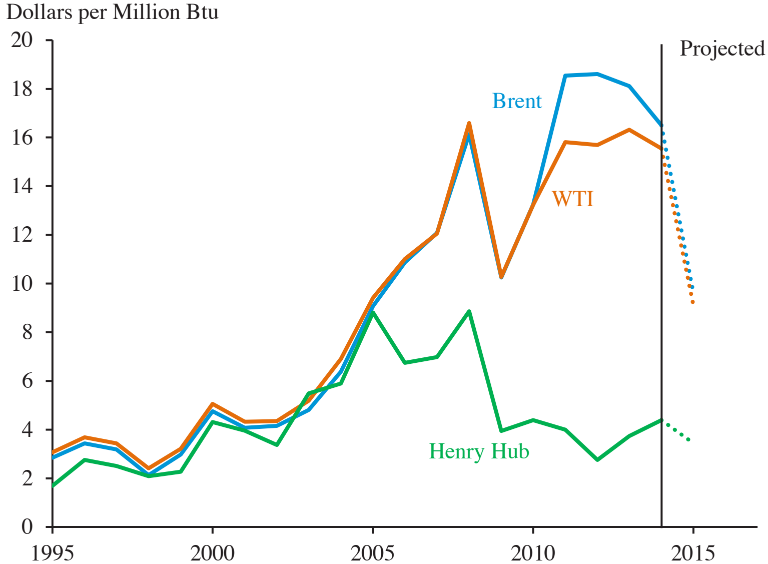
Energy Prices, Households, and Businesses

Since 2006, natural gas prices have fallen well below crude oil prices on an energy-equivalent basis, providing a cheaper source of energy to consumers and businesses in the United States (Figure 6-14). This price decrease has created widespread benefits and opportunities for the U.S. economy.

The decrease in U.S. natural gas prices has opened a gap between U.S. and international prices, presenting an export opportunity for domestic natural gas producers (see Box 6-1). The gap reflects the undeveloped nature of international gas markets combined with the expense of international trade. Liquefaction, transportation from the United States to Europe, and regasification have been estimated to add $6 to $9 per million British Thermal Unit (Btu), which would roughly double the price of U.S. gas entering the pipeline in Europe relative to the Henry Hub price.[5] Under the Natural Gas Act of 1938, as amended, the Department of Energy (DOE) must authorize any natural gas exports. As of November 2014, the DOE has conditionally approved approximately 12 billion cubic feet per day of liquefied natural gas

[5] The Henry Hub price is a benchmark price for natural gas, and it measures the price at a pipeline distribution point in Louisiana.

Figure 6-14
Annual Crude Oil and Natural Gas Spot Prices, 1995–2015



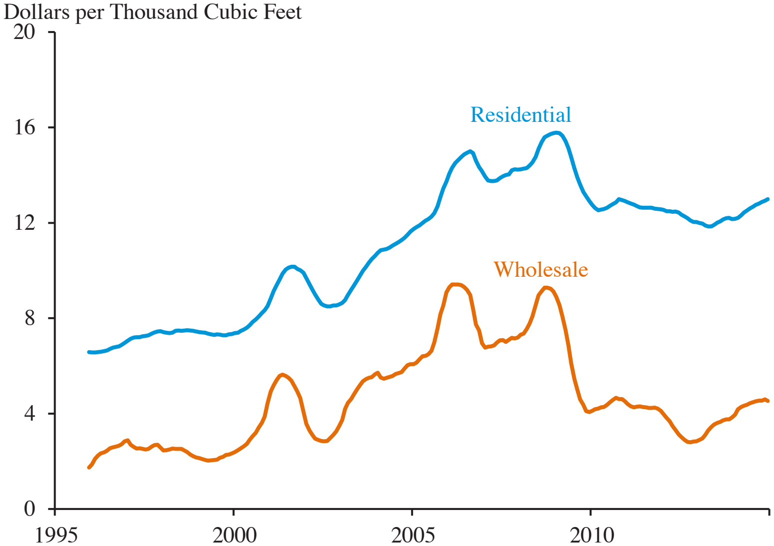
Source: Energy Information Administration, Short-Term Energy Outlook (Jan 2015).

(LNG) export capacity, though the enormous capital expenditure required for LNG facilities raises the possibility that some of this capacity might not actually be built. Because of high transport costs, even if a global market for LNG were to develop, domestic natural gas prices are likely to remain well below prices in the rest of the world for an extended period of time.

Low wholesale natural gas prices broadly benefit the U.S. economy in several direct and indirect ways. Residential natural gas prices have followed the decline in wholesale natural gas prices, and the 12-month average price has declined by 18 percent from its 2009 high (Figure 6-15a). Households, which accounted for about one-fifth of U.S. natural gas consumption in 2014, pay lower gas bills and can either spend or save the difference. Commercial and industrial businesses, which accounted for about 40 percent of domestic consumption in 2014, also benefit from lower gas prices, which raise business profits. Lower gas prices benefit consumers indirectly to the extent that businesses pass on lower energy prices to consumers in the form of lower product prices. Finally, low wholesale natural gas prices have supported a switch in fuels in the electric power sector from coal to natural gas. With natural gas prices falling from 2007 to 2012, retail electricity prices have increased at a slower rate than they had during the previous 15 years (Figure 6-15b). In other words, electricity consumers—businesses and

Figure 6-15a

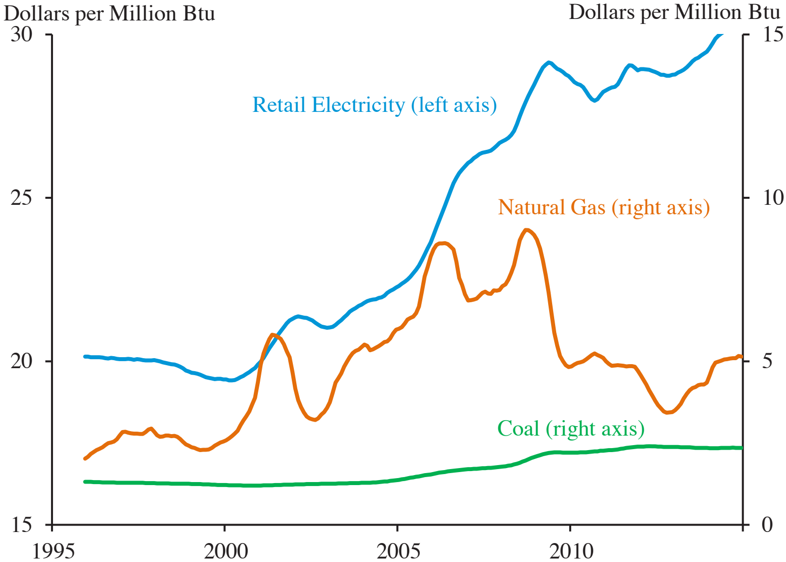
Wholesale and Residential Natural Gas Prices, 1995–2014



Note: Prices illustrated are twelve-month moving averages.
Source: Energy Information Administration, Short-Term Energy Outlook (Jan 2015).

Figure 6-15b

Retail Electricity Prices and Fuel Costs, 1995–2014

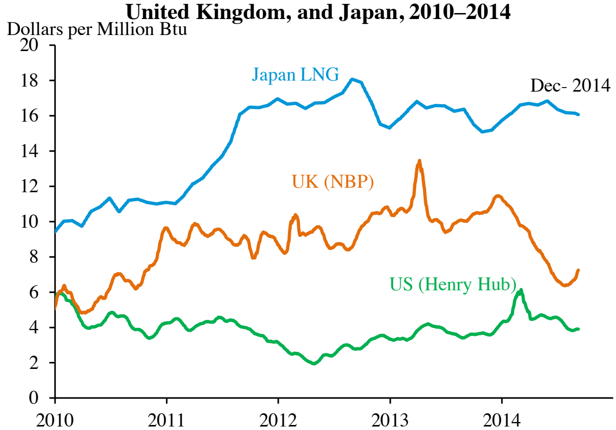


Note: Prices illustrated are twelve-month moving averages.
Source: Energy Information Administration, Short-Term Energy Outlook (Jan 2015).

Box 6-1: Natural Gas Exports

Over the last decade, U.S. natural gas production increased by roughly 40 percent. This sharp increase in domestic production has widened the gap between domestic natural gas prices and natural gas prices in other countries (Figure 6-i), creating potential profitable export opportunities for domestic natural gas producers. In 2014, the United States surpassed Qatar to become the world's largest exporter of Liquefied Petroleum Gas (LPG),[1] for which there is already export capacity in the Gulf region for 400 thousand barrels per day (bpd), with another 700 thousand bpd expected by 2016. The Energy Information Administration (EIA) projects that the United States will become a net exporter of liquefied natural gas (LNG) by 2016 (Figure 6-ii). However, expansion of U.S. natural gas exports requires both governmental action and the construction of additional exporting infrastructure.

Figure 6-i
Natural Gas Prices in the United States, United Kingdom, and Japan, 2010–2014



Note: UK's prices do not include natural gas imported from Russia which is predominately indexed to oil prices. Japanese prices are monthly averages. All series are represented as 30-day moving averages.
Source: Bloomberg.

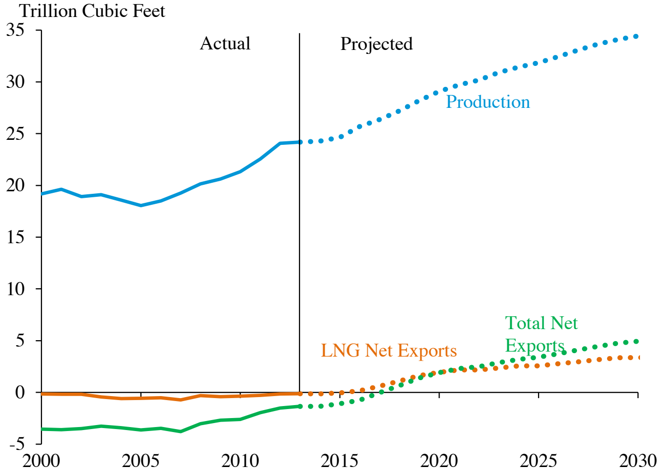
Both transportation costs and government-imposed barriers to trade have caused prices among countries to differ. The gap between U.S. natural gas prices and prices in other countries reflects two main trade impediments. First, transportation costs—liquefaction, transportation abroad, and regasification—roughly double the price of gas entering Europe relative to the price at its origin in the United States. Transport charges must cover substantial infrastructure investments and capital

[1] A group of hydrocarbon gases derived from crude oil refining or natural gas processing.

expenditure—for example, the cost of building a liquefaction terminal that can export up to 2.76 billion cubic feet (bcf) per day for 20 years can be around $12 billion.[2] The second impediment is the Natural Gas Act of 1938 (NGA) and subsequent amendments, which restrict natural gas exports. Under the NGA, natural gas exports require approval from the U.S. Department of Energy (DOE).[3] As of November 2014, DOE has approved applications for the export of about 12 bcf per day of LNG, although some of the approvals are contingent on approval by the Federal Energy Regulatory Commission. Because the recent technological developments have given the United States a natural comparative advantage in gas production over importing regions, both trade impediments – natural and government mandated – depress U.S. gas prices relative to those paid abroad.

What will happen as more export infrastructure comes on line and DOE approves higher volumes of gas exports? When barriers to trade are reduced between a low-cost country (the United States) and

Figure 6-ii
U.S. Natural Gas Production and Net Exports, 2000–2030



Source: Energy Information Administration, Annual Energy Outlook (2014).

[2] Over 15 bcf per day of export capacity is under construction or has been proposed, though cost considerations make it unlikely that all proposed projects will be completed. By comparison, the United States produces almost 70 bcf per day.

[3] Approval is even required for exports to countries with which the U.S. has a free trade agreement, though an amendment to the NGA in 1992 required that applications to authorize exports to free trade partners be granted without modification or delay. As a result, conclusion of the Trans-Pacific Partnership and the Transatlantic Trade and Investment Partnership would vastly increase the range of countries to which U.S. producers could export without administrative barriers (see Chapter 7).

high-cost countries (importers in the rest of the world), basic economic theory predicts a convergence of prices. As U.S. natural gas enters the global market, it will increase global supply and push global prices down. Meanwhile, domestic prices will rise as natural gas leaves the domestic market, reducing supply in the United States. A recent study by EIA estimates that an increase in exports of 12 bcf per day by 2020 would raise U.S. residential retail prices by 2 percent between 2015 and 2040, although the EIA considers such a large exports increase by 2020 to be almost impossible. An increase in U.S. exports of natural gas, and the resulting price changes, would have a number of mostly beneficial effects on natural gas producers, employment, U.S. geopolitical security, and the environment.

- **Higher prices for domestic producers increase domestic production**. Increased production, in turn, spurs investment, increasing U.S. GDP. EIA (2014) estimates that the increase in GDP could range from 0.05 percent to 0.17 percent in different export scenarios ranging from 12 to 20 bcf per year, phased in at different rates beginning in 2015.
- **An increase in exports can create jobs in the short run**. Estimates suggest that natural gas exports of six bcf per year could support as many as 65,000 jobs (Levi 2012). These jobs would arise both in gas production and along the supply chain (for example, in manufacturing machines and parts used as downstream inputs).
- **Lower natural gas prices around the world have a positive geopolitical impact for the United States.** Increased U.S. supply builds liquidity in the global natural gas market, and reduces European dependence on the current primary suppliers, Russia and Iran.
- **More U.S. exports could help promote the use of cleaner energy abroad, including in developing countries that now rely heavily on coal.** Lower foreign emissions would help to counteract global warming and therefore are a direct benefit for the United States. As natural gas becomes cheaper for the rest of the world, countries overseas will replace dirtier, coal-fired power with natural gas. Cheaper natural gas could also replace low-carbon sources and increase electricity consumption abroad; the net global impact is ambiguous. The effects of the natural gas price increase in the United States are also complex. Higher gas prices tend to curb overall emissions by reducing total energy consumption and inducing substitution toward renewable sources of power. However, higher prices might also cause some U.S. substitution toward coal, raising our emissions.
- **U.S. manufacturers would still have a competitive cost advantage in natural gas, albeit smaller than what they would otherwise have.** Because of transportation costs, in equilibrium, U.S. natural

gas prices would still be expected to be persistently lower than prices overseas. The cost advantage, however, would be smaller than it would otherwise be—but any potential impact on manufacturing is likely to be small because in 2010, on average, the cost of natural gas represented less than 2 percent of the value of manufacturing shipments. This suggests that a 2 percent increase in the price of natural gas would raise average production costs by only about 0.04 percent. For the most intensive users—such as producers of flat glass or nitrogen fertilizers—the increase in costs will be higher. But these gas-intensive industries represent only a small share of total manufacturing employment and output. In particular, the top 15 gas-intensive industries account for only 2 percent of total manufacturing employment and 3 percent of manufacturing value added. Businesses with very thin profit margins may also be adversely affected. In contrast, expanded natural gas exports will create new jobs in a range of sectors including natural gas extraction, infrastructure investment, and transportation.

households—have also benefited from the slower growth of electricity prices caused by lower wholesale natural gas prices.

Oil prices decreased dramatically in the second half of 2014. Box 6-2 shows the drop in crude prices, and notes the range of global factors behind the drop, including the boom in U.S. oil production. Retail gasoline prices are closely linked to global crude oil prices, so households now pay less for gasoline. Seasonally adjusted gasoline prices decreased by roughly $0.80 per gallon between June and December 2014. EIA estimates that lower gasoline prices in 2015, compared to 2014, will save the average household about $750. Oil-consuming businesses would also enjoy huge gains—in the tens of billions of dollars. In addition, the fact that lower oil prices are expected to boost the global economy will create additional spillovers for U.S. economic activity by creating higher demand for the products and services we export. On the other hand, these gains are partially offset by the fact that lower crude oil prices reduce the profits and investments of oil producers. On net, however, the recent oil price decrease benefits the U.S. economy (see Chapter 2 for further discussion of the macroeconomic effects of oil prices).

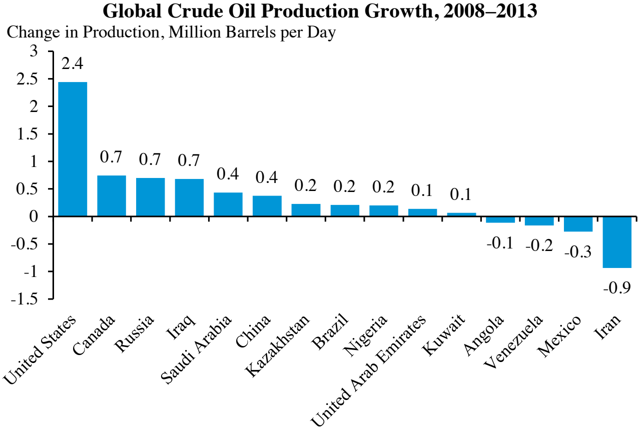
Infrastructure Implications of the Energy Revolution

Expanding domestic energy supply has challenged the U.S. energy infrastructure in different ways. Since some of the best wind and solar resources are located far from population and economic hubs, adding substantially more wind and central-station solar generation usually requires

Box 6-2: U.S. Oil Production in a Global Perspective, and Implications for U.S. GDP

U.S. crude oil production has expanded dramatically since 2008. Technological innovations in horizontal drilling, hydraulic fracturing, and seismic imaging have led to a surge in domestic production from an average of about 5 million barrels per day in 2008 to more than 7 million barrels per day in 2013. Figure 6-iii shows that this growth is largely a U.S. phenomenon. Excluding the United States, the top 15 oil-producing countries experienced an average increase of 0.2 million barrels per day between 2008 and 2013, compared to the 2.4 million barrel per day increase experienced in the United States.

Figure 6-iii
Global Crude Oil Production Growth, 2008–2013

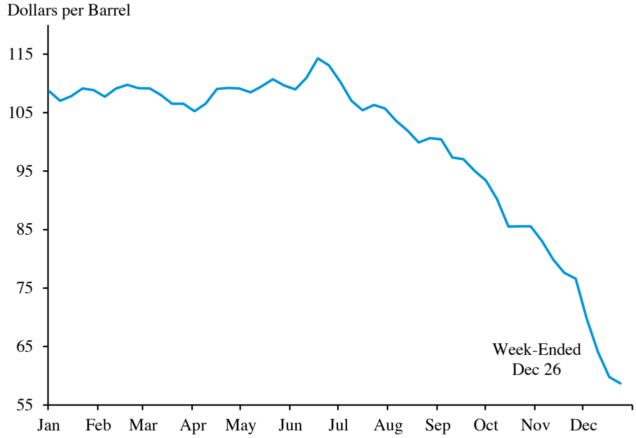


Note: Production includes crude oil and lease condensates.
Source: Energy Information Administration, International Energy Statistics.

Crude oil prices decreased dramatically in the second half of 2014. Between 2011 and the third quarter of 2014, prices were typically between $100 and $120 per barrel (see Figure 6-iv). Crude prices—as measured by the Brent price index, which is a standard global price index—dropped 40 percent between August and the end of December, to about $60 per barrel. Explanations for this price decline include: the major gains in U.S. oil production over the last several years; recent decreases in forecasted global oil demand; and sustained, high levels of production from the Organization of the Petroleum Exporting Countries (OPEC) that has, in fact, produced above its official target in each month from April to October and decided in November not to reduce this target.

Lower crude oil prices have translated into lower prices for petroleum products like gasoline, diesel, heating oil, propane, and jet fuel

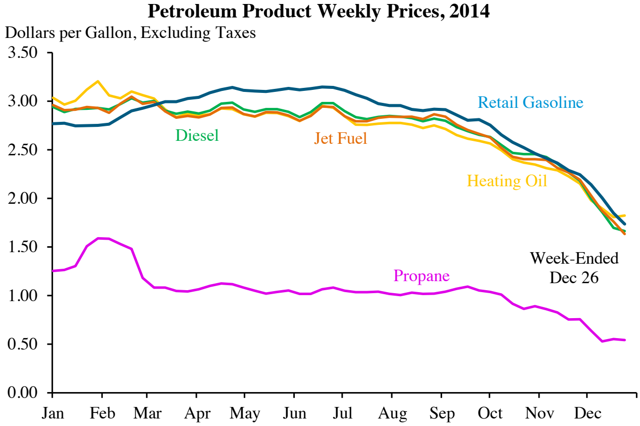
Figure 6-iv
Brent Crude Weekly Spot Prices, 2014



Source: Energy Information Administration, Spot Prices for Crude Oil and Petroleum Products.

(Figure 6-v). In the United States, gasoline accounts for about one-half of crude oil consumption, distillates (diesel and heating oil) for about 20 percent, and propane and jet fuel for about 6 and 7 percent. Lower petroleum product prices increase households' real income and boost businesses' profits, which translate into higher GDP. Prices fell roughly $40 per barrel between August and the end of 2014. Chapter 2 provides an estimate that, if this price decrease is sustained for the next year, GDP will be 0.4 percentage point higher in 2015 that it would be if oil prices were to remain at their mid-2014 levels.

Figure 6-v
Petroleum Product Weekly Prices, 2014



Note: Retail gasoline price excluding taxes calculated using the state average for local, state, and federal gasoline taxes from the American Petroleum Institute.
Source: Energy Information Administration, Spot Prices for Crude Oil and Petroleum Products; American Petroleum Institute.

new construction or upgrades of existing transmission lines. For example, installed wind generator capacity in Texas grew between 2000 and 2008 from 0.17 gigawatts to 10 gigawatts, but most of the new generators were installed in West Texas. Little existing transmission capacity connected the wind generators to electricity demand centers in East Texas. During certain times, such as at night or during the spring, available wind generation in the West exceeded local electricity demand. If there had been sufficient transmission capacity, the excess wind generation could have been transported to East Texas, relieving fossil fuel-fired generators there. But because transmission capacity did not keep pace with wind generation, electricity costs and emissions were higher than they needed to be. Texas recently completed a major transmission project that alleviates these problems, providing an important example of infrastructure investments that can support the energy revolution.

Another reason for insufficient infrastructure is that much of the recent growth in natural gas and oil production has occurred in regions with little recent history of energy production. Oil production in North Dakota increased from 0.1 million bpd in January 2008 to 1.2 million bpd in October 2014. However, transportation bottlenecks have contributed to crude oil prices, particularly in the U.S. interior, falling below international benchmarks. Responding to these bottlenecks, according to EIA estimates, shipments of crude oil by rail increased from nearly zero to about 750 thousand bpd during roughly the same time period. Recent high-profile rail accidents involving crude oil shipments have raised concerns about the safety and environmental consequences of increasing reliance on rail for shipping crude. Recognizing these concerns, the Department of Transportation recently proposed strengthened safety regulations for rail cars transporting crude oil and other flammable materials.

The Administration launched the first Quadrennial Energy Review in January 2014, in part to support long-term planning of energy infrastructure. The first phase of the Review, to be completed by early 2015, focuses on infrastructure for energy transport, storage, and distribution. Subsequent phases will address other dimensions of U.S. energy security and sustainability, thereby providing a multiyear roadmap for Federal energy policy.

The Energy Revolution and Energy Security: A Macroeconomic Perspective

The term energy security is used to mean different things in different contexts, and broadly covers energy supply availability, reliability, affordability, and geopolitical considerations.[6] This section focuses on macroeconomic energy security, which means the extent to which a country's economy is exposed to energy supply risks—specifically, international energy supply disruptions that lead to product unavailability, price shocks, or both. The concept of macroeconomic energy security encompasses domestic risks as well as international supply risks such as disruptions to foreign oil production. In the United States, domestic energy security considerations are important and domestic supply breakdowns can have large costs. For example, CEA and DOE, and other Federal agencies, have estimated substantial costs of electricity-grid outages associated with storms (CEA/DOE 2013). Historically, however, energy supply disruptions of foreign origin have had the greatest overall macroeconomic impact. Foreign oil supply disruptions played a role in the recessions of the 1970s as well as the 1990-91 recession, though disagreement remains about the magnitude of that role. For this reason, this section focuses on the vulnerability of the U.S. economy to international energy supply disruptions rather than to domestic ones.

Because most U.S. energy import dollars are spent on petroleum, the main threats to U.S. macroeconomic energy security come from international oil supply disruptions. During the 1973-74 OPEC oil embargo, price controls and lack of product led to gasoline rationing and long lines at service stations. But in today's global oil market with many producers and domestically deregulated petroleum prices, petroleum products will still be available in the event of a foreign supply disruption, just at a higher price. Today, macroeconomic energy security concerns the resilience of the U.S. economy to temporary unexpected price hikes—price shocks—of foreign origin.

Historically, temporary oil price shocks arising from foreign supply disruptions have cut GDP growth and reduced employment. These events have been studied and debated in depth in the economics literature (see Hamilton 2009 and Kilian 2008b, 2014 for surveys). Table 6-1 presents a list of the major oil supply disruptions from 1973 to 2005 identified in Kilian

[6] In a joint statement released May 6, 2014, the G-7 energy ministers stated: "We believe that the path to energy security is built on a number of core principles: Development of flexible, transparent and competitive energy markets, including gas markets; Diversification of energy fuels, sources and routes, and encouragement of indigenous sources of energy supply; Reducing our greenhouse gas emissions, and accelerating the transition to a low carbon economy, as a key contribution to enduring energy security; Enhancing energy efficiency in demand and supply, and demand response management; Promoting deployment of clean and sustainable energy technologies and continued investment in research and innovation; Improving energy systems resilience by promoting infrastructure modernization and supply and demand policies that help withstand systemic shocks; [and] Putting in place emergency response systems, including reserves and fuel substitution for importing countries, in case of major energy disruptions."

Table 6-1
Major Oil Disruptions, 1973–2005

Event Name	Date	Duration (months)	Gross Peak Global Supply Loss (millions of barrels per day)	Percent Change in Oil Prices
Arab Oil Embargo & Arab-Israeli War	Oct-73 to Mar-74	6	4.3	45%
Iranian Revolution	Nov-78 to Apr-79	6	5.6	53%
Iran-Iraq War	Oct-80 to Jan-81	3	4.1	40%
Persian Gulf War	Aug-90 to Jan-91	6	4.3	32%
Civil Unrest in Venezuela	Dec-02 to Mar-03	4	2.6	28%
Iraq War	Mar-03 to Dec-03	10	2.3	28%

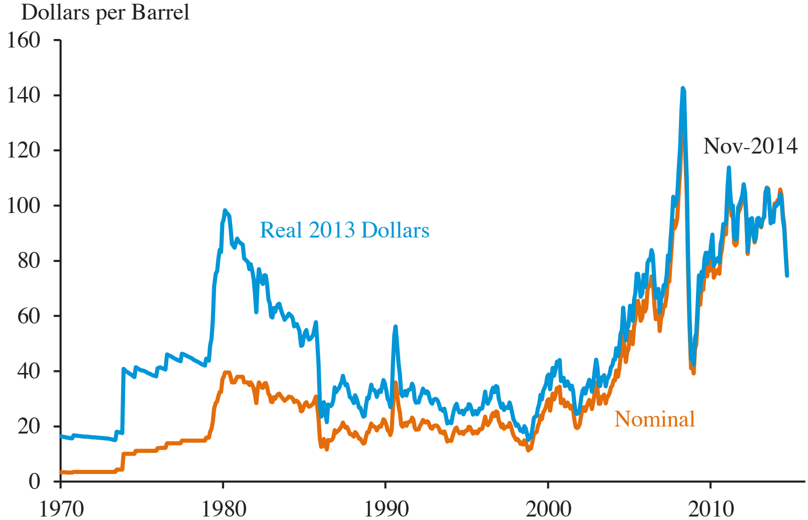
Source: Events as identified in Kilian (2008a) and Hamilton (2009). Dates and gross peak supply loss figures as identified in IEA(2012). Price changes for events over select windows as specified in Hamilton (2009) and price changes before 1982 measured using crude petroleum PPI as in Hamilton (2009).

(2008a) and Hamilton (2009), the estimated gross peak global supply loss, and the percentage change in oil prices in the aftermath of the disruption. For example, in the months following the Iranian Revolution in November 1978, oil prices increased by 53 percent. This link is not perfect, and not every oil price shock has led to an economic slowdown, but as is discussed below in more detail, the empirical evidence points to a negative link between oil price spikes and economic activity.

Trends in Oil Import Prices and Shares

The price of oil plays a central role in macroeconomic energy security. Figure 6-16 shows the price of oil in nominal (current) dollars and in 2013 dollars (deflated by the price index for consumer spending). Jumps in the price of oil are visible around the disruptions described in Table 6-1, as well as during more gradual increases such as in 2007 to 2008. Oil prices in November 2014, of roughly $75 per barrel, are comparable, in real terms,

Figure 6-16
WTI Spot Price: Nominal and Real, 1970–2014

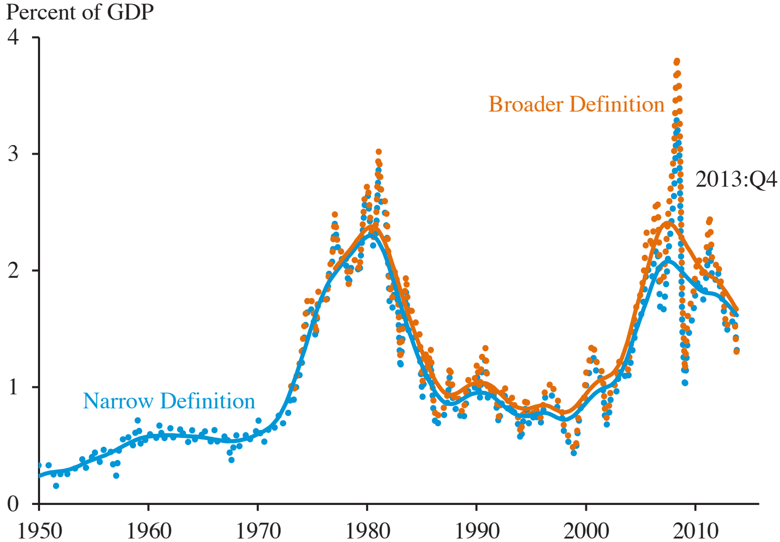


Note: Nominal prices deflated using overall PCE price index.
Source: Energy Information Administration, Spot Prices for Crude Oil and Petroleum Products; Bureau of Economic Analysis, Personal Consumption Expenditures.

with those in the early 1980s, but are roughly twice the real prices of the 1990s.

The expenditure share of net petroleum imports measures the fraction of GDP that is spent on net imports of petroleum. Ignoring compositional differences, this share is the product of net barrels of petroleum imports times the price per barrel, divided by GDP. Figure 6-17 presents two measures of the expenditure share of GDP that is net imports. The first uses a narrow definition of net imports of crude, gasoline, distillates, and fuel oil. The second, which is only available starting in 1973, uses a broader definition that includes other refined products, such as jet fuel. The alternative definition slightly increases the share relative to the narrow measure but does not materially change the overall time series pattern. In order to observe longer-term movements, the Figure also presents smoothed trends of the two measures, which reduce the influence of high frequency fluctuations in these series due to short-term price volatility. During the 1990s, the price of oil was low even though physical imports were higher than in previous years, which kept the expenditure share relatively low. In contrast, between early 2011 and mid-2014, high oil prices have produced a relatively high expenditure share, though this share has declined noticeably over the past few years as domestic demand has declined and domestic oil production has increased. The high correlation of the net import share with

Figure 6-17
Net Import Shares of Petroleum Products, 1950–2013



Source: Energy Information Administration, Monthly Energy Review (Apr 2014); CEA calculations.

price indicates that the short-term price elasticity of demand for petroleum products is quite low, meaning that consumers do not reduce their demand very much when the price rises.

Macroeconomic Channels of Oil Price Shocks

Oil price shocks can affect GDP through several channels, including demand for goods and services, supply (production), and physical product rationing. As Kilian (2009) and Blinder (2009) point out, these channels are conceptually distinct and can have different macroeconomic effects.

Via the demand channel, an increase in the price of oil reduces spending on other goods and services, reducing GDP. Because, as noted above, the short-run demand for petroleum products is quite price-inelastic, the share of expenditures by consumers and firms on petroleum rises when the oil price increases.[7] Because the United States is a net importer of oil, expenditures on net imports also rise when the oil price increases. If the oil shock is known to be temporary, the life-cycle theory of consumption sug-

[7] For example, Kilian and Murphy (2014) estimate the short-run price elasticity of demand for oil to be approximately -0.3, meaning that a one percent oil price increase reduces consumption by 0.3 percent. Earlier estimates show short-run elasticities of even smaller magnitudes. If demand for energy-intensive imported products is similarly insensitive to price changes, an oil price increase would strongly raise U.S. spending on those imported products and therefore strongly diminish the income available to spend on other goods.

gests that consumers would make minimal adjustments to the rest of their consumption and would temporarily finance the additional oil expenditure by drawing down savings. However, in practice consumers do not know the duration of a price hike and many, or most, would instead reduce their consumption of other goods and services to pay for the more expensive fuel needed for daily life. Because expenditures on oil imports go abroad and not to the domestic economy, the additional spending on fuel does not count toward GDP. As a result, the immediate effect of a price increase on an imported good like oil, which has price-inelastic demand, is to decrease consumption of domestic goods and services and, as a result, to decrease GDP. This demand-reducing effect works just as if consumers' wealth had been reduced, so this channel is sometimes referred to as the wealth channel. The wealth channel can be large; for instance, if net oil imports are 2 percent of GDP, as they were in the late 1970s and late 2000s, a 10-percent jump in the price of oil causes a corresponding reduction in spending on everything else and reduces GDP by about 0.2 percent. The wealth channel can be offset by other factors, however, depending on the source of the oil price increase. For example, an increase in overall world economic activity that drives up the demand for, and the price of, oil would also expand U.S. exports, at least partially offsetting the macroeconomic effects of the increased price of oil imports.

There are two other ways, besides the wealth effect, by which an oil price increase can affect demand. First, an oil price increase, like a change in the relative price of any other good, also changes the composition of demand as consumers shift spending from items that are indirectly affected by the price increase (like air travel and cars with low fuel economy) to goods and services that are less energy-intensive. Thus, products of energy-intensive sectors become relatively more expensive and those sectors will see a reduction in demand. Even within sectors, demand can shift across products, such as to cars with greater fuel economy. Moreover, to the extent that shifting from energy-intensive goods reduces purchases of durables such as automobiles or refrigerators, spending today is shifted into the future, depressing aggregate demand. Although this temporal shift increases demand in less energy-intensive sectors, it takes time for displaced workers to find alternative employment in those sectors, so incomes decline and unemployment rises (see for example Hamilton 1988).

Second, an oil price increase can depress domestic demand if it raises uncertainty. Concerns about the economic future can lead consumers to postpone major purchases and convince firms to postpone investment and hiring, which slows the economy (for example, Bernanke 1983, Dixit and Pindyck 1994, Bloom 2009; and for oil investment specifically, Kellogg

2010). Oil price volatility can be causal (the volatility creates uncertainty that postpones investment, hiring, or durables consumption), or the volatility can simply reflect broader market uncertainty about future economic or geopolitical events. Another potential demand-side channel is a fall in aggregate consumption because an oil price rise is regressive and transfers income from individuals with a high marginal propensity to consume to individuals with a lower marginal propensity to consume (for example, Nordhaus 2007).

Oil price increases can also reduce economic activity through the supply side of the economy. To the extent that energy prices more broadly move with oil prices, an increase in oil prices makes energy a more expensive factor of production and increases costs to businesses and households, who will strive to reduce energy consumption and expenditures. Although high energy prices could cause firms and households to shift toward less energy-intensive technology in the long run; in the short run, with fixed technology, higher energy costs can result in layoffs in energy-intensive firms and industries (Linn 2008 and 2009). Because it takes time for displaced workers to find jobs, incomes decline and unemployment rises. This supply-side channel matters most if price increases are long lasting. Because capital and labor are being used less efficiently, this channel also could harm productivity growth. However, because of economy-wide improvements in energy efficiency over the last several decades, as shown in Figure 6-19 below, this supply-side channel is less important today than it has been in the past.

The channels discussed above concern changes in the relative price of oil and assume that oil is available. If, however, prices are not flexible and instead oil or petroleum products are rationed, the effect on GDP can be severe. On the production side, because technology is fixed in the short run, many workers cannot do their jobs without oil. Time spent waiting in line for gasoline is time not spent productively. In such cases, output falls, and even relatively small dollar volumes of unavailable supply can have an outsized influence on the economy. Fortunately, the development of global crude oil markets and deregulated domestic retail markets have made widespread petroleum product rationing a thing of the past, outside of occasional temporary regional events stemming from weather-related supply chain disruptions. Such events can have significant, even life-threatening impacts on the individuals involved, and minimizing those impacts through improving supply chain resilience is an important goal (and indeed is a central topic of the Quadrennial Energy Review). But the temporary nature of these events and regional scope means that the macroeconomic impact of the resulting petroleum product unavailability is limited.

CEA (2014a) presents reduced-form empirical evidence on the relative importance of the different effects of energy supply shocks on the

U.S. economy and on the changing correlations among energy prices. The results of this analysis suggest that a lower share of net oil imports in GDP enhances the resilience of the economy to oil price shocks. Specifically, the same oil-price increase reduces GDP much less in 2015 than it did in 2006, and will reduce GDP even less at the lower import level that EIA projects for 2017. This analysis suggests that the unconventional oil boom and lower oil demand have significantly improved U.S. energy security.

A Path to a Low-Carbon Future

Most anthropogenic emissions of greenhouse gases are energy-related, particularly from the combustion of fossil fuels (EPA 2010). A central challenge of energy and environmental policy is to find a responsible path that balances the economic benefits of low-cost energy with the social and environmental costs to future generations associated with conventional energy production. Addressing these challenges is a central part of the President's All-of-the-Above Energy Strategy, which several recent policy achievements demonstrate. As part of the 2009 Conference of the Parties to the United Nations Framework Convention on Climate Change in Copenhagen, the United States pledged to cut its CO2 and other greenhouse gas emissions in the range of 17 percent below 2005 levels by 2020. Under the President's Climate Action Plan, the United States is expected to meet this target. Moreover, in November 2014 President Obama and President Xi Jinping of China jointly announced historic post-2020 climate targets. Specifically, China committed to peak its emissions by around 2030 and to double the share of non-fossil (nuclear and renewable) energy in its overall economy from about 10 percent today to around 20 percent by 2030. At the same time, the United States announced a new goal to reduce emissions 26 to 28 percent below 2005 levels by 2025. The United States and China also agreed to work together on energy innovation and toward a successful global agreement as part of the continuing United Nations climate negotiations.

A Case for Climate Action

From an economist's perspective, greenhouse gas emissions generate a negative externality. A negative externality occurs when the production or consumption of a good imposes harm on individuals not involved in the production or consumption of that good. For example, a business burning oil to run a generator or a person driving a gasoline-powered car emits greenhouse gasses, which negatively affect other people—including future generations. Economically efficient policies to address this negative externality would require those responsible—the business burning the oil or the person driving the car—to pay the true cost of their additional—or marginal—emissions, which takes into account the harm they caused to third parties. Compelling businesses and individuals to pay the true incremental costs encourages them to produce and consume less of the fuels, and also encourages technological solutions that reduce the externality, such as cars with higher fuel economy. On a larger scale, greenhouse gas emissions from the United States affect residents in other countries and vice versa. In fact, U.S. emissions have the same effect on the global climate as emissions from any other country. Putting a price on emissions that is equal to the global cost of an additional ton of emissions would cause those responsible for the emissions to pay the incremental costs of their actions.

A recent CEA report (2014b) examines the economic consequences of delaying implementing such policies and reaches two main conclusions, both of which point to the benefits of swiftly implementing mitigation policies and to the high costs of delaying such actions. First, although delaying action can reduce costs in the short run, on net, delaying action to limit the effects of climate change is costly. Because CO2 accumulates in the atmosphere, delay allows CO2 concentrations to increase more quickly. Thus, if a policy delay ultimately leads to higher future CO2 concentrations, that delay produces persistent economic damages due to the higher temperatures and CO2 concentrations that result. Alternatively, if a delayed policy still aims to achieve a given climate target, such as limiting CO2 concentration to a given level, then a delay means that when implemented, the policy must be more stringent and thus more costly in subsequent years. In either case, delay is costly.

Costs of delay will take the form of either greater damages from climate change or higher costs associated with implementing more rapid reductions in greenhouse gas emissions. In practice, both forms are possible and potentially large. Based on a leading aggregate damage estimate in the climate economics literature, a delay that results in warming of 3° Celsius above preindustrial levels, instead of 2°, could increase economic damages by approximately 0.9 percent of global output (CEA 2014b, based on Nordhaus 2013). To put this percentage in perspective, 0.9 percent of estimated 2014 U.S. GDP is approximately $150 billion. The incremental cost of an additional degree of warming beyond 3° Celsius would be even greater. Moreover, these costs are not one-time, but instead are incurred year after year because of the recurring damage caused by permanently increased climate warning resulting from the delay.

An analysis of research on the effect of delay on the cost of achieving a specified climate target (typically, a given concentration of greenhouse gases) suggests that net mitigation costs increase, on average, by approximately 40 percent for each decade of delay (CEA 2014b). These costs are higher for more aggressive climate goals: since each year of delay means more CO2 emissions, it becomes increasingly difficult, or even infeasible, to hit a climate target that would result in only moderate temperature increases.

The second conclusion explained in the CEA report (2014b) is that climate policy can be thought of as "climate insurance" taken out against the most severe and irreversible potential consequences of climate change. Events such as the rapid melting of ice sheets and the consequent swell in global sea levels, or temperature rises on the higher end of the range of scientific uncertainty, could pose such severe economic consequences that they could reasonably be thought of as climate catastrophes. Reducing the possibility of such climate catastrophes will require taking prudent steps now to reduce the future chances of the most severe consequences of climate change. The longer that action is postponed, the greater the concentration of CO2 in the atmosphere will be and the greater the risk of severe climate events. Just as businesses and individuals guard against severe financial risks by purchasing various forms of insurance, policymakers can take actions now that reduce expected climate damages. And, unlike conventional insurance policies, climate policy that serves as climate insurance is an investment that also leads to cleaner air (Parry et al. 2014), energy security, and benefits that are difficult to monetize, such as biological diversity.

Two other recent reports underscore these conclusions about the cost of delaying climate action. As part of the Fifth Assessment Report, the Intergovernmental Panel on Climate Change (IPCC) recently released its Synthesis Report, which integrates the Fifth Assessment's separate reports on physical science, impacts, and mitigation (released over the past two years). The Synthesis Report summarizes the literature quantifying the impacts of projected climate change by sector. Impacts include: decreased agricultural production; coastal flooding, erosion, and submergence; increases in heat-related illness and other stresses due to extreme weather events; reduction in water availability and quality; displacement of people and increased risk of violent conflict; and species extinction and biodiversity loss. Although effects vary by region, and some are not well-understood, evidence of these impacts has grown in recent years. The IPCC also cites simulation studies showing that delay is costly, both when all countries delay action and when there is partial delay, with some countries delaying action while awaiting a more coordinated international effort; CEA (2014b) expands on that analysis by including additional studies.

Combining climate projections with empirically based estimates of the links between climate and the U.S. economy, the Risky Business report (Risky Business Project 2014) echoes many of the IPCC's conclusions. The

Risky Business report predicts that, in the coming decades, climate change will likely impose significant costs on many regions and facets of the U.S. economy. The report describes the effects of rising sea levels, storms and flooding, and droughts and extreme heat waves. The report's authors estimate that $66 billion to $106 billion of existing coastal property will likely be below sea level by 2050. Within just the next 15 years, the average costs of coastal storms on the East Coast and Gulf of Mexico will likely increase by $2 billion to $3.5 billion a year. By 2050, the average American likely will annually experience two to three times more days that reach 95°F, to the detriment of human health and labor productivity. Higher temperatures and different weather patterns likely will affect agricultural productivity—with gains for Northern farmers and losses for Midwestern and Southern farmers. Overall, the report emphasizes the considerable risk that climate change is imposing on the U.S. economy.

The Climate Action Plan

Recognizing the case for immediate and strong climate action, the President called on Congress in his 2013 State of the Union address to pass legislation that would provide a market-based mechanism for reducing emissions. Thus far, Congress has failed to act but the President has taken other actions, including direct regulation of greenhouse gas emissions under the Clean Air Act.[8]

To address the broad challenges associated with climate change, the President's Climate Action Plan has three central goals: a) reduce domestic emissions, b) prepare for the impacts of climate change, and c) provide international leadership to address climate change. The remainder of this

[8] Regulations have costs and benefits, and computing the monetary benefits of reducing CO_2 emissions requires an estimate of the net present value of the economic cost of an additional, or marginal, ton of CO_2 emissions. This cost—which covers health, property damage, agricultural impacts, the value of ecosystem services, and other costs of climate change—is often referred to as the "social cost of carbon" (SCC). In 2010, a Federal interagency working group, led by the CEA and the Office of Management and Budget, produced a Technical Support Document that outlined a methodology for estimating the SCC and provided numeric estimates (White House 2010). Since then, the SCC has been used at various stages of rulemaking by the Department of Transportation, the Environmental Protection Agency, and the Department of Energy. The SCC estimate is updated as the science and models underlying the SCC progress, and in November 2013 public comments were invited on the most recent update of the SCC, which produced an estimate of $39 per metric ton CO_2 in 2015 (2011 dollars). The SCC increases over time as the economy grows and emissions cause greater damage, and reaches $76 per metric ton CO_2 in 2050.

Reducing greenhouse gas emissions is likely to yield additional benefits, besides the climate benefits, which are often referred to as co-benefits (Parry et al. 2014). For example, policies that reduce fuel consumption at coal-fired electricity generators cause lower emissions of particulates and other pollutants that harm human health.

section describes the initiatives under the first goal, reducing domestic emissions. As explained below, the first part of the Climate Action Plan includes a broad range of actions, from providing research, demonstration, and deployment funding for new energy technologies to the direct regulation of carbon emissions under the Clean Air Act. For example, in the Clean Power Plan, the Environmental Protection Agency has proposed regulations to reduce electricity-sector CO2 emissions. The proposal is projected to reduce CO2 emissions by about 30 percent from 2005 levels, and the total benefits of emissions reductions are expected easily to outweigh the costs. Box 6-3 provides a list of selected initiatives under the Climate Action Plan.

To date, the United States has made important progress in reducing greenhouse gas emissions, but more work remains. As Figure 6-18 shows, U.S. energy-related CO2 emissions have fallen 10 percent from their peak in 2007. Given a counterfactual, or baseline, path for CO2 emissions, one can attribute the reduction in CO2 emissions to changes in the carbon content of energy, energy efficiency, and in the level of GDP, relative to the baseline path.[9]

The baseline path is computed using a combination of historical trends and published forecasts as of 2005. Relative to this baseline, the decline in post-2013 projected emissions is due to policy-driven improvements, market-driven shifts to cleaner energy, and slower growth than was initially projected in 2005; that is, because of the decline in economic activity as a result of the Great Recession. Importantly, the post-2013 projected emissions exclude the portions of the Climate Action Plan yet to be finalized—notably, the Clean Power Plan and new actions to address methane pollution. Policy and market-driven shifts to cleaner energy make a large contribution to the decline in post-2013 projected emissions. These shifts include the reduction in electricity generated by coal and the increase in cleaner natural gas and zero-emissions wind and solar generation. Improvements in energy efficiency, partly due to vehicle, equipment, and appliance standards, also made a contribution. The recent reduction in emissions shows that while progress has been made, given the magnitude of the climate challenges, policies currently in progress and under development will be important to reaching our 2020 and post-2020 climate targets, but more remains to be done.

[9] Specifically, CO_2 emissions are the product of $(CO_2/Btu)\times(Btu/GDP)\times GDP$, where CO_2 represents U.S. CO_2 emissions in a given year, Btu represents energy consumption in that year, and GDP is that year's GDP. Taking logarithms of this expression, and then subtracting the actual values from the baseline, gives a decomposition of the CO_2 reduction into contributions from clean energy, energy efficiency, and the recent recession.

Box 6-3: Selected Administration Initiatives under the Climate Action Plan

A broad range of Administration initiatives promote the development and adoption of technologies that reduce greenhouse gas emissions. The Administration has:

Electricity

- Proposed the Clean Power Plan, which will help cut CO2 pollution from the electricity sector by 30 percent from 2005 levels. The proposal sets rates of CO2 emissions for each State, and provides States flexibility to meet those standards by 2030.
- Issued about $30 billion in loan guarantees to kick-start utility-scale solar; supported "first mover" advanced nuclear reactors with enhanced safety features in Georgia; and enabled the auto industry to retool for very efficient and electric vehicles.
- In partnership with industry, invested in 4 commercial-scale and 24 industrial-scale coal projects that will store more than 15 million metric tons of CO2 per year.
- Under the Recovery Act, supported more than 90,000 projects by leveraging nearly $50 billion in private, regional, and state dollars to deploy enough renewable electricity to power 6.5 million homes annually.
- As part of a commitment to improvements in permitting and transmission for renewables, approved 50 utility-scale renewable energy proposals and associated transmission, including 27 solar, 11 wind, and 12 geothermal projects since 2009, enough to power 4.8 million homes. Thirteen of the projects are already in operation.

Transportation

- In 2012, finalized national standards to double the fuel economy of light-duty cars and trucks by 2025 and slash greenhouse gas emissions by 6 billion metric tons over the lifetime of the vehicles sold during this period.
- Building on the first-ever medium- and heavy-duty truck fuel economy and greenhouse gas standards released in 2011, began collaborating with industry to develop standards for trucks beyond model year 2018, which will yield large savings in fuel, lower CO2 emissions, and health benefits from reduced particulate matter and ozone.

Energy Efficiency

- In the second term alone, finalized energy conservation standards for 13 products. These standards—when taken together with the final rules already issued under this Administration—mean that more than 70 percent of the President's goal of reducing cumulative carbon pollution by 3 billion metric tons by 2030 through appliance efficiency standards will be achieved, over which time Americans will save hundreds of billions of dollars in energy costs.

- Launched the Better Buildings Challenge in 2011 to help American buildings become at least 20 percent more energy efficient by 2020. More than 190 diverse organizations, representing over 3 billion square feet, 600 manufacturing plants, and close to $2 billion in energy efficiency financing stepped up to the President's Challenge. Participation has grown rapidly and participating organizations include states, cities, school districts, multifamily housing organizations, retailers, food and hospitality service providers, and manufacturing organizations.
- Beginning in 2009, created weatherization programs that helped low-income households save $250 to $500 per year on their energy bills, and provided energy efficiency improvements to nearly 2 million homes.

The President, as part of his FY 2016 Budget, is also proposing new initiatives to:

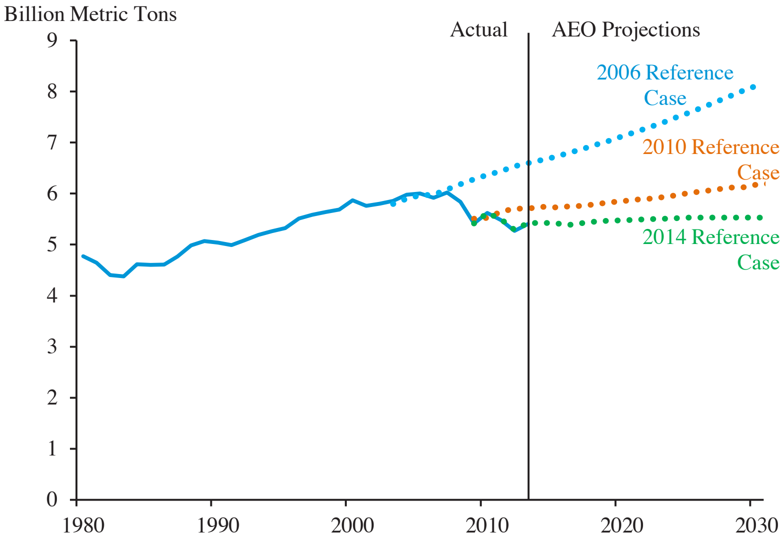
- Invest $5 billion in funding for clean energy technology activities at the Department of Energy, including $900 million for programs and infrastructure that support nuclear energy technologies, $900 million to increase affordability and convenience of advanced vehicles and renewable fuels, and $5 million in cleaner energy from fossil fuels.
- Put $1 billion toward advancing the goals of the Global Climate Change Initiative (GCCI) and the President's Climate Action Plan by supporting bilateral and multilateral engagement with major and emerging economies.

Reducing Emissions through Improved Efficiency

The amount of energy used to produce a dollar of real GDP has declined steadily over the past four decades, and today stands at less than one-half of what it was in 1970 (Figure 6-19). This improvement in overall energy efficiency, which has averaged 1.6 percent a year since 1960, is due both to more efficient use of energy resources to complete the same or similar tasks and to shifts in the types of tasks undertaken. The first contribution is reflected in the Economy-Wide Energy Intensity Index (also shown in Figure 6-19) developed by DOE, which estimates the amount of energy needed to produce a given basket of goods in one year compared to the amount required the year before. Between 1985 and 2011, the Energy Intensity Index fell by 14 percent. The second contribution to the decrease in the energy-to-GDP ratio arises from such factors as shifts in production from more to less energy-intensive sectors of the economy, as well as shifts to imports rather than production of energy-intensive goods. These latter

Figure 6-18

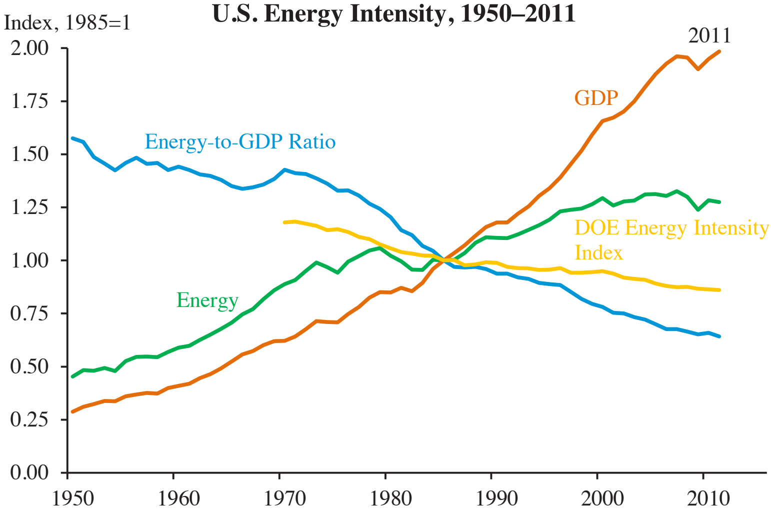
Energy Related Carbon Dioxide Emissions, 1980–2030



Source: Energy Information Administration, Annual Energy Outlook (AEO) 2006, 2010, and 2014.

Figure 6-19

U.S. Energy Intensity, 1950–2011



Note: The DOE Energy Intensity Index illustrates the amount of energy needed to produce a set basket of goods over time. The Energy-to-GDP ratio shows energy use per dollar of overall output.
Source: Department of Energy, Energy Information Administration and Office of Energy Efficiency and Renewable Energy.

factors and the efficiency increases together produced a drop of 36 percent in the ratio of energy to GDP between 1985 and 2011.

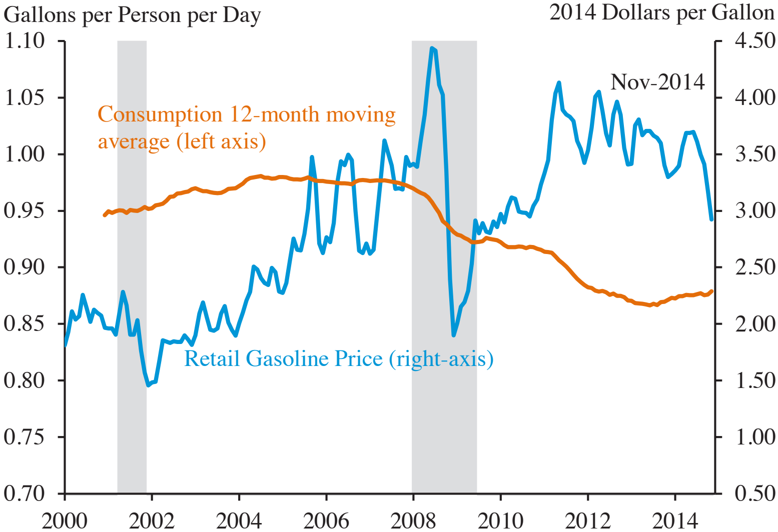
Both market forces and government programs spur energy efficiency improvements. For example, as Figure 6-20a shows, gasoline consumption per capita rose through the early 2000s and plateaued in the mid-2000s before dropping substantially during the Great Recession. As the economy recovered, however, gasoline consumption per capita continued to fall. Some of this continued decline stems from the relatively high real gasoline prices shown in Figure 6-20a, but only in part. Increasing fuel economy brought about by Federal fuel economy standards also played a role. In 2012, the Administration finalized fuel economy standards that, together with the Administration's first round of standards, will roughly double the fuel economy of light-duty vehicles from 2010 levels to the equivalent of 54.5 miles per gallon by the 2025 model year (Figure 6-20b). Further, beginning in model year 2014, medium- and heavy-duty trucks have had to meet their own fuel economy and greenhouse gas standards, which are projected to increase their fuel economy by 10 to 20 percent by 2018. Finally, the Accelerate Energy Productivity 2030 initiative (being undertaken by the Department of Energy with two private-sector partners: the Council on Competitiveness and the Alliance to Save Energy) is supporting the President's goal of doubling energy productivity (GDP per unit of energy use) from its 2010 level by 2030.

The Role of Natural Gas in Lowering CO_2 Emissions

Natural gas is already playing a central role in the transition to a clean energy future. According to the decomposition mentioned in Footnote 12, nearly one-half of the CO2 emissions reductions from 2005 through 2013 stem from fuel switching, primarily switching from the use of coal to natural gas, wind, and solar for the purpose of generating electricity. Unconventional natural gas development has opened a vast resource and, as shown in Figure 6-21, the EIA Reference case (which includes the baseline assumptions for economic growth, oil prices, and technology) projects increasing quantities of natural gas production and steady price growth over the coming two decades.

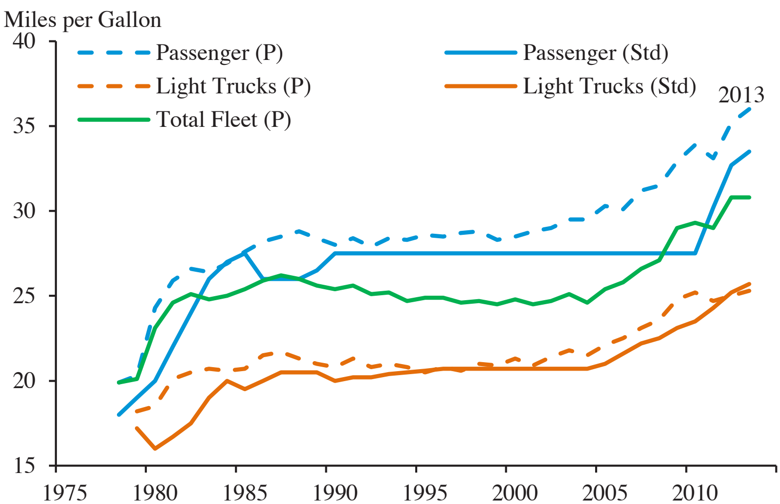
Price is the leading reason for the increased use of natural gas in electricity generation. As Figure 6-22 shows, steep declines in natural gas prices in 2008 through 2009 and in 2012 induced substitution of natural gas for coal in electricity generation. Confirming the link between natural gas prices and fuel substitution is the fact that rising natural gas prices have the opposite effect. In 2013, the benchmark natural gas price increased from $3.33 per million Btu in January 2013 to $4.24 per million Btu in December 2013;

Figure 6-20a
U.S. Per Capita Consumption of Gasoline and Real Gasoline Prices, 2000–2014



Note: Retail gasoline prices deflated using consumer price index (1982-84=100).
Source: Energy Information Administration; Department of Commerce, Census Bureau; CEA calculations.

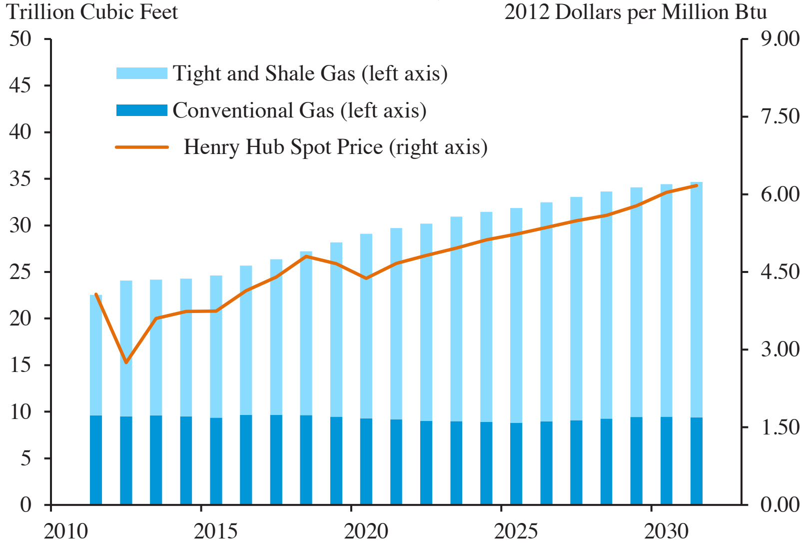
Figure 6-20b
Corporate Average Fuel Economy Standard



Note: Dotted lines represent actual performance (P) and solid lines represent the relevant fuel economy standard (Std).
Source: Energy Information Administration, Annual Energy Outlook.

Figure 6-21

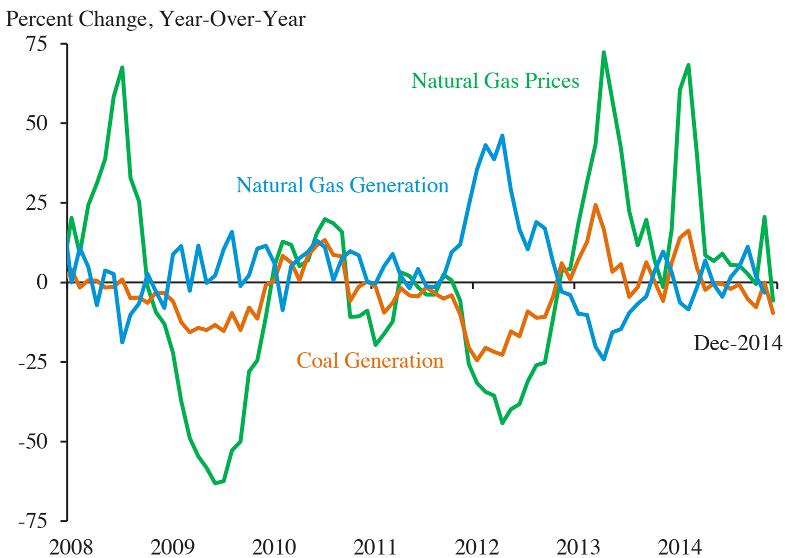
U.S. Natural Gas Production and Wholesale Prices, 2011–2030



Source: Energy Information Administration, Annual Energy Outlook.

Figure 6-22

Change in Monthly Electricity Generation and Prices, 2008–2014



Source: Energy Information Administration, Short-Term Energy Outlook (Jan 2015).

and as natural gas prices rose relative to coal, the use of coal for electricity generation increased while the use of natural gas decreased. Looking ahead, the price of natural gas will make it an economically attractive alternative fuel as market forces as well as state and federal policies further reduce coal-fired electricity generation.

The Administration is taking steps to ensure that the expansion of natural gas and oil production be done responsibly and with environmental safeguards. Environmental concerns include both climate impacts of fugitive methane emissions and flaring, as well as local environmental issues associated with water and land use for hydraulic fracturing operations.[10] The Climate Action Plan includes a strategy both to reduce methane emissions and to address gaps in current methane emissions data. The regulatory structure for addressing local environmental concerns, especially around land and water use, exists primarily at the State and local level. Research that is actively under way will inform prudent local environmental regulation of hydraulic fracturing.

Looking further ahead, the current development of natural gas generation infrastructure prepares the Nation for future widespread deployment of wind and solar generation. Wind and solar are non-dispatchable, meaning that electricity generation depends on how strongly the wind is blowing or the sun is shining, in contrast to fossil fuel-fired generators, whose power output can be largely adjusted as needed. Consequently, high market penetration of both wind and solar would benefit from either storage or backup generation capacity. Developing natural gas infrastructure today facilitates its use tomorrow for peak demand and renewable backup generation.

Supporting Renewables, Nuclear, Cleaner Coal, and Cleaner Transportation

Low- and zero-carbon renewable and nuclear technologies, as well as cleaner coal and transportation technologies, have a central role to play in a clean energy future. Consequently, the President's All-of-the-Above Energy Strategy makes a strong commitment to supporting these low-carbon technologies.

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[10] Natural gas is composed primarily of methane, which is a potent greenhouse gas. Fugitive methane refers to methane that leaks from wells, pipelines, or other parts of the natural gas delivery system. Flaring refers to burning excess gas. Because flared gas emits CO_2 rather than methane, the greenhouse gas footprint is smaller when the gas is flared rather than emitted directly to the atmosphere. However, both fugitive emissions and flaring increase the total greenhouse gas footprint of natural gas. Fugitive methane emissions and flaring are relevant to both natural gas and oil production, because many oil wells contain significant amounts of natural gas.

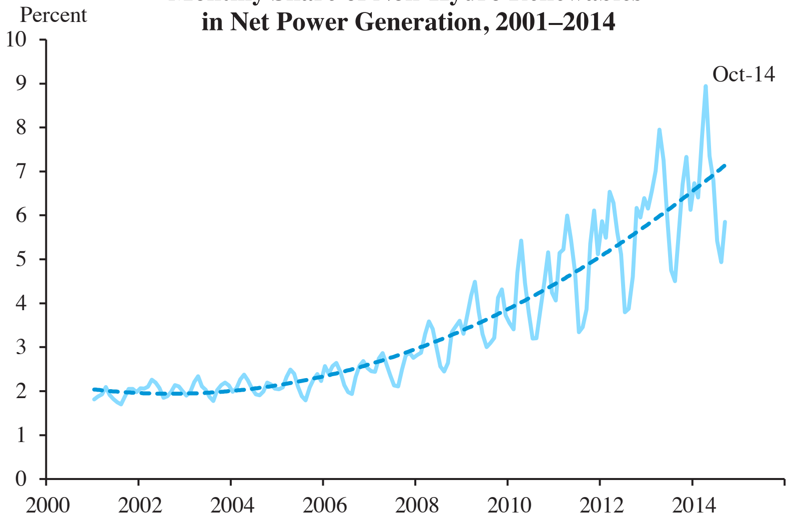
Electricity from Wind and Solar Energy. Historically, tax incentives for wind and solar energy have been based on the avoided-pollution-emissions and infant-industry arguments. Wind and solar generation are zero-emission sources of energy and thus do not create a negative climate externality.

The market demand for these alternative sources is sub-optimally low from society's point of view since emitters do not bear the incremental cost of their emissions-related damages and therefore have little incentive to switch away from more carbon-intensive energy sources. The potential market profits of wind and solar projects, therefore, do not reflect the broad benefits to society of their zero emissions, so policies such as tax incentives are justified. Moreover, offering tax incentives to immature technologies could spur innovation that reduces the costs of renewables in the long run. In a wide range of contexts, both inside and outside of the energy sector, new technologies experience periods of rapid learning. If firms can profit from their own learning—say by improving their products or reducing manufacturing costs—then firms have every incentive to spend resources on learning and improving technology. But with new technologies—so-called infant industries—a market failure could cause too little investment in their research, development, and demonstration. Specifically, a business that learns and improves its technology may see its competitors take those improvements and reduce their own costs or improve their own products (for example, without violating any patents). If the first business anticipates that its competitors will benefit from its own learning, then that business is less likely to spend the resources needed to learn and potential improvements in technology will suffer. In such cases, where learning spills over across firms, private markets create less innovation than is socially optimal. Accordingly, the Administration supports research and early deployment projects aimed at bringing down the ultimate market price of immature renewable energy technologies.

Increasing competitiveness of wind and photovoltaic electricity production, renewable portfolio standards that many states have adopted, and other government policies have together increased the share of electricity generated by non-hydro renewables from roughly 2 percent in 2005 to 7 percent in 2014 (Figure 6-23). The total installed costs of new photovoltaic systems have dropped sharply since around 2008, with the total installed cost of a new system falling by almost 50 percent for residential and commercial-scale systems and by 40 percent for utility-scale systems (Barbose et al. 2014).

The Administration has also supported solar deployment. Five years ago, no significant wind or solar energy projects existed on public lands. Today, the Interior Department is on track to permit enough solar and wind

Figure 6-23
Monthly Share of Non-Hydro Renewables in Net Power Generation, 2001–2014



Note: Solid line shows actual data and dotted line is a smoothed trend, shown to dampen the strong seasonal patterns (the share of non-hydro renewables drops during the winter and summer--both seasons of high power generation demand).
Source: Energy Information Administration, Net Generation for All Sectors.

projects on public lands by 2020 to power more than 6 million homes; the Defense Department has set a goal to deploy three gigawatts of renewable energy—including solar, wind, biomass, and geothermal—on Army, Navy, and Air Force installations by 2025; and, as part of the Climate Action Plan, the Federal Government has committed to sourcing 20 percent of the energy consumed in Federal buildings from renewable sources by 2020.

Nuclear and Cleaner Coal. Nuclear energy provides zero-carbon base load electricity and, through DOE, the Administration is supporting nuclear research and deployment. A high priority of DOE has been to help accelerate the timelines for the commercialization and deployment of small modular reactor (SMR) technologies through the SMR Licensing Technical Support program. Small modular reactors offer the advantage of lower initial capital investment, scalability, and siting flexibility at locations unable to accommodate more traditional larger reactors. They also have the potential for enhanced safety and security; for example, through built-in passive safety systems. DOE is committing $452 million to support first-of-a-kind SMR activities through cost-sharing arrangements with industry partners.

DOE is also supporting deployment of advanced large-scale reactors. In February 2014, the Department issued $6.5 billion in loan guarantees to support the construction of the nation's next generation of advanced nuclear reactors. The two new 1100 megawatt reactors, which will be located in

Georgia, feature advanced safety components and could provide a standardized design for the U.S. utilities market.

The Administration is also advancing lower GHG emission coal technology. DOE's R&D program is focused on improving advanced power generation and carbon capture, utilization, and storage technologies by increasing overall system efficiencies and reducing capital costs. In the near-term, advanced technologies are being developed that both increase the power generation efficiency for new plants, and incorporate new technologies to capture CO2. The longer-term goals are to increase coal plant efficiencies and reduce both the energy and capital costs of CO2 capture and storage from coal plants. As part of its $6 billion commitment to coal technology, the Administration, partnered with industry, is investing in commercial-scale carbon capture and storage projects at power plants and industrial sites, and in research and development on new technologies. In addition, the Department of Energy has made available $8 billion in loan guarantees for advanced fossil energy products that avoid, reduce, or sequester greenhouse gas emissions.

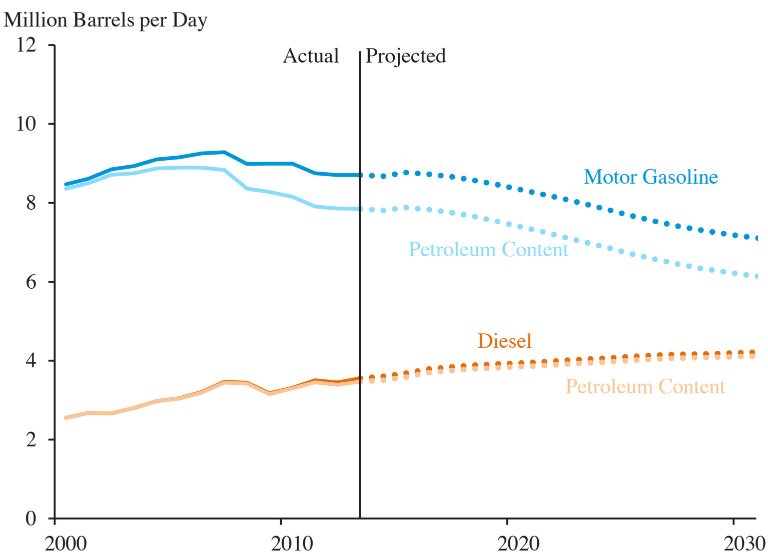
Meeting the Challenge of the Transportation Sector. Low-carbon vehicle technologies and fuels must play an important role in the transportation sector. Promising low-emission alternatives include hybrids, electric vehicles, hydrogen, natural gas, and biofuels. The effective emissions from an electric vehicle depend on the source of electricity, and they will fall as the electric power sector reduces its CO2 emissions. Different fuels are likely to be relatively better suited for different needs; for example, natural gas for busses and heavy-duty fleet vehicles and electricity for private vehicles in urban settings. But the transformation of the transportation sector is in its infancy, and the Administration is supporting research and development of a wide range of advanced transportation fuel options.

The convenience of high-energy content liquid fuels means that their role in the transportation sector could persist for decades. If so, renewable liquid fuels with a low greenhouse gas footprint would prove important for reducing the climate impact of the transportation sector. Already, the U.S. transportation sector uses ethanol, biodiesel, renewable diesel, and lesser quantities of other renewable fuels. Ethanol boosts octane and is blended into nearly all of the U.S. gasoline supply to produce E10, which is 10 percent ethanol by volume. Demand for renewable transportation fuels is further supported by the Renewable Fuel Standard (RFS). To qualify under the RFS as conventional renewable fuel, the fuel must achieve a 20 percent life-cycle greenhouse gas emissions reduction, relative to petroleum gasoline. The legislation authorizing the RFS, which was expanded under the Energy Independence and Security Act of 2007, mandated increasing amounts of renewable fuels over time. As Figure 6-24 shows, blending of ethanol into E10 has already reduced the amount of petroleum in gasoline substantially. The 2007 legislation envisioned conventional renewable fuels such as corn ethanol to be transitional and that their market share would decrease as the market share of advanced renewable fuels would increase. The long-term environmental goal of the RFS is to support the development of advanced biofuels, which have life cycle greenhouse gas emissions reductions of at least 50 percent, and especially to support cellulosic biofuels, which have life cycle greenhouse gas emissions reductions of at least 60 percent (cellulosic biofuels use feedstocks such as corn stover, which includes parts of the corn plant besides the kernels; conventional ethanol production does not use stover).

International Leadership

Actions taken to reduce domestic emissions, the first goal of the Climate Action Plan, provide the foundation for meeting the Plan's third objective: providing international leadership to address climate change. From 2005 to 2012 (the last year of data available from the EIA), the United States reduced its total carbon pollution (measured in tons of CO2-equivalent) more than any other nation on Earth. And, as noted above, the

Figure 6-24
U.S. Motor Gasoline and Diesel Fuel Consumption, 2000–2030

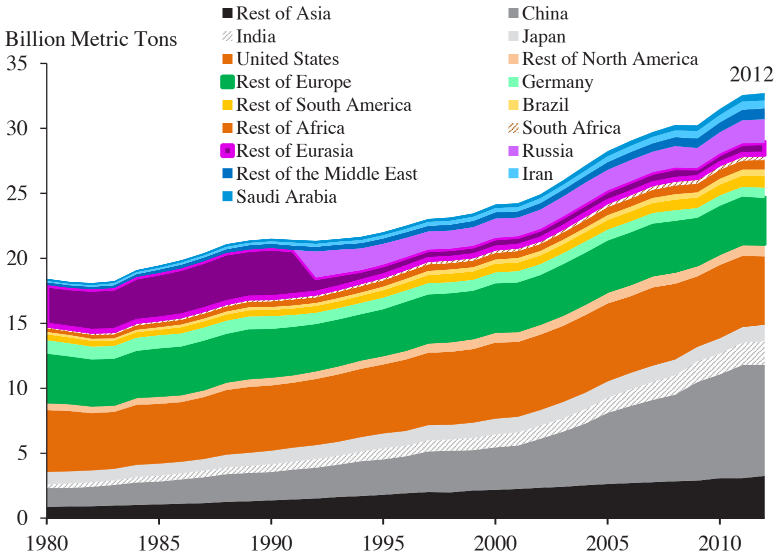


Source: Energy Information Administration, Annual Energy Outlook (2014).

United States is further reducing its greenhouse gas emissions by: improving energy efficiency; taking advantage of unconventional natural gas as a transitional fuel; supporting renewable, nuclear, and clean coal energy sources; and regulating emissions under the Clean Air Act. But curbing greenhouse gas emissions is ultimately an international challenge, as is climate change. The United States produces approximately 16 percent of global energy-related CO2 emissions, second only to China (Figure 6-25). As the economies in the developing world expand, however, their energy needs will increase. Business-as-usual projections indicate that an increasing share of greenhouse gas emissions will come from outside the United States and from the developing world in particular. Fully solving the problem of excessive emissions will therefore require a broad global response.

U.S. leadership is vital to the success of international negotiations to set meaningful reduction goals. This leadership is multifaceted. Through low-carbon technologies developed and demonstrated in the United States (including unconventional natural gas production technology), this Nation can help the rest of the world reduce its dependence on high-carbon fuels. The President's initiative under the Climate Action Plan to lead efforts to eliminate international public financing for new conventional coal plants, except in the poorest countries without economically feasible alternatives, will further help the world move toward cleaner fuels for electric power. Investing in research in new technologies such as carbon capture and storage for cleaner coal and natural gas, as well as biomass co-firing, and advanced renewable liquid fuels, pushes forward these frontiers, and supports U.S. technology leadership in clean energy. More broadly, clean energy technologies developed here, as well as domestically manufactured clean energy products, provide global benefits when they are used abroad to reduce greenhouse gas emissions. And by taking strong steps to reduce emissions at home, the Administration is in a strong position to secure similar commitments from other nations—both in discussions with individual countries and at the United Nations climate negotiations to be held in Paris in 2015. The domestic steps include new initiatives such as the second round of medium and heavy-duty truck greenhouse gas standards, programs to reduce methane emissions and other non-CO2 gases outside the energy sector, and regulation of CO2 emissions from the electric power sector, combined with the large and growing effects of enacted policies such as fuel economy standards for passenger vehicles. This strength is demonstrated by the recent historic joint announcement of post-2020 climate targets with China. In combination, the Administration's efforts lay the foundation for a cleaner energy future that is economically efficient, upholds our

Figure 6-25
World Carbon Dioxide Emissions, 1980–2012



Source: Energy Information Administration, International Energy Statistics.

responsibility to future generations, and provides positive net economic benefits, both directly and through the example we set for other countries.

Conclusion

The U.S. energy sector has changed profoundly over the past decade. Technological innovations and government policies have reversed the decline in oil and gas production and have caused an explosion in renewable energy production. Building on these developments, the Administration's All-of-the-Above Energy Strategy supports job creation and economic growth, while improving the Nation's energy security. The energy revolution has benefited not only domestic energy sectors, but also the energy-consuming businesses and households that enjoy lower energy prices.

Recognizing the need to address climate change domestically and to provide international climate leadership, the President's Climate Action Plan includes a broad range of initiatives to reduce domestic emissions aggressively. These efforts lay the foundation for leadership in securing international agreements to reduce emissions and prepare for climate change. The Administration's energy strategy has built the framework for a sustainable energy future.